Seaweeds:
From Tradition to
Innovation!

ISS2019

# 23rd International Seaweed Symposium

**April 28** (Sun) – **May 3** (Fri), 2019

International Convention Center, Jeju, Korea

## Program & Abstract Book

INTERNATIONAL SEAWEED ASSOCIATION

The Korean Society of Phycology

Jeju 제주특별자치도 Jeju Special Self-Governing Province

WANDO COUNTY

FIRA 한국수산자원관리공단 KOREA FISHERIES RESOURCES AGENCY

MSC MSC CO., LTD.

ISS 2019

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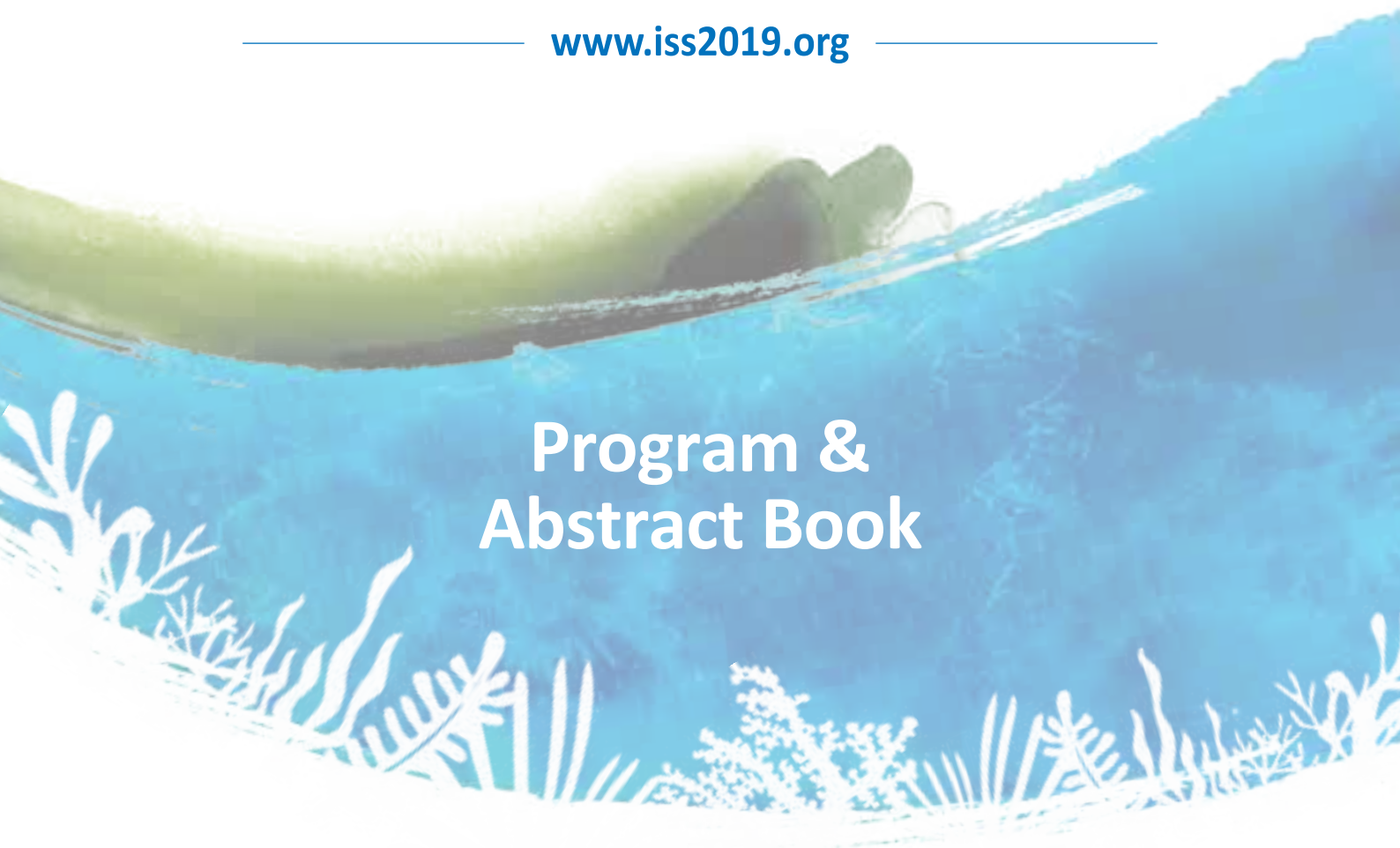
www.iss2019.org



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MSC MSC CO., LTD.

*Undaria pinnatifida*

# CONTENTS

# Program at a Glance

## Day 2 — April 29 (Mon)

| Time | Tamna A (5F) | Halla A(3F) | Halla B(3F) | Samda A(3F) | Samda B(3F) | 303(3F) | Lobby (5F) |
|---|---|---|---|---|---|---|---|
| 8 00~30 | | | | | | | |
| 30~40 | **Plenary 1** (Sung Min Boo ) | | | | | | |
| 40~50 | | | | | | | |
| 50~60 | | | | | | | |
| 9 00~10 | | | | | | | |
| 10~20 | | | | | | | |
| 20~30 | | | | | | | |
| 30~40 | Coffee Break | | | | | | |
| 40~50 | | MS 02 | MS 03 | MS 04 | MS 05 | MS 01 | |
| 50~60 | | Seaweed-to-biofuel: Overview of different biotechno-logical approaches | Seaweed cultivation and breeding for the future | Mechanisms responding to metabolic stressors in microalgae | Macroalgal Blooms on the Rise Around the World | Algal taxonomy – an update after 25 years of molecular phylogenetics | |
| 10 00~10 | | | | | | | |
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| 50~60 | | | | | | | |
| 00~10 | | | | | | | |
| 10~20 | Break | | | | | | |
| 11 20~30 | **Opening Ceremony** (11:20 - 12:40) | | | | | | |
| 30~40 | | | | | | | |
| 40~50 | | | | | | | |
| 50~60 | | | | | | | |
| 12 00~10 | | | | | | | |
| 10~20 | | | | | | | |
| 20~30 | | | | | | | |
| 30~40 | | | | | | | |
| 40~50 | | | | | | | |
| 50~60 | | | | | | | |
| 13 00~10 | **Lunch** (Tamna B) | | | | | | |
| 10~20 | | | | | | | |
| 20~30 | | | | | | | |
| 30~40 | | | | | | | |
| 40~50 | | | | | | | |
| 50~60 | | | | | | | |
| 00~10 | | OR 01 | OR 02 | OR 03 | OR 04 | OR 05 | |
| 10~20 | | | | | | | |
| 14 20~30 | | Open water seaweed aquaculture <1> | Algal natural products, functional foods and pharmacology <1> | Algal blooming <1> | Taxonomy and diversity <1> | Ecology <1> | |
| 30~40 | | | | | | | |
| 40~50 | | | | | | | |
| 50~60 | | | | | | | |
| 00~10 | | | | | | | |
| 10~20 | | | | | | | |
| 15 20~30 | | | | | | | |
| 30~40 | Coffee Break | | | | | | |
| 40~50 | | | | | | | |
| 50~60 | | OR 06 | OR 07 | OR 08 | OR 09 | OR 10 | |
| 00~10 | | | | | | | |
| 10~20 | | | | | | | |
| 16 20~30 | | | | | | | |
| 30~40 | | | | | | | |
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| 17 20~30 | | | | | | | |
| 30~40 | | | | | | | |
| 40~50 | | | | | | | |
| 50~60 | | | | | | | |
| 00~10 | | | | | | | Poster Session 1 (18:00 - 19:30) |
| 10~20 | | | | | | | |
| 18 20~30 | | | | | | | |
| 30~40 | | | | | | | |
| 40~50 | | | | | | | |
| 50~60 | | | | | | | |
| 19 00~30 | | | | | | | |
| 30~60 | | | | | | | |

| Open water seaweed aquaculture <2> | Algal natural products, functional foods and pharmacology <2> | Pathogen and disease | Taxonomy and diversity <2> | Ecology <2> |
|---|---|---|---|---|

## Day 3 — April 30 (Tue)

| Time | Tamna A (5F) | Halla A(3F) | Halla B(3F) | Samda A(3F) | Samda B(3F) | 303(3F) |
|---|---|---|---|---|---|---|
| 8 00~30 | | | | | | |
| 30~40 | **Plenary 2** (Olaf Kruse) | | | | | |
| 40~50 | | | | | | |
| 50~60 | | | | | | |
| 9 00~10 | | | | | | |
| 10~20 | | | | | | |
| 20~30 | | | | | | |
| 30~40 | **Plenary 3** (Elizabeth J Cottier-Cook) | | | | | |
| 40~50 | | | | | | |
| 50~60 | | | | | | |
| 00~10 | | | | | | |
| 10~20 | Coffee Break | | | | | |
| 10 20~30 | | MS 06 | MS 07 | MS 08 | MS 09 | MS 10 |
| 30~40 | | The envisioned bumpy road towards an industrial scaled seaweed aquaculture around the globe | Microalgae; from test tube to market | Hologenomics and evolution of algal symbiosis | Special Session for Women in Algae Science | Seaweed and Climate Change |
| 40~50 | | | | | | |
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| 00~10 | | | | | | |
| 10~20 | | | | | | |
| 11 20~30 | | | | | | |
| 30~40 | | | | | | |
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| 50~60 | | | | | | |
| 12 00~10 | **Lunch** (Tamna B) | | | | | |
| 10~20 | | | | | | |
| 20~30 | | | | | | |
| 30~40 | | | | | | |
| 40~50 | | | | | | |
| 50~60 | | | | | | |
| 00~10 | | MS 11-1 | MS 12-1 | OR 11 | OR 12 | OR 13 |
| 10~20 | | | | | | |
| 13 20~30 | | Holobiome – host, diseases and environmental change | Seaweed derived bioactives compounds | Biostimulants | Climate change and ocean acidification <1> | Algal biomass and biofuel <1> |
| 30~40 | | | | | | |
| 40~50 | | | | | | |
| 50~60 | | | | | | |
| 00~10 | | MS 11-2 | MS 12-2 | OR 14 | OR 15 | OR 16 |
| 10~20 | | | | | | |
| 14 20~30 | | Sustainable seaweed aquaculture: population genetics, biosecurity | Seaweed derived bioactives compounds | Seaweed industry and governance <1> | Climate change and ocean acidification <2> | Algal biomass and biofuel <2> |
| 30~40 | | | | | | |
| 40~50 | | | | | | |
| 50~60 | | | | | | |
| 00~10 | Coffee Break | | | | | |
| 10~20 | | | | | | |
| 15 20~30 | | | | | | |
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| 17 20~30 | | | | | | |
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| 50~60 | | | | | | |
| 00~30 | | | | | | |
| 30~60 | | | | | | |

| Student Competition 1 | Student Competition 2 | Student Competition 3 | Student Competition 4 | Phycocolloids and bioactive compounds |
|---|---|---|---|---|

**Student Night** (19:00~)
at a restaurant ouside the venue

**Day 1 April 28 (Sun)**

- Registration (16:00 - 20:00)
- Welcome Reception / OCEAN VIEW (5F, ICC) (18:00~)

**Workshop 1:** Rocky Shore Ecology Walk
**Workshop 2:** Korean Seaweed Industry Networking
**Workshop 3:** Good Seaweed vs. Bad Seaweed
*Seats are limited. Only for workshop registrants

**Workshop 4 :** Kappaphycus Genome Workshop (#304)
*Seats are limited. Only for workshop registrants

## Day 4 — May 1 (Wed)

| Tamna A (5F) | Halla A(3F) | Halla B(3F) | Samda A(3F) | Samda B(3F) | 303(3F) | Lobby (5F) |
|---|---|---|---|---|---|---|
| | | | | | | |

## Day 5 — May 2 (Thu)

| Tamna A (5F) | Halla A(3F) | Halla B(3F) | Samda A(3F) | Samda B(3F) | 303(3F) | Lobby (5F) |
|---|---|---|---|---|---|---|
| **Plenary 4** (J Mark Cock) | | | | | | |
| Coffee Break | | | | | | |
| **MS 13** Genomic selection in economically important kelp of the Eastern Pacific and North Atlantic | **MS 14** Microalgal biotechnology and industries: construction of a whole value chain from labs, ponds to tables | **MS 15** Seaweed 4Health, bioactives from seaweed in health applications taking into account standards and legislation | **MS 16** Coralline algae, global marine ecosystem engineers: their systematics, physiology and ecology | **MS 17** Algal Culture Collection | | |
| Break | | | | | | |
| **SS 01** Special Session Seaweed Aquaculture: past, present and future | **OR 18** Algae-microbe interaction | **OR 19** Algal natural products, functional foods and pharmacology <3> | **Student Competition 5** | **OR 20** Phylogeo-graphy | **OR 21** Genomics <1> | |
| **Lunch** (Tamna B) | | | | | | |
| | **MS 18** *SPECIAL FIRA Session: Recovery and conservation of marine forest | **OR 22** Seaweed industry and governance <2> | **Student Competition 6** | **OR 23** Algal natural products, functional foods and pharmacology <4> | **OR 24** Genomics <2> | |
| Coffee Break | | | | | | |
| | **MS 19** *SPECIAL Jeju Session: Research agenda for Jeju coastal environmental issues | **OR 25** Seaweed industry and governance <3> | **Student Competition 7** | **OR 26** Algal natural products, functional foods and pharmacology <5> | **OR 27** Algal blooming <2> | |
| | | | | | | **Poster Session 2** (16:50 - 18:20) |
| **Banquet** (18:40~) Aldre Garden, The Seaes Hotel & Resort | | | | | | |

## Day 6 — May 3 (Fri)

| Tamna A (5F) | Halla A(3F) | Halla B(3F) | Samda A(3F) | Samda B(3F) |
|---|---|---|---|---|
| **Plenary 5** (Filipe Alberto) | | | | |
| Coffee Break | | | | |
| **MS 20** Climate-driven changes in seaweed species distributions: drivers and ecological impacts | **MS 21** The novel output and innovative processing of macroalgae using anaerobic digestion | **MS 22** "Chemicale-cology" of algal-microbe interactions | **OR 28** Cultivar, nursery and harvest <1> | **OR 29** Bioreme-diation |
| Break | | | | |
| **OR 30** Genomics <3> | **OR 31** Ecology | **OR 32** Algal derived cosmetics | **OR 33** Cultivar, nursery and harvest <2> | **OR 34** Seaweed Usage |
| **Closing Ceremony** (12:40-13:20) | | | | |

## Date/Time — Room

| Time | Room |
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| 00~10 | |
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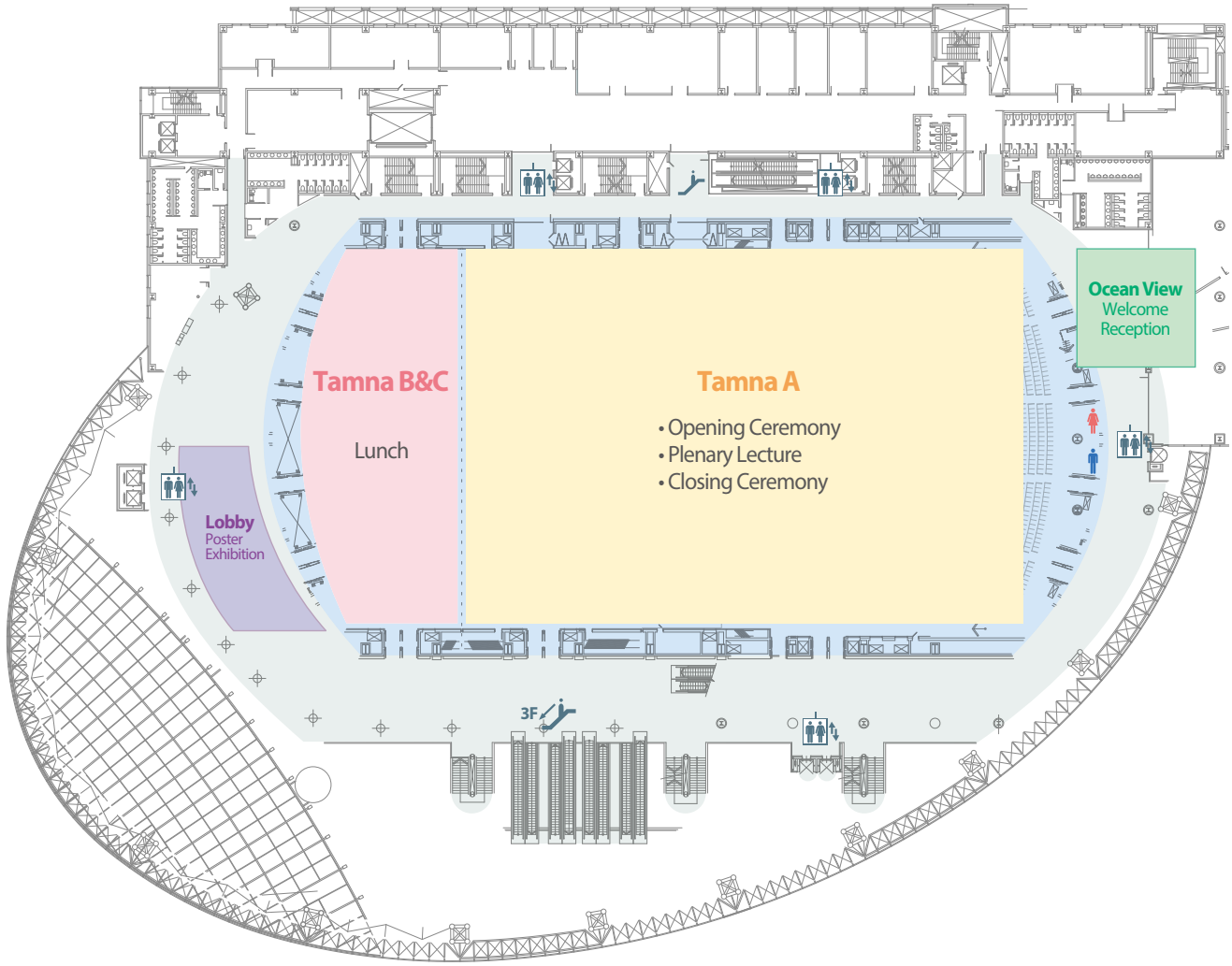
| 20~30 | 18 |
| 30~40 | |
| 40~50 | |
| 50~60 | |
| 00~30 | 19 |
| 30~60 | |

***This program is subject to change.*

# Floor Plan

## JEJU ICC, 3F

## JEJU ICC, 5F


Ocean View
Welcome
Reception
Tamna B&C
Lunch
Tamna A
• Opening Ceremony
• Plenary Lecture
• Closing Ceremony
Lobby
Poster
Exhibition
3F

# Welcome Message

## Jeong Ha Kim, Ph.D.

*Chair, ISS 2019 National Organizing Committee*
*President, The Korean Society of Phycology*
*Professor, Sungkyunkwan University*

I welcome you all to Jeju !!

It is the great moment for all of us to start the 23rd International Seaweed Symposium here in the beautiful island of Korean peninsular with unique nature and culture. Island of Jeju features a diverse marine life, representing a biodiversity hotspot in the Far East Asian region, which you may see some during your stay in Jeju this week.

Surprisingly, we have over 700 regular registrations from 41 different countries including 349 orals and 259 poster presentations in this ISS 2019 Jeju, which may be one of the top 3 biggest ISS in its 70 years history. We invited as many scholars as possible by opening 22 mini-symposia. Given Korea's long history of seaweed aquaculture, with a growing interest in seaweeds as future resources, the scientific theme of ISS 2019 is "Seaweeds: From Tradition to Innovation". To harmonize the 'tradition' and 'innovation', ISS 2019 will take advantages of advanced seaweed aquaculture technologies and the broad spectrum of algal researches in Korea.

I hope you all fully enjoy the symposium academically and socially. Tasting Jeju's local tangerines and walking along the beautiful coastline 'Olle courses' will be another joyful experience while you stay in Jeju I am sure.

Again, welcome to Korea and have a successful meeting of ISS 2019 !!

**Jeong Ha Kim**
*Chair of National Organizing Committee*

# Symposium Overview

## About the Symposium

23rd International Seaweed Symposium (ISS 2019) Overview

| | |
|---|---|
| **Title** | 23rd International Seaweed Symposium (ISS 2019) |
| **Theme** | Seaweeds: From Tradition to Innovation! |
| **Date** | April 28 (Sun) – May 3 (Fri), 2019 |
| **Venue** | International Convention Center, Jeju, Korea (ICC Jeju) |
| **Hosted by** | Korean Society of Phycology (KSP)<br>International Seaweed Association (ISA) |
| **Organized by** | 23rd International Seaweed Symposium : National Organizing Committee |
| **Official Language** | English |
| **Official Website** | www.iss2019.org |
| **ISS 2019 Secretariat** | ISS 2019 National Organizing Committee (NOC)<br>83687, Research Complex 2, SKKU, 2066 Seobu-Ro, Jangan-Gu, Suwon-Si, Gyeonggi-Do, Korea |

# National Organizing Committee

## General Chair

| | |
|---|---|
| Jeong Ha Kim | Sungkyunkwan University |

## Advisory Committee

| | |
|---|---|
| Sung Min Boo | Chungnam National University |
| Hyung Geun Kim | Gangneung-Wonju National University |

## Secretary

| | |
|---|---|
| Jang Kyun Kim | Incheon National University |

## Treasurer

| | |
|---|---|
| Ga Youn Cho | National Institute of Biological Resources |

## Scientific Committee

| | |
|---|---|
| Hwan Su Yoon | Sungkyunkwan University |
| Myung Sook Kim | Jeju National University |
| You Jin Jeon | Jeju National University |
| Eon Seon Jin | Hanyang University |
| Mi Sook Hwang | National Institute of Fisheries Science |
| Woongghi Shin | Chungnam National University |

## Program Committee

| | |
|---|---|
| Han Gil Choi | Wonkwang University |
| Han Gu Choi | Korea Polar Research Institute |
| Young Sik Kim | Kunsan National University |
| Chang Geun Choi | Pukyong National University |
| Myung Gil Park | Chonnam National University |

## Venue

International Convention Center Jeju (ICC Jeju)

The International Convention Center Jeju (ICC Jeju) is located within the Jungmun Tourist Complex, with the cobalt-blue Northern Pacific stretching to the south and towering Mt. Halla commanding the north. A duty-free shopping center is located on the 1st floor of ICC Jeju. This will make the participant's brief time here more enjoyable and fun.

Spreading over an area of more than 5,000, the world-class convention center is a 7-story building.

Artfully blending tourist resources and convention facility, this resort-style convention center is fully equipped for international meetings of any scale and provides professional logistic support for hosting events. All conference halls are fully-equipped and with Wi-Fi Internet access.

| | |
|---|---|
| Address | 224, Jungmungwangwang-ro, Seogwipo-si, Jeju-do, Republic of Korea |
| Telephone | +82-64-735-1000 |
| Homepage | http://www.iccjeju.co.kr/EN/Main |

# Symposium Information

## On-site Information

### Registration

Place : 3F, Lobby
Operating Hours : April 28 (Sun) 16:00 - 20:00
April 29 (Mon) - 30 (Tue) 07:30 - 18:00
May 1 (Wed) Closed
May 2 (Thu) 08:00 - 16:00
May 3 (Fri) 08:00 - 13:00

Credit cards and cash are the only forms of payment accepted for on-site registration. If you are registering in the student category, valid proof of status must be presented at the time of registration.

#### · Registration Fee Coverage

| Participant | Accompanying Person |
|---|---|
| - Session entry<br>- Opening/Closing Ceremony<br>- Welcome Reception<br>- Student Night (Student Registrant only)<br>- Exhibition<br>- Lunch & Coffee Break (except Wednesday, May 1)<br>- Program Materials<br>- Free Shuttle Bus (Venue ↔ Hotels in Jungmun Area Only)<br>- Symposium Kit | - Opening/Closing Ceremony<br>- Welcome Reception<br>- Exhibition<br>- Lunch & Coffee Break (except Wednesday, May 1)<br>- Free Shuttle Bus<br>(Venue ↔ Hotels in Jungmun Area Only) |

※ Name tags will be used as passes in all aspects of the Symposium. Please wear your name tag throughout the Symposium. Please note that admission to the scientific session rooms is strictly limited to registered participants wearing their name tag. If you lose your name tag, ask the registration desk for a replacement.
※ **Abstract book** will be given to all registrants on-site.

#### · Symposium Kit

The Symposium kit will be given to fully registered participant at the registration desk. Each kit contains an important symposium program & abstract book and others materials.

#### · Hotel Desk

For questions or to receive assistance regarding hotel reservations (for official Symposium hotels only), please visit the hotel desk next to the registration desk.

### Lunch

Place : 5F, Tamna B&C
Operating Hours : April 29 (Mon) 12:40 - 14:00 / April 30 (Tue) 12:00 - 13:00
May 2 (Thu) 12:30 - 13:30

Lunch will be provided for registered participants and an accompanied person. Please come to Tamna B&C (5F) and submit a lunch coupon to receive your lunch from the staff. Lunch coupons are in your name tag.

## Preview Room

Place : 3F, 301

Operating Hours : April 28 (Sun) 16:00 - 18:00
May 1 (Wed) Closed
April 29 (Mon) - 30 (Tue), May 2 (Thu) 07:30 - 18:00
May 3 (Fri) 07:30 - 12:00

All speakers are highly encouraged to check in and submit their PowerPoint presentations and materials to ensure that everything is satisfactory. We highly recommend that you visit the Preview Room at least two hours before your presentation.

- If your presentation file contains animations or video clips, you are advised to carefully review all your materials and the technical setup at least three hours prior to your session.
- Please bring your PowerPoint presentation file with you on a USB memory stick so that edits and updates can be made easily.

## Awards

### 1. Maxwell S. Doty Awards

In memory of Dr. Maxwell S. Doty (1919 – 1996), Professor Emeritus of the University of Hawaii, two time President of the ISA and researcher instrumental in developing Eucheumoid seaweed cultivation for the carrageenan industry leading to hundreds of thousands of jobs and hundreds of millions of dollars to coastal communities in the Indo-Pacific, the ISA is proud to present the Dr. Maxwell S. Doty Memorial Award for Outstanding Research in Applied Phycology. Three awards (US$1,500, $1,000 and $500) will be provided for outstanding research presented at the 23rd ISS.

### 2. Best Student Paper Awards I Best Student Poster Awards

The best student presentation awards will be given for the outstanding student papers presented at ISS 2019 as determined by the Student Award Committee. Papers in three different fields will be selected including basic science, application of algae, and algal cultivation. The student awards will be announced during the closing ceremony. The funding for these awards are provided by The Scottish Association for Marine Science (SAMS).

## Photo Contest

The National Organizing Committee of ISS 2019 will hold a photo contest during the symposium. Selected algal photos among hundreds of submissions will be displayed at the lobby of 3rd floor. Vote for the TWO best photos before 4:00PM, Thursday, May 2, by placing your stickers under each photo. Two stickers are placed in your registration badge for voting. The winners will be announced during the closing ceremony.

## Coffee Breaks

Place : 3F, Lobby

Operating Hours : April 29 (Mon) 09:30 - 09:40 / 15:30 - 15:50
April 30 (Tue) 10:10 - 10:30 / 16:10 - 16:30
May 2 (Thu) 09:30 - 09:50 / 15:00 - 15:20
May 3 (Fri) 09:30 - 09:50

## Secretariat Office

Place : 3F, 300

Operating Hours : April 28 (Sun) 16:00 - 20:00 / April 29 (Mon) - 30 (Tue) 07:30 - 18:00 / May 1 (Wed) Closed
May 2 (Thu) 07:30 - 18:00 / May 3 (Fri) 07:30 - 13:00

## Free Wi-fi

Wi-fi service will be available at ICC, Jeju. Please connect your mobile device to "Public WiFi FREE" from the list of available networks.

## First Aid Service

Staff will be available at the registration desk throughout the Symposium to provide first aid kit.

# Social Events

## Welcome Reception

**Date** April 28 (Sun), 2019
**Time** 18:00 - 20:00
**Venue** Ocean View (5F, Jeju ICC)

All participants are welcome and invited to enjoy finger foods while gazing at the amazing seaside views of Seogwipo. Mingle with old friends and new at the reception.

## Opening Ceremony

**Date** April 29 (Mon), 2019
**Time** 11:20 - 12:40
**Venue** Tamna A (5F, Jeju ICC)

Be a part of the grand opening celebration and enjoy the musical 'Ho-oey Story'- the story about haenyeo (women diver) culture.

## Student Night

*Student Applicant ONLY

**Date** April 30 (Tue), 2019
**Time** 19:00
**Venue** Restaurant booked outside of ICC
**Gathering Place and Time** 3F, Lobby 18:40

Night gathering of students at this Chi-Maek (Korean Chicken & Beer) and pizza party! Mingle with new friends and make an unforgettable memory in Korea. * You should wear your name tag to join the Student Night.

## Banquet

*Applicant ONLY

**Date** May 2 (Thu), 2019
**Time** 18:40 - 20:40
**Venue** Aldre Garden, The Seaes Hotel & Resort (10 minutes on foot from ICC, Jeju)
**Gathering Place and Time** 3F, Lobby 18:30

Don't miss out on this fantastic opportunity, and enjoy the beautiful night and ocean view of Jeju.
Ticket will be in your name tag.

## Closing Ceremony

**Date** May 3 (Fri), 2019
**Time** 12:40 - 13:20
**Venue** Tamna A (5F, Jeju ICC)

Join us at the Closing Ceremony.
Award Ceremony will be held during the Closing Ceremony, and all award winners and candidates are expected to attend.

*Ecklonia cava*

# Sponsorship & Exhibition

## Sponsors Acknowledgements

The ISS 2019 National Organizing Committee would like to express its gratitude to those who have generously contributed and actively participated to make this Symposium happen.

### Supporters

Jeju

WANDO COUNTY

FIRA

### Platinum

MSC CO., LTD.

### Silver

DNA Link
www.dnalink.com

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해녀삼춘
HAENYEO UNCLE

## Jeju Special Self-Governing Province

Jeju is the only Special Self-Governing Province as well as the largest island in Korea, with a population of 660,000 and a total area of 1,848 $km^2$. Mt. Halla rises above the center of Jeju at 1950 m above sea level. Over 360 small mountains and hills are also located throughout the island, which are covered with dark gray volcanic rocks and volcanic ash soil. Relatively isolated from the rest of the world, the island's nature has been well preserved in its prehistoric state. Jeju has long been the ideal destination to spend a summer vacation or honeymoon. Tourists can visit without a visa from most countries around the world. UNESCO has listed Jeju Island and its lava tubes as a World Natural Heritage site. Various rare creatures still inhabit the tubes and tourists are able to experience odd-looking stalactites and pristine water; the magnificent creations of mother nature.
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## WANDO COUNTY

Wando County, known as the capital of clean sea and seaweed aquaculture in Korea, is located at the far south of the Korean Peninsula. It contains of 265 islands. It lias beach is formed by foreshore and seaweeds. Elvan rocks and saltpeter are under the sea contributing to abundant nutritious minerals giving nutrition to 2,200 types of sea organisms. These features make Wando for an ideal place for seaweed aquaculture. There are many beautiful tourist attractions. Of the islands in this county, Cheongsando is now offering a 'Cheongsando Slow Walk Festival', to be held for a month starting from April 6, 2019.

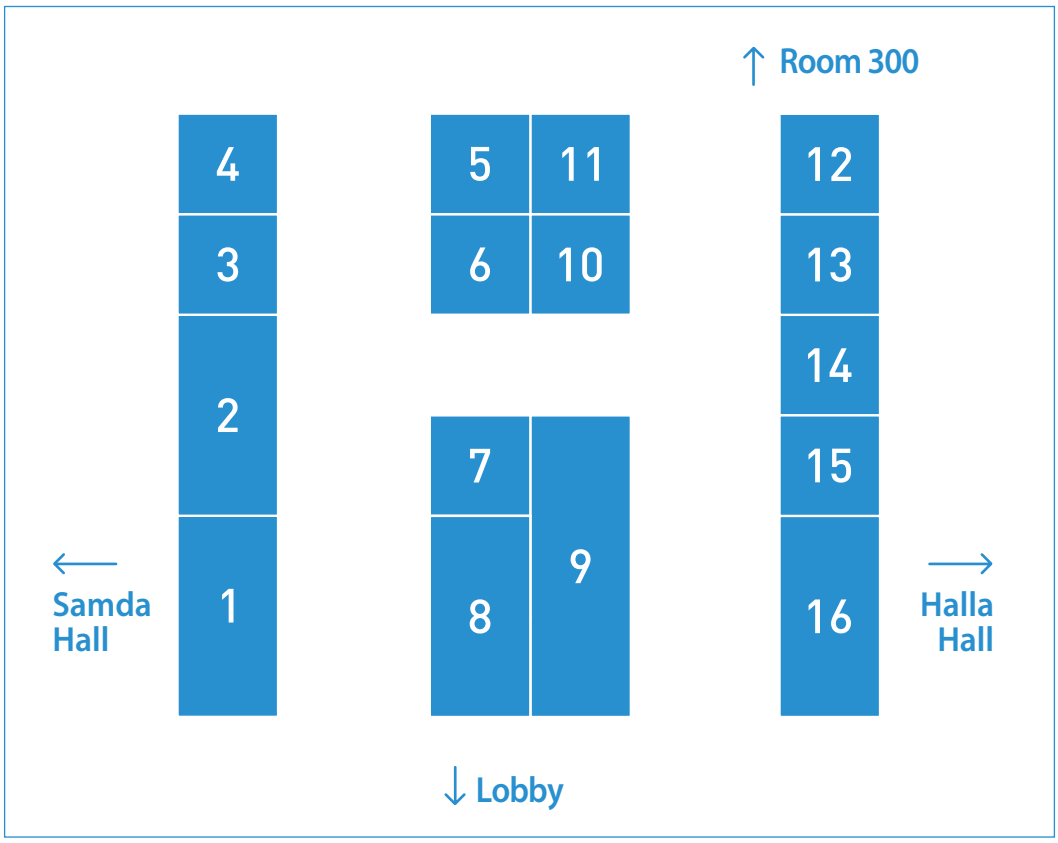
## Korea Fisheries Resources Agency

FIRA is contributing on increasing marine resources. We have been restoring barren ground using various seaweed and also we are carrying out making marine ranches, fisheries seeds releasing and TAC(Total Allowable Catch) system to coexist between human and the ocean.

## MSC CO., LTD.

Under the goal of leading the development of new food culture with the best quality products and the best customer satisfaction, we have been making natural food materials for 40 years based on thorough hygiene management and constant research and development.
In the future, MSC Co., Ltd. will do its best as an honest corporation that makes good food by continuously creating new value in the food industry through steady research and development.

## ◦ Exhibition Floor Plan




| Booth | Company Name | Booth | Company Name |
|---|---|---|---|
| 1 | Jeju Special Self-Governing Province | 9 | Wando County |
| 2 | The business group for Jejutot wellness promotion | 10 | DNA Link |
| 3 | Nakdonggang National Institute of Biological Resource | 11 | *WALZ* |
| 4 | Gallery GIO Jeju | 12 | ZANQUE AQUA FARMS LTD SEAWEED DEVELOPER |
| 5 | SEA & BIOTECH / Kim, Hyeon-ju pressed flower culture space | 13 | SPRINGER NATURE |
| 6 | Gijang Seaweed Breeding Research Center | 14 | C-WEED CORPORATION |
| 7 | International Center for Marine Biodiversity | 15 | INDONESIA SEAWEED |
| 8 | FIRA Korea Fisheries Resources Agency | 16 | MSC CO., LTD. |

*Ecklonia cava*

# Scientific Program

## Plenary Speakers

### Sung Min Boo

*Chungnam National University, Korea*
Beautiful and familiar seaweeds in Jeju Islands; diversity and distribution

### Olaf Kruse

*Bielefeld University, Center for Biotechnology, Germany*
Microalgae as sustainable photosynthetic green cell factories in biotechnology

### Elizabeth J. Cottier-Cook

*Scottish Association for Marine Science (SAMS), UK*
The aquaculture and aliens paradox: Could the reliance of the seaweed aquaculture industry on non-native species lead to its' downfall?

### J. Mark Cock

*Biological Station of Roscoff, France*
Genomic and genetic approaches to explore brown algal biology and support seaweed aquaculture

### Filipe Alberto

*University of Wisconsin-Milwaukee, USA*
Using genetics to unravel the ecology and economic potential of the giant kelp *Macrocystis pyrifera*

# Scientific Program

## Day 2 (April 29, Monday)

### Plenary Lecture

| | | | | | |
|---|---|---|---|---|---|
| Tamna A (5F) | **[PL 1] Plenary 1** | | | | |
| | Chairperson : Kwang Yong Kim (Korea) | | | | |
| | 08:30-09:30 | PL-1 | Beautiful and familiar seaweeds in Jeju Islands; diversity and distribution | Sung Min Boo | Korea |

### Mini Symposium

| | | | | | |
|---|---|---|---|---|---|
| 303 (3F) | **[MS 01] Algal taxonomy – an update after 25 years of molecular phylogenetics** | | | | |
| | Chairperson : Olivier De Clerck (Belgium), Hwan Su Yoon (Korea) | | | | |
| | 09:45-10:05 | MS01-1 | Red algal tree of life and its recent update | Hwan Su Yoon | Korea |
| | 10:05-10:25 | MS01-2 | Systematics of green seaweeds (Ulvophyceae), recent progress and challenges | Olivier De Clerck | Belgium |
| | 10:25-10:45 | MS01-3 | Evolutionary relationships of heterokont algae based upon gene and genome phylogenies | Robert Andersen | USA |
| | 10:45-11:05 | MS01-4 | Phylogenetic studies in brown algae with special reference to the early evolution of Laminariales and taxonomic revision of Ectocarpales | Hiroshi Kawai | Japan |
| Halla A (3F) | **[MS 02] Seaweed-to-biofuel: Overview of different biotechnological approaches** | | | | |
| | Chairperson : Bert Groenendaal (Belgium), Jaap van Hal (The Netherlands) | | | | |
| | 09:45-10:05 | MS02-1 | Biochemical conversions of seaweed for combined ethanol and feed ingredients production | Trine Sofie Bladt | Denmark |
| | 10:05-10:25 | MS02-2 | Economics and environmental sustainability of biological seaweed-to-fuel/energy conversion | Jay Liu | Korea |
| | 10:25-10:45 | MS02-3 | Offshore green algae seagriculture in israel for biorefinery and bioeconomy | Alexander Golberg | Israel |
| | 10:45-11:05 | MS02-4 | Replacing the fossil C-molecule | Justus Wouters | The Netherlands |
| Halla B (3F) | **[MS 03] Seaweed cultivation and breeding for the future** | | | | |
| | Chairperson : Eun Kyoung Hwang (Korea), Shaojun Pang (China) | | | | |
| | 09:45-10:05 | MS03-1 | Seaweed cultivation and breeding programs to adapt environmental changes in Korea | Eun Kyoung Hwang | Korea |
| | 10:05-10:25 | MS03-2 | Current status and assignments of seaweed cultivation and breeding in Japan | Norishige Yotsukura | Japan |
| | 10:25-10:45 | MS03-3 | Seaweed farming in China has benefited from application of cultivars | Shaojun Pang | China |
| | 10:45-11:05 | MS03-4 | Micropropagation of selected *Kappaphycus* strains for the purpose of boosting the supply of much needed, new cultivars for commercial farming | Anicia Hurtado | The Philippines |
| Samda A (3F) | **[MS 04] Mechanisms responding to metabolic stressors in microalgae** | | | | |
| | Chairperson : Jae-Hyeok Lee (Canada) | | | | |
| | 09:45-10:05 | MS04-1 | Signaling pathways regulating photosynthesis in response to nutrient starvation and trophic regimes | Jae-Hyeok Lee | Canada |
| | 10:05-10:25 | MS04-2 | The bZIP1 transcription factor regulates lipid remodeling and contributes to ER Stress management in *Chlamydomonas reinhardtii* | Yasuyo Yamaoka | Korea |
| | 10:25-10:45 | MS04-3 | Gene silencing in microalgae | Eun-Jeong Kim | Korea |
| | 10:45-11:05 | MS04-4 | Algae-microbe interaction – a new twist to biological nitrogen fixation | Sowmyalakshmi Subramanian | Canada |
| Samda B (3F) | **[MS 05] Macroalgal blooms on the rise around the world** | | | | |
| | Chairperson : Peimin He (China), Jang K. Kim (Korea) | | | | |
| | 09:45-10:05 | MS05-1 | Annual periodic formation process for the world's largest *Ulva* blooms in the Yellow Sea | Peimin He | China |
| | 10:05-10:25 | MS05-2 | Golden tide seaweeds in Korean waters: genetic and genomic comparisons between floating and benthic populations | Hyuk Je Lee | Korea |
| | 10:25-10:45 | MS05-3 | Challenges and opportunities in relation to *Sargassum* blooms along the coast of the Mexican Caribbean | Daniel Robledo | Mexico |
| | 10:45-11:05 | MS05-4 | Speciation and identification of species in green tide forming *Ulva* species complex | Masanori Hiraoka | Japan |

## Oral Session

| | | | | | |
|---|---|---|---|---|---|
| **Halla A (3F)** | **[OR 01] Open water seaweed aquaculture <1>** | | | | |
| | Moderator: Alejandro Buschmann (Chile) | | | | |
| | 14:00-14:15 | OR01-1 | Manipulating sporophyte morphology towards an enhanced productivity of *Macrocystis pyrifera* (Ochrophyta) | Alejandro Buschmann | Chile |
| | 14:15-14:30 | OR01-2 | The development of seaweed farming in Europe - environmental impacts and prioritizing key knowledge gaps | Adrian Macleod | UK |
| | 14:30-14:45 | OR01-3 | Latitudinal and seasonal variations of growth and chemical content of the sugar kelp *Saccharina latissima* along the Norwegian Coast | Silje Forbord | Norway |
| | 14:45-15:00 | OR01-4 | Challenges in scaling up to massive self-sustaining seaweed farms | Nelson Vadassery | India |
| | 15:00-15:15 | OR01-5 | Biamass allocation of the brown alga *Sargassum fusiforme* and its relationship with modules | Jingyu Li | China |
| | 15:15-15:30 | OR01-6 | Effect of vector and direct seeding on growth of sugar kelp *Saccharina latissima* at sea | Jorunn Skjermo | Norway |
| **Halla B (3F)** | **[OR 02] Algal natural products, functional foods and pharmacology <1>** | | | | |
| | Moderator: Wonho Yih (Korea) | | | | |
| | 14:00-14:15 | OR02-1 | Biofertilizing effecy of the cyanobateria *Fischerella* sp. ecncapsulated in alginate-chitosane in the growth of radish | Gustavo Hernández | Mexico |
| | 14:15-14:30 | OR02-2 | TPG clade crytomonads as a new microalgal group to enrich zooplankters for marine larviculture | Wonho Yih | Korea |
| | 14:30-14:45 | OR02-3 | Marine algae in french polynesia: from traditions to innovation | Mayalen Zubia | France |
| | 14:45-15:00 | OR02-4 | Development of koji on nori *Pyropia yezoensis* and application to nori sauce manufacture | Motoharu Uchida | Japan |
| | 15:00-15:15 | OR02-5 | Anti-parkinson's effects and mechanism of oligosaccharides derived from *Pyropia yezoensis* | Quanbin Zhang | China |
| | 15:15-15:30 | OR02-6 | R-phycoerythrin : new advances on extraction and characterization. impact of the enzymatic assisted extraction | Justine Dumay | France |
| **Samda A (3F)** | **[OR 03] Algal blooming <1>** | | | | |
| | Moderator : Benoit Queguineur (France) | | | | |
| | 14:00-14:15 | OR03-1 | Monitoring and management of the drifting *Sargassum horneri* golden tide in Korea | Sangil Kim | Korea |
| | 14:15-14:30 | OR03-2 | Golden tides in the Yellow Sea and East China Sea: formation and managment | Jianheng Zhang | China |
| | 14:30-14:45 | OR03-3 | The development of bioactives from blooming seaweeds in Normandy, France: the enteromorphe and snotra projects | Benoit Queguineur | France |
| | 14:45-15:00 | OR03-4 | Seasonal population dynamics of the 'golden tides' seaweed, *Sargassum horneri* on the southern coast of Korea: the extent and formation of golden tides | Sang Rul Park | Korea |
| | 15:00-15:15 | OR03-5 | Fast and Accurate Quantification of Alexandrium Catenella in Very Small Abundance Using DdPCR | Hyemi Kim | Korea |
| | 15:15-15:30 | OR03-6 | Enrichment processes for the production of high-protein feed from the green seaweed *Ulva ohnoi* | Marie Magnusson | New Zealand |
| **Samda B (3F)** | **[OR 04] Taxonomy and diversity <1>** | | | | |
| | Moderator : Paul Gabrielson (USA) | | | | |
| | 14:00-14:15 | OR04-1 | Reinstatement of *Calliblepharis jolyi* (Cystocloniaceae, Rhodophyta) based on topotype specimens and a new record of *C. saidana* in the Atlantic Ocean | Mutue Fujii | Brazil |
| | 14:15-14:30 | OR04-2 | Revisiting some records of marine red algae belonging to the Delesseriaceae (Rhodophyta) within the South China sea basin | Lawrence Liao | Japan |
| | 14:30-14:45 | OR04-3 | Status and diversity of eucheumoid in Western Indian Ocean (WIO) region: towards sustainable farming in Tanzania | Gloria Kavia Yona | Tanzania |
| | 14:45-15:00 | OR04-4 | Phylogenomics of the ceramiales: how many families should we recognize? | Pilar Díaz-Tapia | Spain |
| | 15:00-15:15 | OR04-5 | *Corallina berteroi* (Corallinales, Rhodophyta) an earlier name for the cosmopolitan *Corallina caespitosa* | Paul Gabrielson | USA |

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| 303 (3F) | **[OR 05] Ecology <1>** | | | | |
| | Moderator : David Garbary (Canada) | | | | |
| | 14:00-14:15 | OR05-1 | Reduced biomass of the kelp, *Saccharina japonica*, affects gonad production of sea urchins for following years off northeastern Japan | Kosuke Yatsuya | Japan |
| | 14:15-14:30 | OR05-2 | Photosynthetic characteristics and chloroplast position of *Ulva conglobata* (Ulvophyceae) under continuous light and dark conditions | Jayvee Saco | The Philippines |
| | 14:30-14:45 | OR05-3 | Arctic kelp ecophysiology in a warming winter scenario | Kai Bischof | Germany |
| | 14:45-15:00 | OR05-4 | Habitat mapping to inform customary protection of key fisheries habitats | Matthew Desmond | New Zealand |
| | 15:00-15:15 | OR05-5 | Thallus architecture and phenology as tools for understanding ecological impacts of harvesting the economically important seaweed *Ascophyllum nodosum* (Phaeophyceae) | David Garbary | Canada |
| | 15:15-15:30 | OR05-6 | The feasibility and first steps of restoring Australia's disappearing giant kelp (*Macrocystis pyrifera*) forests | Cayne Layton | Australia |
| Halla A (3F) | **[OR 06] Open water seaweed aquaculture <2>** | | | | |
| | Moderator : Michael Stekoll (USA) | | | | |
| | 15:50-16:05 | OR06-1 | Development of scalable coastal and offshore Macroalgal farming in New England and Alaska | Michael Stekoll | USA |
| | 16:05-16:20 | OR06-2 | Different cultivation practices, to increase the yield of sugar kelp (*S. latissima*), in an estuarine environment | Teis Boderskov | Denmark |
| | 16:20-16:35 | OR06-3 | Biosecurity policy and practice in the global seaweed industry - improving existing frameworks to limit the spread of pests and disease | Iona Campbell | UK |
| | 16:35-16:50 | OR06-4 | Ecosystem impact of large-scale Macroalgae cultivation | Annette Bruhn | Denmark |
| | 16:50-17:05 | OR06-5 | Intelligent management system for integrated multi-trophic aquaculture (IMPAQT) | Kati Michalek | UK |
| | 17:05-17:20 | OR06-6 | The gastropod mollusc *Lacuna vincta* as threat to macroalgal aquaculture in NW Europe | Phil Kerrison | UK |
| | 17:20-17:35 | OR06-7 | Aquaculture act and cultivation of seaweed and harvesting of kelp in Norway | Frode Hovland | Norway |
| | 17:35-17:50 | OR06-8 | Wrinkled blades are putatively dominant to smooth ones as revealed by reciprocal crossing and selfing experiments in *Undaria pinnatifida* (Phaeophyceae) | Tifeng Shan | China |
| Halla B (3F) | **[OR 07] Algal natural products, functional foods and pharmacology <2>** | | | | |
| | Moderator: Eko Nurcahya Dewi (Indonesia) | | | | |
| | 15:50-16:05 | OR07-1 | Microencapsulation of chlorophyll from *Caulerpa racemosa* (sea grape) using fish gelatine and arabic gum as coating materialr | Eko Nurcahya Dewi | Indonesia |
| | 16:05-16:20 | OR07-2 | Green extraction of sulphated polysaccharides and alginate from the south african kelp *Ecklonia maxima,* by subcritical water hydrolysis | Neill Goosen | South Africa |
| | 16:20-16:35 | OR07-3 | Nutrient composition, antioxidant activity and blood pressure lowering effect of brown seaweed, *Sargassum polycystum* enriched bread in prehypertensive subjects | Patricia Matanjun | Malaysia |
| | 16:35-16:50 | OR07-4 | By-products from seaweed industry as source of anti-obesity bio-actives: a preliminary *in vitro* study to compare extracts from three seaweed species | Benoit Queguineur | France |
| | 16:50-17:05 | OR07-5 | R-phycoerythrin of selected red algal species from the Baltic Sea | Mihkel Saluri | Estonia |
| | 17:05-17:20 | OR07-6 | Preparation, characterization and anti-helicobacter pylori activity of algin-based bismuth polyuronate | Xiancui Li | China |
| | 17:20-17:35 | OR07-7 | Red seaweed derived natural products for crop protection | Girish Tr | India |
| | 17:35-17:50 | OR07-8 | Red seaweed oligosaccharides increase productivity, stress and disease tolerance in shrimp (*P. monodon* and *L. vannamei*) and fish (*Tilapia*) | Hemanth Giri Rao Vv | India |

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|---|---|---|---|---|---|
| Samda A (3F) | **[OR 08] Pathogen and disease** | | | | |
| | Moderator : Catherine Leblanc (France) | | | | |
| | 15:50-16:05 | OR08-1 | 1-Octen-3-ol, a self-stimulating oxylipin messenger, can prime and induce defense of marine algae | Haimin Chen | China |
| | 16:05-16:20 | OR08-2 | Prophylactic activation of self-defence: a suitable crop protection concept for kelp aquaculture? | Florian Weinberger | Germany |
| | 16:20-16:35 | OR08-3 | Exploring the molecular bases of biotic interactions between *Saccharina latissima* and an algal endophyte | Catherine Leblanc | France |
| | 16:35-16:50 | OR08-4 | Designing a study to investigate observed anomalies on cultivated seaweed (*Eucheuma*) | Ivy Matoju | Tanzania |
| | 16:50-17:05 | OR08-5 | Disease and pest assessment on farmed carrageenophytes in central and southern Philippines | Joseph P. Faisan Jr. | The Philippines |
| | 17:05-17:20 | OR08-6 | Transcriptomic analysis of innate immunity-related genes in response to necrotrophic pathogen *Pythium porphyrae* in the red alga *Pyropia yezoensis* | Lei Tang | China |
| | 17:20-17:35 | OR08-7 | Pathogens of New Zealand Bangiales | Giuseppe Zuccarello | New Zealand |
| | 17:35-17:50 | OR08-8 | Defense responses triggered by the 22 amino acid peptide (flg22V63) deduced from the n-terminus domain of pathogenic bacterium flagellin in *Saccharina japonica* | Gaoge Wang | China |
| Samda B (3F) | **[OR 09] Taxonomy and diversity <2>** | | | | |
| | Moderator : Mariana C. Oliveira (Brazil) | | | | |
| | 15:50-16:05 | OR09-1 | Preliminary assessment of the diversity of farmed eucheumatoids in central and southern Philippines | Rema C. Sibonga | The Philippines |
| | 16:05-16:20 | OR09-2 | Organellar genome variation architecture and population genetic analysis of Chinese *Pyropia yezoensis* assessed by whole-genome resequencing | Kuipeng Xu | China |
| | 16:20-16:35 | OR09-3 | Molecular investigations of the globally distributed agar-producing genus *Pterocladiella* (Gelidiales, Rhodophyta): how much species diversity? where did it originate? how did it disperse? | GaHun Boo | Korea |
| | 16:35-16:50 | OR09-4 | Gracilariaceae phylogenomics: congruence of organellar and nuclear trees | Mariana C. Oliveira | Brazil |
| | 16:50-17:05 | OR09-5 | Exploring the genetic resources of a marine crop – *Eucheuma* and *Kappaphycus* in the spotlight | Janina Brakel | UK |
| | 17:05-17:20 | OR09-6 | Reinstatement of the family Grateloupiaceae (Halymeniales, Rhodophyta) based on the reproductive structures | Hyung Woo Lee | Korea |
| | 17:20-17:35 | OR09-7 | Taxonomic investigation of *Ralfsia*-Like (Ralfsiales, Phaeophyceae) taxa in the north atlantic ocean based on molecular and morphological data, with descriptions of one novel family and two novel genera and species | Manuela I. Parente | Portugal |
| 303 (3F) | **[OR 10] Ecology <2>** | | | | |
| | Moderator : Anchana Prathep (Thailand) | | | | |
| | 15:50-16:05 | OR10-1 | Effects of light quality and temperature on the photosynthesis and pigment content of an edible red alga *Meristotheca papulosa* (Solieriaceae, Gigartinales) from Kagoshima, Southern Japan | Iris Ann Borlongan | Japan |
| | 16:05-16:20 | OR10-2 | *Sargassum plagiophyllum* population structure in Southern Thailand | Anchana Prathep | Thailand |
| | 16:20-16:35 | OR10-3 | The importance of habitats dominated by macroalgae in the shallow tropical seascape of East Africa | Christina Halling | Sweden |
| | 16:35-16:50 | OR10-4 | Traveling in ice cold water: floating algae in Antarctic Peninsula | Erasmo Macaya | Chile |
| | 16:50-17:05 | OR10-5 | Nitrogen and phosphorus ecophysiology of coralline algae | Hang Nguyen | Vietnam |
| | 17:05-17:20 | OR10-6 | Reduction and core bed protection of macroalgae on the coasts of Ojika Island, off Western Kyushu, Japan | Daisuke Fujita | Japan |
| | 17:20-17:35 | OR10-7 | Effects on cover, abundance and development of early stages of brown seaweed *Lessonia spicata* exposed to contaminated coastal waters of Central Chile | Carolina Oyarzo | Chile |
| | 17:35-17:50 | OR10-8 | Photosynthetic responses in two population of the red seaweed, *Gracilaria salicornia*, from Japan and Thailand | Jantana Praiboon | Thailand |

Lobby (5F) 18:00-19:30 **Poster Session**

# Day 3 (April 30, Tuesday)

## Plenary Lecture

| | | | | | |
|---|---|---|---|---|---|
| Tamna A (5F) | **[PL 2] Plenary 2** | | | | |
| | Chairperson : EonSeon Jin (Korea) | | | | |
| | 08:30-09:20 | PL-2 | Microalgae as sustainable photosynthetic green cell factories in biotechnology | Olaf Kruse | Germany |
| Tamna A (5F) | **[PL 3] Plenary 3** | | | | |
| | Chairperson : EonSeon Jin (Korea) | | | | |
| | 09:20-10:10 | PL-3 | The aquaculture and aliens paradox: Could the reliance of the seaweed aquaculture industry on non-native species lead to its' downfall? | Elizabeth J Cottier-Cook | UK |

## Mini Symposium

| | | | | | |
|---|---|---|---|---|---|
| Tamna A (5F) | **[MS 06] The envisioned bumpy road towards an industrial scaled seaweed aquaculture around the globe** | | | | |
| | Chairperson : Alexander Ebbing (The Netherlands) | | | | |
| | 10:35-10:55 | MS06-1 | The necessity of cheap and reliable gametophyte propagation as a bedrock for a thriving global kelp aquaculture | Alexander Ebbing | The Netherlands |
| | 10:55-11:15 | MS06-2 | Innovative and sustainable ropes for seaweed cultivation | Bert Groenendaal | Belgium |
| | 11:15-11:35 | MS06-3 | Seaweed biorefinery – scaling up low hanging fruits | Olavur Gregersen | Faroe Islands |
| | 11:35-11:55 | MS06-4 | Process and economics of large scale seaweed bio-refineries | Jaap Willem Van Hal | The Netherlands |
| Halla A (3F) | **[MS 07] Microalgae; from test tube to market** | | | | |
| | Chairperson : EonSeon Jin (Korea), Michael Borowitzka (Australia) | | | | |
| | 10:35-10:55 | MS07-1 | Metabolic engineering of microalgae via genome editing method to enhance the production of antioxidant-rich algal oil | EonSeon Jin | Korea |
| | 10:55-11:15 | MS07-2 | Progress and trends in the development of microalgae aquafeeds | Qiang Hu | China |
| | 11:15-11:35 | MS07-3 | Cultivation strategy for *Ettlia* sp. YC001 depending on the target materials | Hee-Mock Oh | Korea |
| | 11:35-11:55 | MS07-4 | *Dunaliella salina* beta-carotene: from the lab to commercialisation | Michael Borowitzka | Australia |
| Halla B (3F) | **[MS 08] Hologenomics and evolution of algal symbiosis** | | | | |
| | Chairperson : Cheong Xin Chan (Australia) | | | | |
| | 10:35-10:55 | MS08-1 | Endosymbiosis and environmental adaptation lead to foreign gene acquisition in algal lineages | Debashish Bhattacharya | USA |
| | 10:55-11:15 | MS08-2 | Genomic insights into the virulence mechanisms used by bacterial pathogens of seaweeds | Suhelen Egan | Australia |
| | 11:15-11:35 | MS08-3 | Interrogating evolution for solutions to algal diseases | Claire Gachon | UK |
| | 11:35-11:55 | MS08-4 | Understanding coral-dinoflagellate symbiosis using genomics and hologenomics | Cheong Xin Chan | Australia |
| Samda A (3F) | **[MS 09] Special session for women in algae science** | | | | |
| | Chairperson : Mi Sook Hwang (Korea), Myung Sook Kim (Korea) | | | | |
| | 10:35-10:50 | MS09-1 | Korean initiatives working towards gender equality in STEM | Heisook Lee | Korea |
| | 10:50-11:05 | MS09-2 | Women in science- in seaweed and denmark | Susan Løvstad Holdt | Denmark |
| | 11:05-11:20 | MS09-3 | Women in algae science: Korean prospective | Jin Ae Lee | Korea |
| | 11:20-11:35 | MS09-4 | Surviving and thriving: wisdom from the past and inspiration for the future (or how I have survived as a female phycologist) | Juliet Brodie | UK |
| | 11:35-11:55 | MS09-5 | Algae science and the gendered roles based on the 4th industrial revolution | Mi-Kyung Kim | Korea |
| Samda B (3F) | **[MS 10] Seaweed and climate change** | | | | |
| | Chairperson : Ik Kyo Chung (Korea), Hiroshi Kawai (Japan) | | | | |
| | 10:35-10:55 | MS10-1 | Carbon budget in the seaweed farm, a life cycle analysis | Put O. Ang, Jr. | Hong Kong |
| | 10:55-11:15 | MS10-2 | Vulnerability and mitigation potential of temperate Australian seaweeds in a changing climate | Alecia Bellgrove | Australia |
| | 11:15-11:35 | MS10-3 | Regeneration of ocean forests: the importance of seaweed | Pål Bakken | Portugal |
| | 11:35-11:55 | MS10-4 | Integrated multi-trophic aquaculture (IMTA): a critical analysis towards the use of seaweed for N and C mitigation | Alejandro H. Buschmann | Chile |

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| Halla A (3F) | **[MS 11-1] Holobiome – host, diseases and environmental change** | | | | |
| | Chairperson : Juliet Brodie (UK) | | | | |
| | 13:05-13:25 | MS11-1 | The host and the holobiome: a study of the carrageenophyte *Chondrus crispus* | Georgia Ward | UK |
| | 13:25-13:45 | MS11-2 | Microbiome shifts in the agarophyte *Gracilaria* under high temperature and grazing events: understanding potential disease causative microbes in seaweed aquaculture | Lim Phaik Eem | Malaysia |
| | 13:45-14:05 | MS11-3 | Epiphytes susceptibility and sustainability of algae farms, the host point of view: population genetics of *Gracilaria chilensis* assessed using microsatellite and SNP data sets | Marie-Laure Guillemin | Chile |
| | 14:05-14:25 | MS11-4 | Host and pathogen autophagy are central to the inducible resistance of brown algae against intracellular parasitic water moulds | Pedro Murua Andrade | UK |
| | **[MS 11-2] Sustainable seaweed aquaculture: population genetics, biosecurity** | | | | |
| | Chairperson : Elizabeth Cottier-Cook (UK) | | | | |
| | 14:45-15:05 | MS11-5 | Challenges for the sustainabe *Pyropia* farming: newly arising diseases and changing environment | Gwang Hoon Kim | Korea |
| | 15:05-15:25 | MS11-6 | Seaweed industry trends in Tanzania: success and constraints | Amelia Buriyo | Tanzania |
| | 15:25-15:45 | MS11-7 | Marine biosecurity frameworks for aquaculture | Chad Hewitt | Australia |
| | 15:45-16:05 | MS11-8 | Diversified aquaculture production and markets- seaweeds and sustainable development goals | Nidhi Nagabhatla | Canada |
| Halla B (3F) | **[MS 12-1] Seaweed derived bioactives compounds** | | | | |
| | Chairperson : Charles S. Vairappan (Malaysia), Damien N. Stringer (Australia) | | | | |
| | 13:05-13:25 | MS12-1 | Structural diversity and bioactive potential of halogenated secondary metabolites from four major species of red algae genus laurencia in sulu-sulawesi coral triangle region (Malaysia) | Charles S. Vairappan | Malaysia |
| | 13:25-13:45 | MS12-2 | The effects of marine algal natural products on skeletal muscle growth and inflammatory myopathy | You Jin Jeon | Korea |
| | 13:45-14:05 | MS12-3 | Fucoidan as an integrative therapy | Damien N. Stringer | Australia |
| | 14:45-15:05 | MS12-4 | Potential antioxidant and antiobesity effect of bioactive components from *Sargassum thunbergii* extract | Hyo Geun Lee | Korea |
| | **[MS 12-2] Seaweed derived bioactives compounds** | | | | |
| | Chairperson : Charles S. Vairappan (Malaysia), Damien N. Stringer (Australia) | | | | |
| | 15:05-15:25 | MS12-5 | Isolation of secondary metabolites from marine cyanobacteria and their biosurfactant activity | Jakia Jerin Mehjabin | Japan |
| | 15:25-15:45 | MS12-6 | Proteomic insights on fucoxanthin biosynthesis regulation in microalgae *Phaeodactylum tricornutum* under light limitation | Manoj Kumar | Australia |
| | 15:25-15:45 | MS12-7 | Squalene-derived polyethers, inhibiting adult t-cell leukemia cell, isolated from the red alga, *Chondria armata* | Toshiyuki Hamada | Japan |
| | 15:45-16:05 | MS12-8 | Brown algal extracts for gut health applications | Ah Young Park | Australia |
| **Oral Session** | | | | | |
| Samda A (3F) | **[OR 11] Biostimulants** | | | | |
| | Moderator: Anong Chirapart (Thailand) | | | | |
| | 13:00-13:15 | OR11-1 | Brown algal extracts (AMPEP, Kelpak®) influence growth and thermal resistance in *Saccharina* spp. | Schery Umanzor | USA |
| | 13:15-13:30 | OR11-2 | Growth and epiphytic responses of *Gracilaria fisheri* to the seaweed extract AMPEP under controlled-culture conditions | Anong Chirapart | Thailand |
| | 13:30-13:45 | OR11-3 | Micro-propagation of selected, comercial *Kappaphycus* cultivars, and out-planting (nursery studies) | Majid Khan | Malaysia |
| | 13:45-14:00 | OR11-4 | Red seaweed derived bioformulation, agrogain, improves crop yields by enhancing photosynthesis, metabolism and nutrient uptake | Sri Sailaja Nori | India |
| | 14:00-14:15 | OR11-5 | Seaweed extracts for plant growth & nutrition | Cécile Le Guillard | France |
| | 14:15-14:30 | OR11-6 | Tropical seaweed based agricultural bio-stimulant (sagarika of IFFCO) for the improvement of crop production and plant health | Shanmugam Munisamy | India |

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| Samda B (3F) | **[OR 12] Climate change and ocean acidification <1>** | | | | |
| | Moderator: Ju-Hyoung Kim (Korea) | | | | |
| | 13:00-13:15 | OR12-1 | Global climate change and *Macrocystis pyrifera* (Ochrophyta): does environmental history affect the ability to acclimate to future oceanic conditions? | Pamela Fernandez | Chile |
| | 13:15-13:30 | OR12-2 | *Diploneis serrate* (Bacillariophyceae), a new diatom species from Kenting, Taiwan, and the structural mechanistic analysis of the striae pattern of its frustrule under shear, normal and uniform loading | John Perez | Taiwan |
| | 13:30-13:45 | OR12-3 | Historical climate-driven range shifts shape latitudinal diversity gradients of the marine brown alga *Sargassum thunbergii* in the northwest Pacific | Zi-Min Hu | China |
| | 13:45-14:00 | OR12-4 | Physiological and transcriptomic responses of *Saccharina latissima* from the arctic to dark exposure simulating a warming winter | Huiru Li | China |
| | 14:00-14:15 | OR12-5 | Seaweed solution and carbon zero seaweed town (CØST) with Asian network of algae as mitigation and adaptation measures (ANAMAM) | Ik Kyo Chung | Korea |
| 303 (3F) | **[OR 13] Algal biomass and biofuel <1>** | | | | |
| | Moderator : Jaap Van Hal (The Netherlands) | | | | |
| | 13:00-13:15 | OR13-1 | Effect of inorganic micronutrients on growth of *Arthrospira (Spirulina) maxima* | Won-Kyu Lee | Korea |
| | 13:15-13:30 | OR13-2 | Light and balanced growth in *Ulva pertusa* | Rigoberto Sanchez-Medina | New Zealand |
| | 13:30-13:45 | OR13-3 | Scaling-up bio-fuel production in the H2020 project MacroFuels. | Jaap Van Hal | The Netherlands |
| | 13:45-14:00 | OR13-4 | Seaweed biorefinery: co-extraction of hydrocolloids, plant bioactive compounds and bioplastics | Jeremy Brébion | France |
| | 14:00-14:15 | OR13-5 | Agrobacterium-mediated genetic transformation of seaweed *Kappaphycus alvarezii* using gα gene and callus cultures | Erina Sulistiani | Indonesia |
| | 14:15-14:30 | OR13-6 | Effects of light quantity, quality and duration on the growth rate, pigment composition and photosynthesis of *Spirulina maxima* geitler | Jihae Park | Korea |
| Samda A (3F) | **[OR 14] Seaweed industry and governance <1>** | | | | |
| | Moderator : Fredrik Gröndahl (Sweden) | | | | |
| | 14:40-14:55 | OR14-1 | Development of a Swedish kelp industry - the seafarm project | Fredrik Gröndahl | Sweden |
| | 14:55-15:10 | OR14-2 | Who gets what from whom? Support mechanisms in the Philippine seaweed industry | Jee Grace B. Suyo | The Philippines |
| | 15:10-15:25 | OR14-3 | East African seaweed farming; huge potential but vast challenges | Christina Halling | Sweden |
| | 15:25-15:40 | OR14-4 | Establishing an aquaculture-based large-scale seaweed industry in Norway: strategic, environmental and economic considerations | Celine Rebours | Norway |
| | 15:40-15:55 | OR14-5 | Flow cytometer cell sorting as an alternative method for kelp meiospore isolation | Michael Marty-Rivera | USA |
| | 15:55-16:10 | OR14-6 | The emergence of seaweed aquaculture in the united states: a case study of institutional dynamics and industry structuration | Holly Cronin | Canada |
| Samda B (3F) | **[OR 15] Climate change and ocean acidification <2>** | | | | |
| | Moderator : Janet Kübler (USA) | | | | |
| | 14:40-14:55 | OR15-1 | Exploring solar radiation relations of seaweeds floating at sea: a tool to counteract ocean warming? | Ricardo Radulovich | Costa Rica |
| | 14:55-15:10 | OR15-2 | A model to assess the relative impacts of multiple climate stressors on macroalgal productivity | Janet Kübler | USA |
| | 15:10-15:25 | OR15-3 | Globally driven changes in carbon chemistry change threatens a rare seaweed community and associated industry in the Baltic sea | Liina Pajusalu | Estonia |
| | 15:25-15:40 | OR15-4 | Better local management of kelp forests supports ecosystem resilience in a changing ocean | Christopher Hepburn | New Zealand |
| | 15:40-15:55 | OR15-5 | Investigating the potential impact of ocean warming events on the productivity of two south African kelp species; the ecologically dominant *Ecklonia maxima* and The rare *Macrocystis pyrifera.* | Mark Rothman | South Africa |

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| 303 (3F) | **[OR 16] Algal biomass and biofuel <2>** | | | | |
| | Moderator : Yimin Qin (China) | | | | |
| | 14:40-14:55 | OR16-1 | Overexpression of gα gene increases growth and hyposaline tolerance in *Kappaphycus alvarezii* transgenic plantlets | Erina Sulistiani | Indonesia |
| | 14:55-15:10 | OR16-2 | Application of seaweed constituents in chemicals, materials and fuels | Paulien Harmsen | The Netherlands |
| | 15:10-15:25 | OR16-3 | Achieving high lipid productivity with high biomass productivity in *Ettlia* sp. under optimized nitrogen concentration and UV-A exposure | Seong-Hyun Seo | Korea |
| | 15:25-15:40 | OR16-4 | Hydrothermal liquefaction technology for the conversion of red seaweeds to bio crude | Shrikumar Suryanarayan | India |
| | 15:40-15:55 | OR16-5 | Impacts of *Ascophyllum* marine plant extract powder (ampep) on the carrageenan quality such as carragenan yield, viscosity and gel strength of tissue culture outplanted seaweed in field trial | Majid Khan | Malaysia |
| | 15:55-16:10 | OR16-6 | Applications of bioactive seaweed substances in functional food products | Yimin Qin | China |
| **Student Competition (Oral Session)** | | | | | |
| Halla A (3F) | **[ST 01] Student Competition 1** | | | | |
| | Chairperson : Juliet Brodie (UK),You Jin Jeon (Korea), John Bolton (South Africa) | | | | |
| | 16:30-16:45 | ST01-1 | Environmental effects on potentially valuable components of *Ulva Intestinalis* along the Swedish coast | Joakim Olsson | Sweden |
| | 16:45-17:00 | ST01-2 | Production of bio-hydrogen from macroalgae following hydrothermal treatment | Aaron Brown | UK |
| | 17:00-17:15 | ST01-3 | Opportunities for energy and resource recovery from macroalgae using sequential hydrothermal conversion | Iram Razaq | UK |
| | 17:15-17:30 | ST01-4 | Effect of Blanching on the Metabolites Profiling in Wakame and Mekabu | Shahlizah Sahul Hamid | Japan |
| | 17:30-17:45 | ST01-5 | Protective effect of sulfated polysaccharides from *Hizikia fusiforme* against ultraviolet B-induced skin photoaging | Lei Wang | Korea |
| | 17:45-18:00 | ST01-6 | Key factors to test before formulating a cosmetic emulsion using active phenolic compounds from a brown macroalga: seasonal variability and stability of compounds | Leslie Gager | France |
| | 18:00-18:15 | ST01-7 | Vortex-assisted solid-liquid microextraction methodology for Rapid HPLC/PDA determination of fucoxanthin in seaweed biomass | Nuno Nunes | Portugal |
| | 18:15-18:30 | ST01-8 | Antioxidant activity of sulfated polysaccharide extract from green seaweed (*Caulerpa lentillifera*) Makassar, Indonesia | Ilmi Fadhilah Rizki | Indonesia |
| Halla B (3F) | **[ST 02] Student Competition 2** | | | | |
| | Chairperson : Charles S. Vairappan (Malaysia), Claire Gachon (UK) | | | | |
| | 16:30-16:45 | ST02-1 | Variability in the composition of mycosporine-like amino acids (MAAs) in red macroalgae from Brittany (France) | Fanny Lalegerie | France |
| | 16:45-17:00 | ST02-2 | Semi-dry storage as a maturation process to develop the sensory characteristics of the red seaweed dulse (*Palmaria palmata*) | Pierrick Stévant | Norway |
| | 17:00-17:15 | ST02-3 | 3-Hydroxy-5,6-epoxy-β-ionone isolated from *Sargassum horneri* protect MH-S mouse lung cells against fine dust induced inflammation and oxidative stress | KK Asanka Sanjeewa | SriLanka |
| | 17:15-17:30 | ST02-4 | The identification of pigment extract of green seaweed (*Ulva lactuca* L) from Gunung Kidul, Yogyakarta using UHPLC-high resolution mass spectra | Windu Merdekawati | Indonesia |
| | 17:30-17:45 | ST02-5 | Cellulase-assisted *Ecklonia cava* extract prevents against diet-induced obesity in mice | Xining Li | Korea |
| | 17:45-18:00 | ST02-6 | Oral administration of *Sargassum horneri* ethanol extract ameliorates atopic dermatitis in house dust mite/DNCB-stimulated NC/Nga mice model | Eui Jeong Han | Korea |
| | 18:00-18:15 | ST02-7 | Composition and seasonal variation of the metabolic profile of *Osmundea pinnatifida* | Cecilia Biancacci | UK |
| | 18:15-18:30 | ST02-8 | Fucoidan from brown algae reduces cell migration in human bladder cancer T24 cells | Chun-Ju Sung | Taiwan |

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| Samda A (3F) | **[ST 03] Student Competition 3** | | | | |
| | Chairperson : Thomas Wernberg (Australia), Jessica Adams (UK) | | | | |
| | 16:30-16:45 | ST03-1 | Exploring ecological network structure, dynamics, and function of *Microcystis* genotypes and microbes | Seong-Jun Chun | Korea |
| | 16:45-17:00 | ST03-2 | Responses of seaweeds that use $CO_2$ as their inorganic carbon source to ocean acidification: Differential effects of fluctuating pH but little benefit of $CO_2$ enrichment | Damon Britton | Australia |
| | 17:00-17:15 | ST03-3 | The effect of elevated $CO_2$ on production and respiration of *Sargassum thunbergii* communities | Peeraporn Punchai | Japan |
| | 17:15-17:30 | ST03-4 | Transgenerational temperature effects in the kelp *Laminaria digitata* | Daniel Liesner | Germany |
| | 17:30-17:45 | ST03-5 | Biotic and abiotic controls of *Saccharina latissima* gametogenesis | Alexander Ebbing | The Netherlands |
| | 17:45-18:00 | ST03-6 | Effect of hydrodynamics on the horizontal structuring of macroalgal communities | Thomas Burel | France |
| | 18:00-18:15 | ST03-7 | The effects of velocity and canopy deformation on the photosynthesis of a seaweed bed in a recirculating flow chamber. | Yukio Inoue | Japan |
| | 18:15-18:30 | ST03-8 | Recovery of kelp forest: two case studies in Korea | Kwonmo Yang | Korea |
| Samda B (3F) | **[ST 04] Student Competition 4** | | | | |
| | Chairperson : Olivier De Clerck (Belgium), Philippe Potin (France) | | | | |
| | 16:30-16:45 | ST04-1 | Towards an understanding of the biodiversity and taxonomy of the genus *Ulva* (Ulvaceae, Chlorophyta) | Thi Lan Anh Tran | Vietnam |
| | 16:45-17:00 | ST04-2 | SoEM: a novel PCR-free biodiversity assessment method based on small-organelles enriched metagenomics | Jihoon Jo | Korea |
| | 17:00-17:15 | ST04-3 | Diversity and spatial pattern of marine macroalgae in Itu Aba Island (Taiping Island, Taiwan), South China Sea: an updated inventory with comprehensive molecular references | Pin-Chen Chen | Taiwan |
| | 17:15-17:30 | ST04-4 | Revisions of *Ralfsia* and *Endoplura* (Ralfsiales, Phaeophyceae) from Korea including new candidate species | Antony Oteng'o | Korea |
| | 17:30-17:45 | ST04-5 | Taxonomic revision of the order bangiales (Rhodophyta) from Korea based on morphology and molecular analysis | Young Ho Koh | Korea |
| | 17:45-18:00 | ST04-6 | Measuring both oxygenic and anoxygenic photosynthetic organisms using pulse amplitude modulation (PAM) fluorometry in wastewater ponds | Piamsook Chandaravithoon | Thailand |
| | 18:00-18:15 | ST04-7 | Propagating a cellular stress into the environment: revealing hydrogen peroxide as an external stressor in coastal ecosystems | Isla Twigg | New Zealand |
| | 18:15-18:30 | ST04-8 | Chemical defence by allelopathic active metabolites on the surface of cultivated Mexican rhodophyta *Halymenia floresii* against biofouling | Shareen A Abdul Malik | France |
| **Oral Session** | | | | | |
| 303 (3F) | **[OR 17] Phycocolloids and bioactive compounds** | | | | |
| | Moderator: Maya Puspita (Indonesia) | | | | |
| | 16:30-16:45 | OR17-1 | Farming of *Kappaphycus alvarezii* in Sri Lanka: current status and opportunity develop carrageenan industry | Sivaram Kulendran | SriLanka |
| | 16:45-17:00 | OR17-2 | Indonesian seaweed hydrocolloids: challenges and perspective for future development in global value chain | Maya Puspita | Indonesia |
| | 17:00-17:15 | OR17-3 | Age growth, pigments and carageenan content of the brown and the green varieties of marine algae *Eucheuma* | Yenny Risjani | Indonesia |
| | 17:15-17:30 | OR17-4 | Differential growth performance and carrageenan quality of gametophyte and sporophyte *Kappaphycus alvarezii* grown from spores and some notes on morphology, fecundity, spore survival rates and chimera | Maria Rovilla J Luhan | The Philippines |
| | 17:30-17:45 | OR17-5 | Biomolecular composition and revenue explained by interactions between extrinsic factors and endogenous rhythms of *Saccharina latissima* | Xueqian Zhang | Denmark |
| | 17:45-18:00 | OR17-6 | Structural and functional characterisation of high-value bioactive compounds from *Alaria esculenta* cultivated on long-lines in Bantry Bay, Ireland | Silvia Blanco Gonzalez | Ireland |
| | 18:00-18:15 | OR17-7 | Bioactive compound production and stability in long term cultures of *Asparagopsis armata* (Bonnemaisoniales, Rhodophyta) | Marianela Zanolla | Ireland |
| | 18:15-18:30 | OR17-8 | *Macrocystis pyrifera* source for the production of bioactive compounds | Allison Leyton | Chile |

# Day 5 (May 2, Thursday)

## Plenary Lecture

**Tamna A (5F)**

**[PL 4] Plenary 4**

Chairperson : Hwan Su Yoon (Korea)

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| 08:30-09:30 | PL-4 | Genomic and genetic approaches to explore brown algal biology and support seaweed aquaculture | J Mark Cock | France |

## Mini Symposium

**Tamna A (5F)**

**[MS 13] Genomic selection in economically important kelp of the Eastern Pacific and North Atlantic**

Chairperson : Scott Lindell (USA), Carolina Camus (Chile)

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| 09:55-10:15 | MS13-1 | Genetic Diversity Exploitation of *Saccharina latissima* For Innovative Macro-Algal Biorefinery in Europe | Phillipe Potin | France |
| 10:15-10:35 | MS13-2 | Fine scale population genetics of sugar kelp in the North Atlantic for a selective breeding program | Simona Augyte | USA |
| 10:35-10:55 | MS13-3 | Kelp seed banks and sterilization procedures | Sergey Nuzhdin | USA |
| 10:55-11:15 | MS13-4 | Breeding *Macrocystis pyrifera*: what have we learned? | Carolina Camus | Chile |

**Halla A (3F)**

**[MS 14] Microalgal biotechnology and industries: construction of a whole value chain from labs, ponds to tables**

Chairperson : Song Qin (China)

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| 09:55-10:15 | MS14-1 | The freshwater algae culture collection (FACHB-Collection): algal resources for fundamental and applied research in China | Lirong Song | China |
| 10:15-10:35 | MS14-2 | Industrial development of microalgal cultures and seaweeds' filamentous tissue cultures for pharmaceutical and nutraceutical source material | Hongnong Chou | China |
| 10:35-10:55 | MS14-3 | A new thin-film microfluidic platform for continuous flow biodiesel production from wet microalgae | Wei Zhang | Australia |
| 10:55-11:15 | MS14-4 | Microalgal biotechnology and industries in China: construction of both new innovation mode and driving force | Song Qin | China |

**Halla B (3F)**

**[MS 15] Seaweed4Health, bioactives from seaweed in health applications taking into account standards and legislation**

Chairperson : Stefan Kraan (Ireland), Susan Løvstad Holdt (Denmark)

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| 09:55-10:15 | MS15-1 | Fucoidan, health benefits and implications for gut health | Stefan Kraan | Ireland |
| 10:15-10:35 | MS15-2 | Seaweed legislation and standards in Europe | Susan Løvstad Holdt | Denmark |
| 10:35-10:55 | MS15-3 | The case for whole dietary seaweeds | Jane Teas | USA |
| 10:55-11:15 | MS15-4 | Dietary *Sargassum fusiforme* improves memory and reduces amyloid plaque load in an alzheimer's disease mouse model | Monique Mulder | The Netherlands |

**Samda A (3F)**

**[MS 16] Coralline algae, global marine ecosystem engineers: their systematics, physiology and ecology**

Chairperson : Paul W. Gabrielson (USA), So Young Jeong (Korea)

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| 09:55-10:15 | MS16-1 | The ecology of non-geniculate coralline red algae | Gavin W. Maneveldt | South Africa |
| 10:15-10:35 | MS16-2 | Effects of water temperature, light and nitrate on the growth of sporelings of the nongeniculate coralline alga *Lithophyllum okamurae* (Corallinales, Rhodophyceae) | Aki Kato | Japan |
| 10:35-10:55 | MS16-3 | Corallinapetrales: a new order of coralline algae including a new family with *Corallinapetra gabrieli* comb. nov. | So Young Jeong | Korea |
| 10:55-11:15 | MS16-4 | The role of crustose calcifying red algae in phase transitions on tropical pacific reefs | Tom Schils | Guam |

**Samda B (3F)**

**[MS 17] Algal culture collection**

Chairperson : Thomas Friedl (Germany), Jee-Hwan Kim (Korea)

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| 09:55-10:15 | MS17-1 | The SAG culture collection of microalgae: a traditional bioresource serves modern science | Thomas Friedl | Germany |
| 10:15-10:35 | MS17-2 | An Australian perspective on managing a biodiversity collection for research impact. | Ian Jameson | Australia |
| 10:35-10:55 | MS17-3 | Diversity, conservation and utilization of freshwater bioresources | Jee-Hwan Kim | Korea |
| 10:55-11:15 | MS17-4 | The Korean marine microalgae biobank: in the formation process | Ji-won Hong | Korea |

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| Tamna A (5F) | **[SS 1] Special Session : Seaweed aquaculture: past, present and future** | | | | |
| | Chairperson : Charles Yarish (USA) | | | | |
| | 11:30-11:50 | SS1-1 | Kelp aquaculture in Northeast America: opportunities, challenges and future directions | Charles Yarish | USA |
| | 11:50-12:10 | SS1-2 | Growing *Ulva* (Chlorophyta) in commercial integrated systems with abalone in South Africa for feed and bioremediation: an update | John Bolton | South Africa |
| | 12:10-12:30 | SS1-3 | A day in the life of a future tropical seaweed farmer | Iain Neish | Indonesia |
| **Oral Session** | | | | | |
| Halla A (3F) | **[OR 18] Algae-microbe interaction** | | | | |
| | Moderator : Jang K. Kim (Korea) | | | | |
| | 11:30-11:45 | OR18-1 | Endophytic and epiphytic core microbiota associated with an invasive seaweed across the Northern Hemisphere | Florian Weinberger | Germany |
| | 11:45-12:00 | OR18-2 | Selective utilization of fatty acids of two copepods with five algae | Min-Chul Lee | Korea |
| | 12:00-12:15 | OR18-3 | Microbiota interactions with Laminariales gametophytes, impact on phytochemistry | Erwan Le Gélébart | France |
| | 12:15-12:30 | OR18-4 | Do microbes play a role in facilitating the range expansion of tropical fish into temperate systems? | Adriana Verges | Australia |
| Halla B (3F) | **[OR 19] Algal natural products, functional foods and pharmacology <3>** | | | | |
| | Moderator : Mangaiyarkarasi Ravirajan (India) | | | | |
| | 11:30-11:45 | OR19-1 | Optimization of the production of single cell protein and hydrophobins from Marine fungi fed using seaweed and seaweed waste | Catalina Landeta Salgado | Chile |
| | 11:45-12:00 | OR19-2 | Antioxidant, anti-inflammatory and anti-proliferative effects of fucoidan extracted from the brown seaweed *Sargassum ilicifolium* (Turner) C.Agarth (*in vivo* and *in vitro*) | Mangaiyarkarasi Ravirajan | India |
| | 12:00-12:15 | OR19-3 | The potential transfer of arsenic species from a seaweed animal meal | Michéal Mac Monagail | Ireland |
| | 12:15-12:30 | OR19-4 | Protein extraction by Enzyme-assisted Extraction (EAE) followed by alkaline extraction from red seaweed *Eucheuma denticulatum* (*Spinosum*) used in carrageenan production | Susan Løvstad Holdt | Denmark |
| **Student Competition (Oral Session)** | | | | | |
| Samda A (3F) | **[ST 05] Student Competition 5** | | | | |
| | Chairperson : Aschwin Hillebrand Engelen (Portugal), Debashish Bhattacharya (USA) | | | | |
| | 11:30-11:45 | ST05-1 | Can RNA transcriptomes accurately resolve a phylogenetic tree? | Seongmin Cheon | Korea |
| | 11:45-12:00 | ST05-2 | Effect of antioxidant addition during extraction of protein from *Ulva* sp. | Louise Juul Pedersen | Denmark |
| | 12:00-12:15 | ST05-3 | Toxicity evaluation of 6 antifouling biocides measured based on chlorophyll fluorescence of gametophytes of the brown macroalga *Undaria pinnatifida* (Harvey) Suringar | Hojun Lee | Korea |
| | 12:15-12:30 | ST05-4 | Deformity of benthic diatom as biomarkers of marine environment | Soyeon Choi | Korea |
| **Oral Session** | | | | | |
| Samda B (3F) | **[OR 20] Phylogeography** | | | | |
| | Moderator : Narongrit Muangmai (Thailand) | | | | |
| | 11:30-11:45 | OR20-1 | Phylogeographic diversification and postglacial range dynamics shed light on the conservation of the kelp *Saccharina japonica* | Jie Zhang | China |
| | 11:45-12:00 | OR20-2 | Phylogeographic pattern of the marine red alga *Gracilaria salicornia* (Gracilariales) in Thailand: evidence for an east-west genetic break around the Thai-Malay peninsula | Narongrit Muangmai | Thailand |
| | 12:00-12:15 | OR20-3 | Developing novel biomarkers targeting stage-specific transcripts for monitoring harmful marine organisms | Juhee Min | Korea |
| | 12:15-12:30 | OR20-4 | Phylogenomic analysis of brown algal organelle genome | Ji Won Choi | Korea |

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| 303 (3F) | **[OR 21] Genomics <1>** | | | | |
| | Moderator : Nianjun Xu (China) | | | | |
| | 11:30-11:45 | OR21-1 | Comparative characterization of putative chitin deacetylases from *Phaeodactylum tricornutum* and *Thalassiosira pseudonana* highlights potential for distinct chitin-based metabolic processes in diatom | Zhanru Shao | China |
| | 11:45-12:00 | OR21-2 | Genomic analysis of thermoacidophilic environmental adaptation of cyanidiophyceae (Rhodophyta) | Seung In Park | Korea |
| | 12:00-12:15 | OR21-3 | Genomic analyses of unique carbohydrate and phytohormone metabolism in the macroalga *Gracilariopsis lemaneiformis* (Rhodophyta) | Nianjun Xu | China |
| | 12:15-12:30 | OR21-4 | Identification of candidate SNPs regions related to red mutation in *Pyropia yezoensis* by QTL-seq | Xinzi Yu | China |
| **Mini Symposium** | | | | | |
| Halla A (3F) | **[MS 18] FIRA Session: Recovery and conservation of marine forest** | | | | |
| | Chairperson : Kyung-Seon Lee (Korea) | | | | |
| | 13:35-13:55 | MS18-1 | Marine forest reforestation project of Korea Fisheries Resources Agency (FIRA) | Jin Woo Kang | Korea |
| | 13:55-14:15 | MS18-2 | Restoration of artificial eelgrass seabed using industrial byproducts | Kyunghoi Kim | Korea |
| | 14:15-14:35 | MS18-3 | Enhanced $CO_2$ uptake by planted sea forest counteracts | Kitack Lee | Korea |
| | 14:35-14:55 | MS18-4 | Ocean acidification in coastal environments | Han Gil Choi | Korea |
| **Oral Session** | | | | | |
| Halla B (3F) | **[OR 22] Seaweed industry and governance <3>** | | | | |
| | Moderator : Raul Ugarte (Canada) | | | | |
| | 13:30-13:45 | OR22-1 | Certification of environmental sustainable and social responsible seaweed production | Mark (Jongseok) Seo | Korea |
| | 13:45-14:00 | OR22-2 | Net-works(TM) : making seaweed farming positive for the ocean and people | Amado Blanco | The Philippines |
| | 14:00-14:15 | OR22-3 | Feminisation of seaweed industry? | Josephine Tsui | UK |
| | 14:15-14:30 | OR22-4 | A systematic analysis of national biosecurity framework of seaweed aquaculture in Indonesia | Cicilia Selviane Kambey | Korea |
| | 14:45-15:00 | OR22-5 | Changing the traditional *Ascophyllum nodosum* harvesting method in Ireland: advantages and challenges under a non-regulated harvest situation | Raul Ugarte | Canada |
| **Student Competition (Oral Session)** | | | | | |
| Samda A (3F) | **[ST 06] Student Competition 6** | | | | |
| | Chairperson : Adriana Verges (Australia), Gwang Hoon Kim (Korea) | | | | |
| | 13:30-13:45 | ST06-1 | Can shifting in cultivation condition improve the growth and carbohydrate content of sugar kelp (*Saccharina latissima*)? | Saifullah Saifullah | Norway |
| | 13:45-14:00 | ST06-2 | Emersion effect on growth, pigments and biochemical responses in *Pyropia yezoensis* | Sojin Jang | Korea |
| | 14:00-14:15 | ST06-3 | Physiological responses and growth of the seaweed *Ulva* sp. under changing cultivation conditions in pilot land-based ponds | Stephanie Revilla-Lovano | Mexico |
| | 14:15-14:30 | ST06-4 | Protoplast isolation from four brown algal species using a simple mixture of commercial enzymes | Jose Avila Peltroche | Korea |
| | 14:30-14:45 | ST06-5 | Hatchery strategies for long term storage of *Saccharina latissima* seed string in Alaska | Ann Raymond | USA |
| | 14:45-15:00 | ST06-6 | Effects of stocking density on productivity and nutrient removal of *Gracilaria vermiculophylla* in *Paralichthys olivaceus* biofloc effluent | Sookkyung Shin | Korea |
| **Oral Session** | | | | | |
| Samda B (3F) | **[OR 23] Algal natural products, functional foods and pharmacology <4>** | | | | |
| | Moderator : Maya Puspita (Indonesia) | | | | |
| | 13:30-13:45 | OR23-1 | Development of functional fish sausage using seaweed dietary fibre | Jesmi Debbarma | India |
| | 13:45-14:00 | OR23-2 | Metabolic engineering of *Escherichia coli* for efficient biosynthesis of fluorescent phycobiliprotein | Huaxin Chen | China |
| | 14:00-14:15 | OR23-3 | Innovative product development at ALGAIA: alginate-based mucoadhesive films | Benoit Queguineur | France |
| | 14:15-14:30 | OR23-4 | Review on Indonesian *Sargassum* species bioprospecting: potential applications of bioactive compounds and challenge for sustainable development | Maya Puspita | Indonesia |
| | 14:30-14:45 | OR23-5 | Novel antioxidants from seaweed- source, extraction and application | Susan Løvstad Holdt | Denmark |

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| 303 (3F) | **[OR 24] Genomics <2>** | | | | |
| | Moderator : Koki Nishitsuji (Japan) | | | | |
| | 13:30-13:45 | OR24-1 | Draft genome of the brown alga, *Nemacystus decipiens*, Onna-1 strain: fusion genes related to sulfated fucan | Koki Nishitsuji | Japan |
| | 13:45-14:00 | OR24-2 | Complete plastid genome of the *Saccharina* cultivar "rongfu" and its phylogenetic analyses | Jing Zhang | China |
| | 14:00-14:15 | OR24-3 | Transcriptome of *Paulinella micropora* under high light stress condition | Duckhyun Lhee | Korea |
| | 14:15-14:30 | OR24-4 | Mitogenome characteristics of crucial *Saccharina* cultivars in China | Yahui Yu | China |
| | 14:30-14:45 | OR24-5 | Progress in QTL mapping for blade length and width of *Saccharina japonica* | Xiuliang Wang | China |
| | 14:45-15:00 | OR24-6 | Synergistic effects of HSE and LTR elements from Hsp70 gene promoter of *Ulva prolifera* (Ulvaphyceae, Chlorophyta) upon temperature induction | Chunhui Wu | China |
| **Mini Symposium** | | | | | |
| Halla A (3F) | **[MS 19] Jeju Session: Research agenda for Jeju coastal environmental issues** | | | | |
| | Chairperson : Jeong Ha Kim (Korea) | | | | |
| | 15:25-15:45 | MS19-1 | Japan's nationwide long-term monitoring survey of seaweed communities known as the "monitoring sites 1000": ten-year overview and future perspectives | Ryuta Terada | Japan |
| | 15:45-16:05 | MS19-2 | *Ecklonia* kelp forests – globally significant habitats under pressure | Thomas Wernberg | Australia |
| | 16:05-16:25 | MS19-3 | Drifted *Sargassum horneri* in the Yellow Sea: its origin, life cycle and fate | Shaojun Pang | China |
| | 16:25-16:45 | MS19-4 | Biogeography and seascape genetics of the bull kelp, *Nereocystis luetkeana* | Filipe Alberto | USA |
| **Oral Session** | | | | | |
| Halla B (3F) | **[OR 25] Seaweed industry and governance <3>** | | | | |
| | Moderator : Sander Van den Burg (The Netherlands) | | | | |
| | 15:20-15:35 | OR25-1 | Prospects for upgrading European seaweeds; a value chain perspective | Sander Van den Burg | The Netherlands |
| | 15:35-15:50 | OR25-2 | Seaweed governance for sustainability: a case study of using the triple helix approach in Malaysia | Adibi Nor | Malaysia |
| | 15:50-16:05 | OR25-3 | Tanzania seaweed value chain assessment | Msafiri Andrew | Tanzania |
| | 16:05-16:20 | OR25-4 | Model management for sustainable seaweed farming in Pulau Sembilan Island, Sinjai district, Indonesia | Nurlita Pertiwi Arif Madjid | Indonesia |
| | 16:20-16:35 | OR25-5 | Entrepreneurial capacity of the seaweed farmers in south Sulawesi, Indonesia | Gufran Darma Dirawan | Indonesia |
| | 16:35-16:50 | OR25-6 | A systematic analysis of policies protecting the seaweed industry of the Philippines | Jonalyn P. Mateo | The Philippines |
| **Student Competition (Oral Session)** | | | | | |
| Samda A (3F) | **[ST 07] Student Competition 7** | | | | |
| | Chairperson : Mark Cock (France), Cheong Xin Chan (Australia) | | | | |
| | 15:20-15:35 | ST07-1 | Construction of a genetic linkage map in *Pyropia yezoensis* (Bangiales, Rhodophyta) and QTL analysis of several economic traits of blades | Lin-bin Huang | China |
| | 15:35-15:50 | ST07-2 | Population and landscape genomics in the sugar kelp *Saccharina latissima* | Alexander Thomson | UK |
| | 15:50-16:05 | ST07-3 | Gametophyte transcriptome reveals sex-biased gene expression in the kelp *Saccharina latissima* | Catia Monteiro | Germany |
| | 16:05-16:20 | ST07-4 | Evolutionary dynamics of mitogenomes in cyanidiophyceae (Rhodophyta) | Chung Hyun Cho | Korea |
| | 16:20-16:35 | ST07-5 | Genome sequencing and population genomic analyses provide insights into domestication and adaptation to new environments in the kelp *Undaria pinnatifida* | Louis Graf | Korea |
| | 16:35-16:50 | ST07-6 | Large-scale gene duplication events in the dinoflagellate lineage | Sung-Gwon Lee | Korea |

## Oral Session

### [OR 26] Algal natural products, functional foods and pharmacology <5>

Moderator : Eun Chan Yang (Korea)

| | | | | | |
|---|---|---|---|---|---|
| Samda B (3F) | 15:20-15:35 | OR26-1 | Application of various types of local seaweed extract to the growth and yield of shallot (*Allium wakegi* A.) | Ramal Yusuf | Indonesia |
| | 15:35-15:50 | OR26-2 | Targeted enzymatic modification of seaweed hydrocolloids | Nanna Rhein-Knudsen | Denmark |
| | 15:50-16:05 | OR26-3 | Advances in knowledge of seaweed as a natural alternative to sub-therapeutic antibiotics in livestock production | Augustine Owusu-Asiedu | USA |
| | 16:05-16:20 | OR26-4 | Individual and combined effects of heavy metals (HM) and polycyclic aromatic hydrocarbons(PAH) toward spore release, settlement and germination of brown kelps *Lessonia spicata* and *Macrocystis pyrifera* | Andrés Meynard | Chile |
| | 16:20-16:35 | OR26-5 | Antioxidant responses and phenolic compounds of *Palisada perforata* (Rhodomelaceae, Rhodophyta) against environmental stressors from different microhabitats of a tropical reef | Juliane Bernardi | Brazil |
| | 16:35-16:50 | OR26-6 | Chemical analysis of iodine in fermented seaweed salad and human risk assessment in relation to total intake of iodine | Susan Løvstad Holdt | Denmark |

### [OR 27] Algal blooming <2>

Moderator: Daniel Robledo (Mexico)

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|---|---|---|---|---|---|
| 303 (3F) | 15:20-15:35 | OR27-1 | Co-occurrence patterns of bacteria, archaea, and phytoplankton in *Cochlodinium polykrikoides* bloom in south sea of Korea | Chi-Yong Ahn | Korea |
| | 15:35-15:50 | OR27-2 | Harmful algal blooms in newly constructed weir/dam and their management | Heesuk Lee | Korea |
| | 15:50-16:05 | OR27-3 | Green tide dynamics revealed by tracking the floating ecotype of *Ulva prolifera* in the Yellow Sea | Peng Jiang | China |
| | 16:05-16:20 | OR27-4 | Assessment of salinity tolerance based on physiological and oxidative stress responses in *Ulva* and *Pyropia* | Palas Samanta | Korea |
| | 16:20-16:35 | OR27-5 | The development of bioactives from blooming seaweeds in Normandy, France: the Enteromorphe and Snotra projects | Benoit Queguineur | France |
| | 16:35-16:50 | OR27-6 | Socioeconomic dimension of the *Sargassum* blooms: the Mexican experience during the last four years | Daniel Robledo | Mexico |

Lobby (5F) 16:50-18:20 **Poster Session**

# Day 6 (May 3, Friday)

## Plenary Lecture

**Tamna A (5F)**

**[PL 5] Plenary 5**

Chairperson : Jeong Ha Kim (Korea)

| | | | | |
|---|---|---|---|---|
| 08:30-09:30 | PL-5 | Using genetics to unravel the ecology and economic potential of the giant kelp *Macrocystis pyrifera* | Filipe Alberto | USA |

## Mini Symposium

**Tamna A (5F)**

**[MS 20] Climate-driven changes in seaweed species distributions:drivers and ecological impacts**

Chairperson : Adriana Verges (Australia), Vianney Denis (Taiwan)

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|---|---|---|---|---|
| 09:55-10:15 | MS20-1 | Climate-driven declines in kelp forests and the global rise of turfs | Thomas Wernerg | Australia |
| 10:15-10:35 | MS20-2 | Cryptic loss of genetic diversity and directional selection in marine forests following an extreme climatic event | Melinda Coleman | Australia |
| 10:35-10:55 | MS20-3 | Redistribution of macroalgae and herbivores by climate change in Japan | Daisuke Fujita | Japan |
| 10:55-11:15 | MS20-4 | Tropicalisation of temperate reefs: implications for ecosystem functions and management actions | Adriana Verges | Australia |

**Halla A (3F)**

**[MS 21] The novel output and innovative processing of macroalgae using anaerobic digestion**

Chairperson : Jessica Adams (UK), Andrew Ross (UK)

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|---|---|---|---|---|
| 09:55-10:15 | MS21-1 | Assessing the methane yields of whole and residue *Ulva* spp. following anaerobic digestion of samples prepared from varied long-term storage arrangements | Jessica Adams | UK |
| 10:15-10:35 | MS21-2 | Opportunities for production of bioenergy from macroalgae by integration of hydrothermal carbonisation and anaerobic digestion | Andrew Ross | Uk |
| 10:35-10:55 | MS21-3 | Towards macro algae bioprocessing: dark fermentation of algal components to biohydrogen and high-value chemicals | Sean Scully | Iceland |
| 10:55-11:15 | MS21-4 | Outcomes of the three-year SEAGAS project: advancing the anaerobic digestion of *Saccharina latissima* for biomethane | Phillip Kerrison | UK |

**Halla B (3F)**

**[MS 22] "Chemicalecology" of algal-microbe interactions**

Chairperson : Catherine Leblanc (France), Aschwin Hillebrand Engelen (Portugal)

| | | | | |
|---|---|---|---|---|
| 09:55-10:15 | MS22-1 | Eavesdropping seaweed - bacteria cross-talk | Mahasweta Saha | UK |
| 10:15-10:35 | MS22-2 | Bacteria in algal growth and stress response: a metabolic point of view | Simon Dittami | France |
| 10:35-10:55 | MS22-3 | Chemical mediators in algae-bacteria interactions: novel functions of thallusin as algal morphogenesis inducer for the green seaweed *Ulva* (Chlorophyta) | Thomas Wichard | Germany |
| 10:55-11:15 | MS22-4 | Metatranscriptomic differentiation in microbiome composition and function across *Ectocarpus siliculosus* strains and cell types | Aschwin Hillebrand Engelen | Portugal |

## Oral Session

**Samda A (3F)**

**[OR 28] Cultivar, nursery and harvest <1>**

Moderator : Wenlei Wang (China)

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|---|---|---|---|---|
| 09:50-10:05 | OR28-1 | Study on the underlying mechanism of the thermotolerance strains of *Pyropia haitanensis* | Wenlei Wang | China |
| 10:05-10:20 | OR28-2 | Characterization of the improved strain (*HR-5*) of *Pyropia haitanensis* and its pilot cultivation in mariculture farm | Hong-chang Ding | China |
| 10:20-10:35 | OR28-3 | Development of a new cultivar with high yield and high-temperature tolerance by crossbreeding of *Undaria pinnatifida* (Laminariales, Phaeophyta) | Kyosuke Niwa | Japan |
| 10:35-10:50 | OR28-4 | Heterosis breeding for upper temperature tolerance in *Laminaria* | Neusa Martins | Portugal |
| 10:50-11:05 | OR28-5 | Building chimeric kelps (*Lessonia* spp.) to restock overharvested populations along Central Chile | Alejandra Gonzalez | Chile |

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| Samda B (3F) | **[OR 29] Bioremediation** | | | | |
| | Moderator : Yufeng Yang (China) | | | | |
| | 09:50-10:05 | OR29-1 | Bioremediation and carbon sink effects of large-scale cultivation of *Gracilaria lemaneiformis*, a case study in Nanao, South China | Yufeng Yang | China |
| | 10:05-10:20 | OR29-2 | Maximising the productivity of *Ulva tepida* by effectively using the three-dimensional culture space | Andrew Cole | Australia |
| | 10:20-10:35 | OR29-3 | The relationship between heavy metals and the seaweed *Gracilaria lemaneiformis* | Hongtian Luo | China |
| | 10:35-10:50 | OR29-4 | Estimation of production and bioremediation of seaweed *Kappaphycus alvarezii* in an IMTA system using a STELLA model | Cicilia Selviane Kambey | Korea |
| | 10:50-11:05 | OR29-5 | Cultivation potential and bioremediation efficiency of the brown seaweed *Halopteris scoparia* (Ochrophyta) | Rita F. Patarra | Portugal |
| | 11:05-11:20 | OR29-6 | Colonized zooplankton communities on cultivated seaweeds in a typical mariculture zone, China | Qing Wang | China |
| Tamna A (5F) | **[OR 30] Genomics <3>** | | | | |
| | Moderator : Delin Duan (China) | | | | |
| | 11:30-11:45 | OR30-1 | Genetic tools for the development of improved cultivars of *Saccharina latissima* | Zofia Nehr | France |
| | 11:45-12:00 | OR30-2 | Analysis of gene expansion and expression profiles in the Siphonous Macroalga, *Caulerpa lentillifera* | Asuka Arimoto | Japan |
| | 12:00-12:15 | OR30-3 | Identification and characterization of the centromere-associated protein Nuf2 in the kelp *Saccharina japonica* (Phaeophyta) | Zhi-Gang Zhou | China |
| | 12:15-12:30 | OR30-4 | Piloting genome editing of the brown algal model *Ectocarpus* | Yacine Badis | UK |
| | 12:30-12:45 | OR30-5 | Non-coding RNAs Involved with aureochrome and regulation of cry-dash in the early development and growth of *Saccharina japonica* (Laminariales, Phaeophyceae) | Delin Duan | China |
| Halla A (3F) | **[OR 31] Ecology** | | | | |
| | Moderator: Raymond J. Ritchie (Thailand) | | | | |
| | 11:30-11:45 | OR31-1 | Newly restored kelp beds reveal rapid recovery of food web complexity | Moonjung Kim | Korea |
| | 11:45-12:00 | OR31-2 | 30 years revisit survey for the long term changes in the Antarctic subtidal algal community | Dong Seok Lee | Korea |
| | 12:00-12:15 | OR31-3 | Characterize of a type III polyketide synthase (PKS1) response to light intensity in the brown alga *Saccharina japonica* | Jing Li | China |
| | 12:15-12:30 | OR31-4 | Calcium carbonate productivity by *Halimeda macroloba* in the tropical intertidal ecosystem; the significant contributor to global carbonate budgets | Jaruwan Mayakun | Thailand |
| | 12:30-12:45 | OR31-5 | An extremophile terrestrial chlorophyte growing on galvanised iron lamp posts | Raymond J. Ritchie | Thailand |
| Halla B (3F) | **[OR 32] Algal derived cosmetics** | | | | |
| | Moderator : Dang Diem Hong (Vietnam) | | | | |
| | 11:30-11:45 | OR32-1 | Evaluation of bioactivities and cream mask formulation from Vietnamese seaweeds | Dang Diem Hong | Vietnam |
| | 11:45-12:00 | OR32-2 | Inhibitory effects of tropical seaweed on tyrosinase activity and melanogenesis in B16F10 melanoma cells | Pradtana Choosuwan | Thailand |
| | 12:00-12:15 | OR32-3 | Phenolic compounds from *Sargassum fusiforme* and their application in cosmetics | Xiaoting Fu | China |
| | 12:15-12:30 | OR32-4 | Whitening activity of fucoidans extracted from polar *Ascophyllum nodosum* and valorisation of process by-products in cosmetic applications | Jeremy Brebion | France |

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| Samda A (3F) | **[OR 33] Cultivar, nursery and harvest <2>** | | | | |
| | Moderator: Jeff Hafting (Canada) | | | | |
| | 11:30-11:45 | OR33-1 | *Palmaria palmata* (dulse) cultivation in Denmark – new strategies for hatchery optimization | Mette Møller Nielsen | Denmark |
| | 11:45-12:00 | OR33-2 | Advancements in Canadian on-land seaweed cultivation | Jeff Hafting | Canada |
| | 12:00-12:15 | OR33-3 | Land-based cultivation of the Atlantic nori species *Porphyra dioica* in Portugal | Helena Abreu | Portugal |
| | 12:15-12:30 | OR33-4 | Thermophysical properties and stickiness of sugar kelp influence process parameters during drying | Balunkeswar Nayak | USA |
| | 12:30-12:45 | OR33-5 | Preliminary performance assessment of *Kappaphycus alvarezii* mechanical harvester prototype | Leila Hayashi | Brazil |
| Samda B (3F) | **[OR 34] Seaweed Usage** | | | | |
| | Moderator: Charles Santhanaraju Vairappan (Malaysia) | | | | |
| | 11:30-11:45 | OR34-1 | Probiotic fortified marine silage as supplement in marine fish hatchery | Charles Santhanaraju Vairappan | Malaysia |
| | 11:45-12:00 | OR34-2 | How suitable are seaweed as a feed ingredient for salmon? - the feed industry's experiences and insights | Celine Rebours | Norway |
| | 12:00-12:15 | OR34-3 | Optimization of algal culture medium capable to higher biomass and lipid content in diverse types of algae | Bhumi Nath Tripathi | India |
| | 12:15-12:30 | OR34-4 | Evaluation of seaweed *Gelidium latifolium* as potential medicinal food | Eka Prasedya | Indonesia |
| | 12:30-12:45 | OR34-5 | *Kappaphycus alvarezii* hatchery: a micropropagation production system | Simon Davis | Malaysia |

# Poster Session

## Poster session will take place in the Lobby on the 5th floor.

**Poster Session 1** — **April 29 (Monday) 18:00-19:30**

| Presentation No. | Presenter | Country | Abstract Title |
|---|---|---|---|
| PP01 | Eun Jae Kim | Korea | Lipid formation by arctic microalga *Chlamydomonas* sp. KNF0008 at low temperatures |
| PP03 | Akiko Yamada Taniguchi | Japan | Component analysis and development of functional food from Japanese *Sargassum horneri* |
| PP05 | Xueqian Zhang | Denmark | A review of top value-added products from seaweed biomass and prospects of cascading biorefinery: preliminary results |
| PP09 | Yunianta Yunianta | Indonesia | Bioactivity of different polarities of *Sargassum crystaefolium* extracts on human mammary carcinoma cell line MCF7 |
| PP11 | Xiaoqian Zhang | China | Preparation and identification of antioxidant peptides from protein hydrolysate of marine alga *Gracilariopsis lemaneiformis* |
| PP13 | Yung Hyun Choi | Korea | Protective effect of phloroglucinol on oxidative stress-induced DNA damage and apoptosis through activation of the Nrf2/HO-1 signaling pathway in HaCaT human keratinocytes |
| PP15 | Motoharu Uchida | Japan | Development of fermentation foods from seaweeds |
| PP19 | Rando Tuvikene | Estonia | Polyelectrolyte complexes of red algal galactans and chitosan |
| PP21 | Junseong Kim | Korea | *Stichopus japonicus* suppresses inflammatory and cancer progression by promoting ROS-mediated inhibition of MAPK signaling |
| PP23 | Junseong Kim | Korea | 5-bromoprotocatechualdehyde suppresses lung cancer growth through regulation of ROS and the AKT/MAPKs signaling pathway in human lung cancer cells |
| PP25 | Nalae Kang | Korea | Ishophloroglucin a from *Ishige okamurae* alleviates the high fat diet-induced obesity through leptin signaling pathway on peripheral metabolism |
| PP27 | Ji Won Hong | Korea | Korean marine microalgae with biotechnological potential: a review |
| PP29 | Kadri Saluri | Estonia | Anticoagulant and antioxidant activity of native and alkali treated lambda-carrageenans of different molecular weights |
| PP31 | Yolanda Freile-Pelegrín | Mexico | Valorization of *Chaetomorpha* spp. (Cladophoraceae, Chlorophyta) filamentous seaweed discarded from an IMTA system using a biorefinary concept |
| PP33 | Suraiami Mustar | Malaysia | Inhibition of alpha-amylase and alpha-glucosidase activities by *Himanthalia elongata* and the mode of inhibition of alpha-glucosidase |
| PP35 | Yi Yuan | China | Carrageenan as shaping agent to produce the modified starch capsule |
| PP37 | Zhi Yuan Wu | Taiwan | Investigation of extraction of fucoidan from Taiwan local *Sargassum* spp. in different coast. and analyze its composition |
| PP39 | Mi-Seong Kim | Korea | A study on the improvement and effective extraction of UVAPs in marine microalgae *Spirulina* (*Arthrospira platensis*) |
| PP41 | Hirotaka Kakita | Japan | Suitable unialgal strains for algal hemagglutinin production |
| PP43 | Byung Soo Chun | Korea | Effect of organic acid catalysts on the subcritical water hydrolysis in *Sargassum horneri* |
| PP45 | Byeori Kwon | Korea | Development of microalgae *Phaeodactylum tricornutum* transformants which produce hFGF1, hFGF2 and hIGF1 |
| PP47 | Xiaonan Zang | China | Cloning of allophycocyanin gene from *Gracilariopsis lemaneiformis* and studying on its optical activity in recombinant expression in heterologous host |
| PP49 | Byung Soo Chun | Korea | Fucoxanthin contained oil extraction from *Sargassum horneri* by supercritical carbon dioxide |
| PP51 | Seo-Young Kim | Korea | The effects of marine algal polyphenols on muscle growth in C2C12 muscle cells through myogenesis pathways |
| PP53 | Minjeong Seo | Korea | A polysaccharide isolated from *Lactobacillus brevis*-fermented *Ecklonia cava* protects splenocytes against oxidative stress caused by gamma ray irradiation. |
| PP55 | Katharina Kreissig | Denmark | Characterization of 17 elements in ten edible seaweed species from Greenland |
| PP57 | Nicolás Latorre Padilla | Chile | Effect of pollutants in the free fatty acid profile and their oxidized derivatives in two brown algae |

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|---|---|---|---|
| PP59 | Ji Woong Lee | Korea | Characterization of CrELIP involved in the cold-stress resistance of a green alga, *Chlamydomonas reinhardtii* |
| PP61 | Jin-Woo Han | Korea | Induction of recombinant mannose binding lectin expression by an artificially constructed tandem repeat structure |
| PP63 | Lucia Elizabeth Cruz-Suárez | Mexico | In vitro gastrointestinal digestion and colonic fermentation of a *S. compressa* hydroethanolic extract and its polysaccharide fraction, and their effect on human fecal microbiota |
| PP65 | Hyun-Ju Hwang | Korea | Differential expression of proteins involved in photosynthesis in the life cycle of marine red alga, *Pyropia tenera* |
| PP67 | Chaiwat Monmai | Korea | Anionic macromolecules extracted from *Codium fragile* enhance the immune-associated cells of cyclophosphamide-treated mice |
| PP69 | Eun Kyoung Hwang | Korea | Cultivation performance and genetic characteristics of Korean (Sugwawon No. 301) and Chinese strains (Huangguan No. 1) of *Saccharina japonica* (Phaeophyceae) |
| PP71 | Kyosuke Niwa | Japan | Possibility of polyploidy breeding using cryptic species in the marine crop *Pyropia yezoensis* (Bangiales, Rhodophyta) |
| PP73 | Flower Msuya | United Republic of Tanzania | Impact of climate change on seaweed farming and the role of the GlobaSeaweedSTAR project in Tanzania |
| PP75 | Cecilia Biancacci | United Kingdom | Establishment of a tumbling cultivation system for *Osmundea pinnatifida* |
| PP77 | Ratih Pangestuti | Indonesia | Tropical seaweed innovation network (TSIN): bringing innovation to business |
| PP79 | Li Su | China | Observation on haptera development of *Saccharina japonica* in culture and on longline in commercial farming |
| PP81 | Joon Kim | Korea | Difference of cell shape and length of *Grateloupia asiatica* between crust and erect thalli in culture |
| PP83 | Sadock Rusekwa | United Republic of Tanzania | Biosecurity policy and legislation of the seaweed aquaculture industry in Tanzania |
| PP85 | Anicia Hurtado | The Philippines | The role of UKRI-GCRF-GlobalSeaweedSTAR project in meeting the challenges of the Philippine seaweed industry |
| PP87 | Leila Hayashi | Brazil | The use of carbon dioxide followed by irradiance increment as a strategy to improve the cultivation of the red seaweed *Kappaphycus alvarezii* in tanks |
| PP89 | Jaime Zamorano | Chile | Small-scale cultivation of *Chondracanthus chamissoi* in a suspended system in southern *Chile* |
| PP91 | Sol Han | Korea | Thermal stress effect on growth and color histogram of *Pyropia* collected from different vertical habitats |
| PP93 | Yu Jung Cho | Korea | Effect of Kelpak® on growth and temperature tolerance in *Pyropia* |
| PP95 | Jin Suk Heo | Korea | Shell-inhabiting conchocelis Growth characteristics of *Pyropia* species aquaculture in South Korean |
| PP97 | Yong Yi Kim | Korea | The effects of temperature and irradiance on the growth of regenerated basal crust of *Gloiopeltis tenax* (Rhodophyta) |
| PP99 | Jeong Chan Kang | Korea | Growth and survival rates of *Sargassum macrocarpum* and *Ecklonia cava* transplanted on artificial reefs |
| PP102-1 | Kyounghyoun Moon | Korea | Indoor cultivation of *Pyropia tenera* |
| PP103 | Yahe Li | China | Darkness and low nighttime temperature modulate the growth and photosynthetic performance of *Ulva prolifera* under lower salinity |
| PP107 | Sze-Wan Poong | Malaysia | Gauging the impact of climate change on the physiology of the mangrove-associated *Bostrychia tenella* (Rhodophyta) |
| PP109 | Jee Eun Lee | Korea | The interactive effects of elevating temperature and nutrient concentrations on *the Ulva linza* linnaeus (Ulvales, Chlorophyta) |
| PP111 | Alasdair O'Dell | United Kingdom | Scotland's blue carbon: the contribution from seaweed detritus |
| PP113 | Jianrong Xia | China | Physiological response of *Ulva lactuca* to ocean acidification in nitrogen-limited environment |
| PP115 | Seung Wook Jung | Korea | A benthic marine algal community characteristics of Ulleung-do and Dok-do, eastern coast of Korea |
| PP117 | Sangil Kim | Korea | Depth-related responses of kelp *Ecklonia cava* Community to seasonal disturbance in Jeju Island, Korea |
| PP119 | Julio Vasquez | Chile | *Lessonia berteroana* in northern Chile: effects of harvest on populations and communities |
| PP121 | Ryuta Terada | Japan | Photosynthetic activity including the chilling-light sensitivity of a temperate Japanese brown alga, *Sargassum macrocarpum* |
| PP123 | Renato Westermeier | Chile | Population biology and chemical composition of the edible red alga *Callophyllis variegata* (Rhodophyta; Cryptonemiales) in southern Chile. |

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| PP125 | Mangu Kang | Japan | Ecological studies on the seasonal changes of *Pyropia katadae* and its host species in mie prefecture, Japan |
| PP127 | Jingjing Li | China | High acclimation capacity of *Sargassum horneri* (Phaeophyta) floating on the sea surface to a changing environment |
| PP129 | Jeong Bae Kim | Korea | Photosynthetic characteristics of *Pyropia yezoensis* Ueda measured in situ by Diving-PAM in the Jindo-Haenam region on the southwestern coast of the Korean Peninsula |
| PP131 | Jongil Bai | Korea | Field experiments on the growth conditions of halophyte(*Salicornia europaea, Suaeda glauca, Suaeda japonica, Suaeda maritima*) from Daebu-do Tidal Flats, West Sea of Korea |
| PP133 | Jong-Ahm Shin | Korea | Principal considerations in marine afforestation |
| PP135 | Sookkyung Shin | Korea | Effects of the sources of light on growth, phosphate uptake and photosynthetic efficiency in *Ulva* |
| PP137 | Nam-Gil Kim | Korea | Stomach contents and marine algal flora of sea hare, *Aplysia kurodai* habitat in the east coasts and the south coasts, Korea |
| PP138-1 | Suk Min Yun | Korea | Study on the variations in temporal and spatial distribution of micro-algae in a resident aquatic ecosystem |
| PP138-3 | Alvaro Israel | Isarael | Changing marine environments: do invasive seaweeds and blooms in the eastern mediterranean shores have really negative consequences? |
| PP139 | Hoang Thi Lan Anh | Vietnam | Pyruvate Production by *Halomonas* sp. using carbon source from the green seaweed *Ulva reticulata* |
| PP143 | Hirotaka Kakita | Japan | Effects of indole-3-acetic acid on algal growth and components of the red alga, *Gracilariopsis chorda* From Japan |
| PP147 | Ha Jun Park | Korea | Removal and bioremediation of chlorpyrifos by *Chlorella sorokiniana* isolated From Korean paddy fields |
| PP149 | Sangmok Jung | Korea | New approach to the restoration of seaweed beds using *Sagassum* sp. |
| PP151 | Youngwoo Kim | Korea | Assessment of phytoremediation potentiality of lead (Pb) by *Gracilaria* |
| PP153 | Pedro Murua | United Kingdom | Disease resistance strategies across phaeophyceae are multi-layered and conserved mechanisms against phylogenetically unrelated pathogens |
| PP155 | Je Jin Jeon | Korea | Three causative pathogens infection pattern analysis of olpidiopsis blight from *Pyropia yezoensis* |
| PP157 | Khaoula Ettahi | Korea | *Pleurostomum flabellatum* genomics; new paradigm to unveil the adaptation of extreme salinity |
| PP159 | Fanna Kong | China | Genome-wide identification, phylogeny, and expressional profiles of the mitogen-activated protein kinase kinase kinase (MAPKKK) gene family in *Pyropia yezoensis* |
| PP161 | Danilo E. Bustamante | Peru | Conspecificity of the peruvian *Corallina ferreyrae* with *C. caespitosa* inferred from genomic analysis of the type specimen |
| PP163 | Hyun Dae Hong | Korea | First report on draft genome sequence of coenocytic green alga, *Bryopsis plumosa* |
| PP165 | Seok-Wan Choi | Korea | An investigation into the organellar genomes of brown algal relatives |
| PP167 | Dongmei Wang | China | Functional characterization and evolutionary analysis of glycine-betaine biosynthesis pathway in red seaweed *Pyropia yezoensis* |
| PP168-1 | Yiyi Hu | China | A study of heterozygous single nucleotide polymorphism loci in haploid gametophyte of *Gracilariopsis lemaneiformis* (Rhodophyta) |
| PP169 | Pilar Díaz-Tapia | Spain | New records of cryptic introduced species of the red algal family Rhodomelaceae in Tasmania (Australia) |
| PP171 | Mi Yeon Yang | Korea | Comparative phylogeogaphy of two intertidal seaweeds, *Grateloupia asiatica* and *G. jejuensis* (Halymeniales, Rhodophyta), along the Northwest Pacific |
| PP173 | Hyunsik Chae | Korea | A new *Chlorella* species (Chlorophyta, Trebouxiophyceae) from Antarctica |
| PP175 | Mi-Sook Hwang | Korea | Diversity and phylogenetic relationships of foliose bangiales (Rhodophyta) from Korea |
| PP177 | Eun Chan Yang | Korea | Phylogeny and evolution of haptophytes based on three new mitogenomes |
| PP179 | Jae Woo An | Korea | *Derbesia maxima* sp. nov. (Bryopsidales, Chlorophyta) from korea based on morphological and molecular data |
| PP181 | Martha S. Calderon | Chile | Assessing the coralline algae diversity in the sub-antarctic region of Chile |
| PP183 | Pil Joon Kang | Korea | *Grateloupia fasciculata* sp. nov. (Halymeniaceae, Rhodophyta) from korea based on morphology and rbcL sequences |
| PP185 | So Young Jeong | Korea | A new species of *Phymatolithon* (Hapalidiaceae, Rhodophyta) from the Northeast Atlantic Ocean |
| PP187 | Pui Ling Tan | Malaysia | Potential DNA barcodes for red algae *Halymenia* C. Agardh (Halymeniaceae, Rhodophyta) |

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| PP189 | Nair Yokoya | Brazil | A new species of *Rhodachlya* (Rhodachlyales, Rhodophyta) from Brazil, unmasked by rbcL DNA sequences, thallus development and ultrastructure |
| PP191 | Byeongseok Kim | Korea | *Amphisiphonia* gen. nov. derived from the genus *Polysiphonia* by integrating morphological and molecular analyses |
| PP193 | Jong Chul Lee | Korea | Species delimitation of the red algal genus *Scinaia* (Scinaiaceae, Nemaliales) from the northern pacific based on molecular analyses |
| PP195 | Seung Won Nam | Korea | Ultrastructure of the flagellar apparatus in *Rhodomonas salina* |
| PP197 | Sang Deuk Lee | Korea | Morphological identification and diversity of late holocene diatoms from reservoir Gonggeomji, Korea |
| PP199 | Lanping Ding | China | The molecular-assisted alpha taxonomy of marine green algal family cladophaceae on the coasts of Chinese sea |

## Student Competition (Best Poster Presentation Award)

All student competition poster presentations are scheduled to present on April 29th Monday 18:00 - 19:30.

| Presentation No. | Presenter | Country | Abstract Title |
|---|---|---|---|
| PA02 | Kk Asanka Sanjeewa | SriLanka | Dieckol; an algal polyphenol attenuates urban fine dust-induced inflammation in raw 264.7 cells via the activation of anti-inflammatory and antioxidant signaling pathways |
| PA03 | Ah-hyun Park | Korea | A study on a species of littoral brown algae *Leathesia difformis* extract on melanogenesis by regulating the gene expressions in B16F10 melanoma cells |
| PA04 | Won-Hwi Lee | Korea | Melanogenesis regulation of extracts from *Polyopes affinis* in α-MSH-stimulated B16F10 melanoma cells |
| PA05 | Jae Woo Jeong | Korea | Effects of seaweed extracts on the determination of chemokine in human keratinocyte cell line |
| PA06 | Nuno Nunes | Portugal | Constructing ethanol derived bioactive extracts using the brown seaweed *Zonaria tournefortii* performed with timatic extractor by means of response surface methodology (RSM) |
| PA08 | Kk Asanka Sanjeewa | SriLanka | Indole derivatives isolated from brown alga *Sargassum thunbergii* inhibit adipogenesis through AMPK activation in 3T3-L1 preadipocytes |
| PA09 | Lei Wang | Korea | Inhibition of adipogenesis by diphlorethohydroxycarmalol (DPHC) through AMPK activation in adipocytes |
| PA10 | Thilina U. Jayawardena | Korea | Purification of fucoidan from turbinaria ornata; attenuation of lps-induced inflammatory responces in *In-vitro* and *In-vivo* models |
| PA11 | Thilina U. Jayawardena | Korea | *Sargassum horneri* ethanol extract inhibits fine dust induced inflammation via Nrf2/HO-1 signaling pathway in raw 264.7 macrophages |
| PA12 | K.H.N. Fernando | Korea | Effects of ishophloroglucin a isolated from *Ishige okamurae* on high glucose-induced angiogenesis |
| PA14 | Yulin Dai | Korea | Anti-inflammation effect of diphlorethohydroxy-carmalol from a brown alga *Ishige okamurae* by treatment of urban fine dust particles in keratinocytes and macrophages |
| PA15 | Hyo Geun Lee | Korea | Evaluation of anti-obesity effect of *Grateloupia elliptica* ethanol extract on 3T3 preadipocytes and high fat diet induced obese mice |
| PA16 | Jun Geon Je | Korea | Anti-obesity effects of seaweeds collected in Jeju Island on 3T3-L1 preadipocytes and obese mice |
| PA17 | Enrique Zepeda | Mexico | Nutraceutical assessment of the red seaweeds *Solieria filiformis* and *Gracilaria cornea* pigments by light quality modulation in culture |
| PA18 | Yu An Lu | Korea | Anti-obesity effects of *Plocamium telfairiae* ethanol extracts in the 3T3-1 cell line and obese mice fed a high-fat diet |
| PA19 | Hakiki Melanie | Japan | Natural pigments from Indonesian red seaweeds: extraction and characterization |
| PA20 | Hye-Won Yang | Korea | Ca2+-dependent beneficial effect of Diphlorethohydroxycarmalol on induced glucose uptake in C2C12 cells and zebrafish model |
| PA21 | Yunfei Jiang | Korea | Anti-melanogenesis effects of Ishophloroglucin A Isolated from *Ishige okamurae* in α-MSH- stimulated murine melanoma cells |
| PA22 | Eui Jeong Han | Korea | 5-bromo-3,4-dihydroxybenzaldehyde from *Polysiphonia morrowii* suppress the IgE-mediated allergic response in mast cell and passive cutaneous anaphylaxis animal mouse model |
| PA23 | Jae-Young Oh | Korea | Fucoidan isolated from *Undaria pinnatifida* sporophylls using enzyme assistant extraction inhibits oxidative stress in zebrafish model |
| PA24 | Eui Jeong Han | Korea | *Sargassum horneri* methanol extracts protect human keratinocytes against UVB-induced cellular damages via the activation of Nrf2/HO-1 signaling |

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| PA25 | Yuna Ha | Korea | *Pyropia yezoensis* extract inhibits TNF-α and IFN-γ- induced TARC and MDC expression via down-regulation of NF-κB activation in HaCaT cells |
| PA26 | Jimin Choi | Korea | Antifouling ability of calcium sulfide crystal found in coralline algae |
| PA27 | Nunik Cokrowati | Indonesia | Content of *Sargassum* sp. from ekas gulf Lombok Indonesia |
| PA28 | Sun Kyeong Choi | Korea | Application of magma seawater to the cultivation of seaweed: effects of nutrients addition on *Ecklonia cava* growth |
| PA29 | Urd Grandorf Bak | Denmark | An investigation of the nutritional composition of *Saccharina latissima*, *Alaria esculenta* and *Laminaria digitata* and commercial open-ocean cultivation in the Faroe Islands |
| PA30 | Jose Avila Peltroche | Korea | Factors affecting survival and cell division during protoplast culture of *Undaria pinnatifida* sporophyte |
| PA31 | Che Khairun Aisyah Che Khazahari | Malaysia | Use of AMPEP K+ and coconut water in the micropropagation of red seaweed *Kappaphycus alvarezii* var. *tambalang* (Doty) |
| PA32 | Hanbi Moon | Korea | Scaling-up estimation of $CO_2$ regulation and mitigation capacity of *Pyropia* aquaculture beds |
| PA32-1 | Jiha Shin | Korea | Seeding method and salinity effects on the growth of edible *Caulerpa okamurae* |
| PA33 | Myeong Hwan Lim | Korea | The effect of ocean acidification on the expected thermal niche of chattonella marina |
| PA35 | Young Jin Kim | Korea | Induced oxidative stress and DNA damage of red sea bream exposed to red tide caused by *Karenia mikimotoi* |
| PA36 | Gerli Albert | Estonia | Could ocean acidification influence epiphytism? A comparison of carbon-use strategies between *Fucus vesiculosus* and its epiphytes in the Baltic Sea |
| PA37 | Chung Hyeon Lee | Korea | The effect of climate change on growth rate and chain-forming capacity of the *Alexandrium pacificum* |
| PA38 | Sukyeon Lee | Korea | Invasion potential of subtropical seaweed *Caulerpa sertularioides* (Ulvophyceae) into temperate ocean with ecophysiolgical acclimation under future climate conditions |
| PA38-1 | Nahyeon Kim | Korea | Interactive effects of ocean acidification and warming on photosynthesis and growth of crustose coralline algae |
| PA39 | Boryuan Chen | Japan | Ecology of an Edible Seaweed *Eucheuma serra* (J. Agardh) J. Agardh in the Northeast Coast of Taiwan |
| PA40 | Bora Lee | Korea | Seasonal dynamics and mixotrophy of the toxic benthic dinoflagellate ostreopsis |
| PA41 | Dominic Belleza | Japan | Effects of predation risk on urchin grazing behavior on *Sargassum patens* C. Agardh |
| PA42 | Hoshimi Kamisaki | Japan | Phenology of diatoms attached on *Sargassum macrocarpum* and *Zostera marina* in Arikawa Bay, Goto Islands, Nagasaki, Japan |
| PA43 | Thomas Burel | France | Conditioning of seaweed dominated environments by hydrodynamics |
| PA44 | Wendel Raymond | United States of America | Using reflectance to estimate condition of giant kelp (*Macrocystis pyrifera*) and its relationship to environmental variability between California and Alaska |
| PA45 | Yuhei Matsuda | Japan | The growth and survival of *Sargassum macrocarpum* C. Agardh juveniles in vegetated and barren ecosystems |
| PA46 | Shin Ja Ko | Korea | Application of RF and VF index to the analysis of growth and maturation pattern of *Sargassum macrocarpum* C. Agardh in Jeju Island, Korea |
| PA47 | Jatdilok Titioatchasai | Thailand | Effects of degree of bleaching and herbivore exclusion on coral-algal community dynamics |
| PA48 | Kyeonglim Moon | Korea | The composition and structure of marine benthic community in Terra Nova Bay, Antarctica: responses of benthic assemblage to anthropogenic impact |
| PA49 | Jessica Schiller | Germany | Difference in cold tolerance of a native and an invasive *Undaria pinnatifida* population |
| PA50 | Fatemeh Ghaderiardakani | United Kingdom | The cross-kingdom interaction: morphogenetic factors as drivers of morphogenesis in the marine green macroalgae *Ulva* spp. |
| PA51 | Dajeong Lee | Korea | NADPH oxidase-mediated oxidative burst plays a key role in resistance to pathogen attacks in red alga *Pyropia tenera* |
| PA52 | Bao Le | Korea | Effect of salinity and desiccated on antioxidant defense responses in a *Pyropia yezoensis* |
| PA53 | Hyun-Hee Hong | Korea | DinoRsour: a comprehensive dinoflagellate rna sequence database and bioinformatics resources |
| PA54 | Luz Karime Polo | Brazil | Quantitative proteomic profiling of the brown seaweed *Sargassum filipendula* : insights into UV radiation stress |

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| PA55 | Jooseong Oh | Korea | Identification of best features and design of machine learning model for proteins binding either DNA or RNA |
| PA56 | Young-Eun Choi | Korea | *De novo* assembly of transcriptome from the green macroalgae *Ulva pertusa* and identification of heavy metal stress response related gene |
| PA57 | Yuna Ha | Korea | Transcriptional profiling of *polyopes affinis* extract in human keratinocyte cell line identifies specific patterns of gene expression |
| PA58 | Ming Herng Gan | Malaysia | Marine algae checklist of South China Sea focussing on Malaysia region |
| PA59 | Antony Oteng'O | Korea | A new crustose brown algal species, *Diplura koreana* sp. nov. (Ishigeales, Phaeophyceae) from Korea |
| PA60 | Sinjai Phetcharat | Thailand | DNA-assisted identification of species diversity of the calcareous macroalgae *Halimeda* (Bryopsidales, Chlorophyta) in Taiwan including Spratly Island and Dongsha Atoll from South China Sea |
| PA61 | Kattika Pattarach | Thailand | DNA assisted diversity assessment of the green algal genus *Caulerpa* J.V. Lamouroux (Chlorophyta) in Thailand |
| PA62 | Francesco Rendina | Italy | Algal composition and structural complexity of different mediterranean rhodolith beds found off the Campania Coast (Italy) |
| PA63 | Soyeong Jin | Korea | The consideration of ambiguity in species identification with DNA barcodes on a public database |
| PA64 | Geonhee Kim | Korea | Variations in the thallus morphological and pigmentation in four *Ulva* spp. |
| PA65 | Zoe Brittain | Australia | Learning from communities: can historical indigenous uses of seaweeds inform a sustainable Australian seaweed industry |
| PA66 | Jamie Du Plessis | South Africa | DNA barcoding of South African Rhodophyta |
| PA67 | Lu Zhou | United Kingdom | Exploration of the innovative implications of seaweed fibers in the fashion industry in Asia and Europe |

| Poster Session 2 | | | May 2 (Thursday) 16:50-18:20 |
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| Presentation No. | Presenter | Country | Abstract Title |
| PP02 | Eun Jae Kim | Korea | Biofuel production using arctic psychrophilic microalga *Chlamydomonas* sp. KNM0029C |
| PP04 | Songhyun Lee | Korea | Effect of substratum types on the growth of erect and stolon fronds of edible *Caulerpa okamurae* |
| PP06 | Erwan Le Gélébart | France | Metabolic Induction, a powerful tool to enhance the chemodiversity of macroalgae cell culture |
| PP08 | Yoon Yen Yow | Malaysia | Neuroprotective activities of Malaysian agarophyte: *Gracilaria manilaensis* Yamamoto & Trono with cholinesterase and nitric oxide inhibitory activities |
| PP10 | Juanjuan Chen | China | The variation of floridoside and isofloridoside of *Pyropia haitanensis* response to stress by high performance liquid chromatography-mass spectrometry |
| PP12 | Youn-Ji Lee | Korea | Antioxidant activities of *Hizikia fusiforme* by extraction methods |
| PP14 | Shori Takano | Japan | On suppression of postprandial blood glucose level in Mekabu (sporophyll of *Undaria pinnatifida*) in young women |
| PP16 | Vimala Balasubramaniam | Malaysia | Prevention of diet-induced obesity by red edible seaweed *Eucheuma denticulatum in vivo* |
| PP18 | Sangmi Sun | Korea | Antioxidant and prebiotic properties of polysaccharide fractions from *Ulva pertusa* by microwave-assisted aqueous two-phase extraction |
| PP20 | Eun-A Kim | Korea | Tuberatolide B protects LPS-stimulated inflammatory response in RAW264.7 cells and zebrafish model through inhibiting MAPKs and NF-kB signalings |
| PP22 | Eun-A Kim | Korea | Saringosterol acetae inhibits liver cancer progression via PI3K/Akt/mTOR signaling in a zerafish xenograft model |
| PP24 | Nalae Kang | Korea | Beneficial effects of ishophloroglucin a from *Ishige okamurae* on obesity in leptin deficient obese mice |
| PP26 | Yu-Chen Chen | Taiwan | The effect of fucoidan from brown algae reduces migration on human head and neck squamous cell carcinoma cells |
| PP28 | Hirotaka Kakita | Japan | Microanalysis of uronic acid monomers and oligomers by high performance liquid chromatography with fluorimetric detection |
| PP30 | Yolanda Freile-Pelegrín | Mexico | Biochemical composition and antiviral activity against herpes simplex virus type-1 of enzymatic hydrolysates from *Solieria filiformis* (Gigartinales, Rhodophyta) |
| PP32 | Ahmad Mansur | United Kingdom | Anticancer and immunomodulatory activities of the brown seaweeds *Cystoseira* spp. |
| PP34 | Taeho Kim | Korea | Cultivation of *Spirulina (*Arthrospira) *maxima* for quality standardization and sustainable biomass production in Jeju Island, Korea |
| PP36 | Jin Hwang | Korea | Antihypertensive effect of peptides derived from *Chlorella ellipsoidea* |
| PP38 | Min-Hsuan Tsou | Taiwan | Investigation of extraction of polysaccharides from southern Taiwan local *Sargassum ilicifoium* and analyze its composition |
| PP40 | Sol Jang | Korea | Research of functional materials from the brown alga *Sargassum horneri* (Turner) C. Agardh |
| PP42 | Min Ju Kim | Korea | *Ecklonia cava* ameliorates the gluten-caused inflammation and oxidative damages in a human keratinocytes |
| PP44 | Celine Rebours | Norway | The Norwegian seaweed biorefinery platform (SBP-N) |
| PP46 | Suk Jin Kim | Korea | Evaluation of anti-adipogenic effect of seaweed extracts in Korea |
| PP48 | Juliane Bernardi | Brazil | Antioxidant potential of common seaweeds from the Azores Archipelago, Portugal |
| PP50 | Seo-Young Kim | Korea | The effects of marine algal natural product on inflammatory myopathy in *in vitro* and *in vivo* zebrafish model |
| PP52 | Wonwoo Lee | Korea | Inhibition of inflammatory responses elicited by urban fine dust particles in keratinocytes and macrophages by diphlorethohydroxycarmalol isolated from a brown alga *Ishige okamurae* |
| PP54 | Peili Shen | China | Applications of seaweed fertilizers in agriculture |
| PP56 | Kangsadan Boonprab | Thailand | Approach application of an edible film from gracillaroid, *Gracillaria fisheri* |
| PP58 | Chan Young Hong | Korea | Light-regulated cytoplasmic streaming in coenocytic green alga *Bryopsis plumosa* |
| PP60 | Hancheol Jeon | Korea | CRISPR/Cas9-mediated heterologous gene silencing in *Chlamydomonas reinhardtii* |

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| PP62 | Denis Ricque-Marie | Mexico | *Ulva clathrata* silver nanoparticles, a potential approach to manage bacterial diseases in shrimp: toxicity, bioaccumulation and depuration |
| PP64 | Hancheol Jeon | Korea | Development of cell-penetrating peptides-mediated molecule delivery system in red alga *Pyropia tenera* |
| PP66 | Jong Su Yoo | Korea | Purification and characterization of antiviral lectin from red alga, *Glateoupia chiangii* |
| PP68 | Éric Tamigneaux | Canada | Reproduction and cultivation of *Palmaria palmata* (Palmariales, Rhodophyta) in the Gulf of St Lawrence, Canada |
| PP72 | Sang Rul Park | Korea | Bioremediation potential of five seaweed species applied to fish-seaweed integrated aquaculture system |
| PP74 | Wui Ting Lim | Taiwan | Effect of single and different ratio of led light combination on growth rate, pigment content, antioxidant activities and phytoene desaturase gene expression in the green alga *Caulerpa lentillifera* |
| PP76 | Cecilie Wirenfeldt Nielsen | Denmark | Decreasing iodine content in *Saccharina latissima* by hydrothermal processing and determining the possible loss of nutritive and bioactive compounds |
| PP80 | Djusdil Akrim | Indonesia | Entrepreneurial capacity building of the seaweed farmers in Takalar district, south Sulawesi, Indonesia |
| PP82 | Hyung Geun Kim | Korea | Comparative growth of *Gelidium coreanum* (Gelidiales, Rhodophyta) in laboratory and in the field |
| PP84 | Di Xu | China | Microscopic observation of reproductive apparatus and fertilization initiation of *Gracilaria vermiculophylla* |
| PP86 | Leila Hayashi | Brazil | Fertilization of *Kappaphycus alvarezii* with biofloc effluents: effects on growth and carrageenan yield |
| PP88 | Leila Hayashi | Brazil | Effect of a carrageenan feed additive on Pacific-white shrimp growth and white spot virus resistance |
| PP90 | Sigrid Mikkelsen | Denmark | Optimal cultivation and harvest strategies for bladderwrack |
| PP92 | Hyein Song | Korea | Growth, pigment contents and nutrient uptake capacity of *Pyropia yezoensis* under LED lightings |
| PP94 | Sookkyung Shin | Korea | Commercial seaweed extract (AMPEP) effect on nutrient uptake, pigment and thermal resistance of *Gracilaria* |
| PP96 | Kwanhyuk Kwak | Korea | Variation of the number of periphytic diatom *Licmophora* sp. according to the presence or absence of *Pyropia yezoensis* at low dissolved inorganic nitrogen concentration |
| PP98 | Jeoung Sook Ko | Korea | Comparative growth of *Gelidium coreanum* (Gelidiales, Rhodophyta) in laboratory and in the field |
| PP100 | Angelos Photiades | United Kingdom | Biorefinery processing of green macroalgae for the production of high added-value products |
| PP102 | Ida Capacio | The Philippines | Empowering the *Gracilaria* producers in Sorsogon |
| PP104 | Catherine Oliver | United Kingdom | Macroalgal blooms: is the sustainable harvesting of opportunistic macroalgae a solution for associated ecological, social and economic problems? |
| PP106 | Adrian Fagundo Mollineda | Mexico | Extraction and characterization of antioxidant compounds in *Sargassum* spp. from the Mexican Caribbean |
| PP108 | Chunxiang Liu | China | *Gracilariopsis lemaneiformis* in the future ocean: potential for carbon acquisition, PSII function and biochemical production |
| PP112 | Rapeeporn Ruangchuay | Thailand | Effects of carbon dioxide levels on sea lettuce, *Ulva rigida* C. Agardh (Ulvales, Chlorophyceae) |
| PP114 | Marcela Avila | Chile | Effect of fresh diet of macroalgae on survival, growth, feed conversion and gonadic index of the sea urchin *Loxechinus albus* in laboratory, Puerto Montt, Chile |
| PP116 | Chang Geun Choi | Korea | Marine algal flora and invertebrate fauna of uninhabited island in Sinan-gun, Jeollanam-do, Korea |
| PP118 | Jeonghee Shim | Korea | Evaluations and comparisons in carbon and nitrogen stable isotopes and in heavy metal contents of mariculture kelp *Undaria pinnatifida* and *Saccharina japonica* in Gijang, southeastern Korea |
| PP120 | Alejandro Buschmann | Chile | Environmental factors (nitrogen, light and temperature) effects and genetic background implications on the reproduction success of the giant kelp *Macrocystis pyrifera* |
| PP122 | Yeon-Jeong Park | Korea | Comparison of spatio-temporal distribution characteristics of phytoplankton in four streams downstream of the Nakdong River |
| PP124 | Eun Ju Kang | Korea | Photophysiology of intertidal seaweeds along the fluctuated light condition |
| PP126 | Gregory (Naoki) Nishihara | Japan | The dynamics of nutrients within a *Zostera marina* at Arikawa Bay, Nagasaki, Japan |
| PP128 | Juliane Bernardi | Brazil | Environmental disturbance index (EDI) based on the frequency of indicator seaweeds for anthropic impacts: a study on tropical reefs from Brazil |

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| PP130 | Seo Kyoung Park | Korea | Temporal and spatial variations in growth and reproduction of a field population of *Chondrus ocellatus* |
| PP132 | Jongil Bai | Korea | A study on the distribution of sedimentary environment and Benthic Macro-fauna Community according to presence or absence of *Suaeda japonica* on the Daebudo, West Coast of Korea |
| PP134 | Andrés Mansilla Muñoz | Chile | Can glacier melting influence marine macroalgal assemblages?: the case of canal de las montañas (51-52ºs) at subantarctic ecoregion of Chile |
| PP136 | Jun Zhu | China | Stress response to high light of two benthic seaweeds |
| PP138 | Xue Sun | China | Role of trehalose and trehalase in stress response of *Gracilariopsis lemaneiformis* (Rhodophyta) |
| PP138-2 | Mirye Park | Korea | Development of sandwich hybridization integrated with nuclease protection (NPA-SH) probes to monitor *Heterosigma akashiwo* |
| PP142 | Siqi Sun | China | Study on antibacterial activity of macroalgae in Zhejiang Coast |
| PP144 | Sinyang Kim | Korea | Artificial biofilm for growth of *Ulva fasciata* spore |
| PP146 | Eiichi Shoguchi | Japan | Comparative genomics of alphaproteobacteria associated with the dinoflagellate symbiodiniaceae |
| PP148 | Jonatas Canuto De Souza | Brazil | Physiological responses and biofilter potential of *Gracilaria domingensis* (Gracilariales, Rhodophyta) cultivated in different concentrations of nitrate and phosphate |
| PP150 | Hirotaka Kakita | Japan | Purification of wastewater derived from fish farming by a red alga, *Gracilariopsis chorda* |
| PP152 | Soon Jeong Lee | Korea | Species specific detection for red rot disease pathogens (*Pythium chondricola* / *P. porphyrae*) of *Pyropia yezoensis* (Rhodophyta) using PCR-RFLP method |
| PP154 | Yacine Badis | United Kingdom | Hidden diversity in the oomycete genus *Olpidiopsis* may threaten red algal cultivation and conservation worldwide |
| PP156 | Minseok Kwak | Korea | Metagenomics analysis of distribution of phycodnavirus in the marine environment of the south sea in Korea |
| PP158 | Seojeong Park | Korea | Transcriptome analysis of high-growth-rate *Pyropia yezonesis* mutant using RNA-seq |
| PP160 | Min Cao | China | The complete genome sequence of *Pyropia haitanensis* at chromosome level using shotgun, single-molecule sequencing and optical mapping |
| PP162 | Eun Young Shim | Korea | Isolation of two sex-specific importin-alpha-like genes in the red alga *Bostrychia moritziana* |
| PP164 | Chun Chi Shih | Taiwan | Reappraising phylogenetic plastid markers of the red algae in the genomic era |
| PP166 | Dongseok Kim | Korea | Comparative genomic study of the genus *Porphyridium* |
| PP168 | Jong-Il Choi | Korea | Proteomic changes of *Zygnema* sp. by gamma-irradiation |
| PP170 | Mi Yeon Yang | Korea | Deep genetic divergences among the regional populations of the red algae *Caulacanthus ustulatus* (Gigartinales) |
| PP172 | Han-Gu Choi | Korea | Phylogenetic relationship of the Antarctic bangiales |
| PP174 | Kyeong Mi Kim | Korea | Complete mitochondrial genome and phylogeny of *Sargassum yezoense* (Fucales) |
| PP176 | Jung Kwan Ahn | Korea | Algal diversity of marine national parks, Korea |
| PP178 | Eun Chan Yang | Korea | Mitochondrial genome analysis and systematics of Halymeniaceae (Halymeniales, Rhodophyta) |
| PP180 | Hyeong Seok Jang | Korea | Genetic diversity of regional populations of chondrus *Ocellatus-nipponicus* complex inhabiting the Korean Peninsula |
| PP182 | Nair Yokoya | Brazil | Assessment of intraspecific diversity based on physiological and biochemical responses of colour variants of *Hypnea pseudomusciformis* (Gigartinales, Rhodophyta) |
| PP184 | Su-Min Kang | Korea | Morphology and phylogenetic systematics of new species *Heterocapsa* sp. (Dinophyceae) from sand beaches of Jeju Island |
| PP186 | Pil Joon Kang | Korea | *Ulva grossa* sp. nov. (Ulvales, Chlorophyta) from Korea based on molecular and morphological analyses |
| PP188 | Zhongmin Sun | China | Seaweeds in the earliest Chinese catalog of marine creatures |
| PP190 | Jeong Chan Kang | Korea | Reassessment of taxa with polyneura-type procarp in the tribe Phycodryeae (Delesseriaceae, Rhodophyta) |
| PP192 | Hyung Woo Lee | Korea | Cryptic species diversity of *Ulva* and *Umbraulva* (Ulvaceae, Chlorophyta) from subtidal of the Korean coast |
| PP194 | Jeong Chan Kang | Korea | Species diversity of the family Sargassaceae (Fucales, Ochrophyta) with distribution at Jeju Island, Korea |

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|---|---|---|---|
| PP196 | Ju Il Lee | Korea | Genetic diversity and distribution of edible brown algae, *Petalonia* and *Scytosiphon*, from Ulleungdo Island, Korea |
| PP198 | Mirye Park | Korea | Physiological and genetic characterization of cryo-preserved *Anabaena variabilis* isolated from Nakdong River |

**Poster Session 1** (April 29th Monday 18:00 - 19:30) **: Presentations with odd numbers**

ex) PP 01, 03, 05

**Poster Session 2** (May 2nd Thursday 16:50 - 18:20) **: Presentations with even numbers**

ex) PP 02, 04, 06

All student competition poster presentations are scheduled to be presented on April 29th Monday 18:00 - 19:30

*Ecklonia cava*

ISS 2019

23rd International Seaweed Symposium

# Plenary Lecture

PL 01

# Beautiful and familiar seaweeds in Jeju Islands; diversity and distribution

**Sung Min Boo**[*1]

[1]*Department of Biological Sciences, Chungnam National University, Korea*

Korean people have been very familiar with seaweeds in their life for a very long time. People like to eat baked Gim (*Pyropia*) from the Silla Dynasty (BC 57-AD 935) and Miyok-guk (*Undaria* soup) from Koryo Dynasty (918-1392). Korea is only country to celebrate birthday with Miyok-guk for breakfast, reminding their love, gratitude and respect to mother. Turner (1809), a British botanist, for the first time introduced three new seaweeds from Korean Straits to international community; *Sargassum fulvellum, S. horneri* and *S. pallidum*. Cotton (1906) figured out that " The coast of Corea is not by any means poor in marine vegetation, and will amply repay the time and trouble spent in collecting". The current checklist of Korean seaweeds contains 952 species (613 reds, 198 browns and 141 greens), compiled from illustrated books, floras, and taxonomic papers. Jeju Islands, volcanic islands raised about 2 million years ago, are the center of magnificent diversity and abundance of Korean seaweeds, embracing a total of 707 species (74%) of Korean seaweeds; 473 reds (77%), 133 browns (67%) and 101 greens (72%). *Dasysiphonia jejuensis*, described by Lee and West (1980), is the first new genus and species based on specimens collected in Jeju Islands. Subsequent taxonomic studies have reported more than 40 new species from Jeju Islands. Most of these species are endemic to Jeju Islands, and representatives are *Dipterocladia yongdeokkoi*, *Gelidium jejuense, Leptofauchea munseomica*, and *Pyropia submarina*. *Ecklonia cava* and several species of *Sargassum* are ecosystem engineers that create the diversity of subtidal community. Udo Isle has a unique sand beach built up only by broken pieces of the non-articulated calcareous red algae and various subtidal seaweeds that have survived through strong currents. *Gelidium elegans* for agar and *Sargassum fusiformis* for food are harvested yearly by local people. *Ishige foliacea*, an edible brown alga, and *I. okamurae* are abundant on intertidal rocky areas in spring. Both species formed monophyly with *I. sinicola* from Baja California, Mexico, suggesting a wide genetic bridge between Jeju Islands and the Pacific coast of Mexico in the early stage of *Ishige* evolution. Various haplotypes of *Colpomenia sinuosa, Scytosiphon lomentaria*, *Gelidium elegans*, and *Gelidiophycus freshwateri* occurred in Jeju Islands. Recently, repeated blooms of *Martensia*, *Sargassum horneri*, and *Ulva* have yearly raised public issues. Continued ecological and/or taxonomic monitoring of seaweeds is needed to check disturbance in native marine ecosystem of beautiful Jeju Islands.

PL 02

# Microalgae as sustainable photosynthetic green cell factories in biotechnology

**Olaf Kruse**[*1]

[1]*Faculty of Biology/ Center for Biotechnology, Bielefeld University, Germany*

Microalgae are capable of efficiently converting inorganic $CO_2$ with the help of sunlight energy and water splitting into organic biomass, which is composed of energy-rich carbon-based compounds. Efficient photon energy conversion into bio-products of interest requires the understanding of the regulation of light energy conversion mechanisms, as well as the availability of molecular tools for the generation of mutants, with enhanced efficiency as green cell factories. New insights into components involved in regulation of light use efficiency and metabolic engineering results, performed with the microalga *Chlamydomonas reinhardtii* for the synthesis of a variety of terpenes, will be presented. In addition, new insights into the fundamentals of an alga-bacteria biocoenosis with the terpene-producing microalga *Botryococcus braunii* will be discuessed.

PL 03

# The aquaculture and aliens paradox: could the reliance of the seaweed aquaculture industry on non-native species lead to its' downfall?

**Elizabeth Cottier-Cook**[*1], Claire Gachon[1], David Bass[2], Grant Stentiford[2], Juliet Brodie[3], Louise Shaxson[4], Flower Msuya[5], Amelia Buriyo[5], Anicia Hurtado[6], Maria Luhan[7], Victor Ferriols[6], Phaik Eem Lim[8], Nidhi Nagabhatla[9]

[1] *Science, Scottish Association for Marine Science, United Kingdom*
[2] *Pathology and Microbial Systematics, CEFAS, United Kingdom*
[3] *Life Sciences, Natural History Museum, United Kingdom*
[4] *RAPID, Overseas Development Institute, United Kingdom*
[5] *Botany, University of Dar es Salaam, United Republic of Tanzania*
[6] *Institute of Aquaculture, University of the Philippines Visayas, The Philippines*
[7] *Science, SEAFDEC, The Philippines*
[8] *Institute of Ocean and Earth Sciences, University of Malaya, Malaysia*
[9] *Institute for Water, Environment and Health, United Nations University, Canada*

Global aquaculture production continues to increase, whilst capture fisheries stagnate. The cultivation of marine and freshwater species has undergone a dramatic global expansion since the 1960s (5.8 – 6.9% $yr^{-1}$), exceeding the annual growth rates of many other important commercial agricultural products, such as livestock (1.9% $yr^{-1}$) and cereals (2% $yr^{-1}$). Yet, this exponential increase in aquaculture has been enhanced in many countries by the cultivation of non-native species. Examples include, the Pacific oyster *Magallana gigas* in Europe, the (Eastern) Pacific white leg shrimp *Penaeus vannamei* in Southeast Asia and the Asian red alga Kappaphycus alvarezii in Tanzania. Despite the apparent success of this industry to date, outbreaks of 'introduced' pests and disease are becoming increasingly common and are having significant negative consequences both directly on yields and more widely on the surrounding environment. In the case of seaweed aquaculture, countries are facing the acute problem of disease outbreaks and pest infestations, many linked to the introduction of the red algae *Kappaphycus* and *Eucheuma*. Significant global losses in production of these species (>15%), equating to almost US$0.3 billion $yr^{-1}$ in lost revenue, have been attributed to disease and pests and have had major socio-economic impacts on communities reliant on this industry. Key challenges include legislation and farm management practices regarding biosecurity and risk management, which are minimal, if present at all, in the majority of seaweed-producing countries. The 'GCRF GlobalSeaweedSTAR' (www.globalseaweed.org) programme addresses these key challenges and aims to build capacity in seaweed-producing developing countries. Our core Partners are the Philippines, Tanzania and Malaysia, but we hope to work with other DAC-list countries through our GSSTAR Fund. The main objective is to ensure the sustainable growth of this vital industry in seaweed-producing DAC-list countries, while supporting the implementation of Sustainable Development Goal 14.

PL 04

# Genomic and genetic approaches to explore brown algal biology and support seaweed aquaculture

**J. Mark Cock**[*1]
[1]*UMR8227, Station Biologique de Roscoff, France*

Worldwide, seaweed aquaculture is developing rapidly and this sector has great potential for large-scale, sustainable production of food and biomass. The history of the expansion of terrestrial crop plant cultivation over the past century has highlighted the importance both of obtaining a detailed knowledge of the basic biology of crop species and of developing sophisticated breeding strategies to increase yield and combat problems such as biotic and abiotic stresses. For the brown algae, the establishment of the filamentous brown alga *Ectocarpus* as a model species has significantly accelerated our capacity to investigate fundamental aspects of this group's biology. This presentation will provide an overview of the resources that have been established for *Ectocarpus,* focusing on recent improvements to the complete, annotated genome sequence, in particular with regard to large-scale genome assembly, gene annotation, identification of non-coding genes and the incorporation of new types of data such as epigenetic information. The presentation will also look at how these genomic resources, coupled with genetic methodologies, are being used to investigate the functions of genes involved in a range of important biological processes. Finally, we will discuss current efforts to extend information, tools and resources generated using this model system to other brown algal species, particularly commercially important cultivated seaweeds. In this respect, one particularly important initiative involves the generation of complete, annotated genome sequences for a broad range of brown algae.

PL 05

# Using genetics to unravel the ecology and economic potential of the giant kelp *Macrocystis pyrifera*

**Filipe Alberto**[*1]
[1]*Department of Biological Sciences, University of Wisconsin-Milwaukee, USA*

The giant kelp *Macrocystis pyrifera*, is a fast growing brown algae of economic interest that forms luxurious submerged forests in many parts of world. Following decades of exciting giant kelp ecological research in California, in the last ten years population genetics analysis has tackled giant kelp life history secrets. Genetic analysis extended our knowledge in many areas from gene-flow and meta-population dynamics; biogeography; mating system and inbreeding depression to inter individual heterogeneity and clonality. In this presentation I will synthesize our findings in the aforementioned areas and discuss how this background knowledge contributed to first genomic selection program targeting this important kelp.

*Undaria pinnatifida*

*Ecklonia cava*

ISS 2019

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# Mini Symposium

## MS 01-1

### Red algal tree of life and its recent update

**Hwan Su Yoon**[*1], Eun Chan Yang[2], RedToL Research Team[3]
[1] *Biological Sciences, Sungkyunkwan University, Republic of Korea*
[2] *Marine Ecosystem Research Center, Korea Institute of Ocean Science & Technology (KIOST), Republic of Korea*
[3] *Biology, Multi-national consortium, Republic of Korea*

Red algae (Rhodophyta) include more than 7,000 species thrive in both marine and freshwater habitats. Red algae play a critical role in the eukaryote tree of life as the donor through secondary endosymbiosis of the plastid that subsequently gave rise to chlorophyll-c containing groups such as diatoms, dinoflagellates, haptophytes, and cryptophytes. Despite its obvious importance, the Rhodophyta is under-studied. Starting from 2009's NSF-funded RedToL project, we have endeavored to address phylogenetic relationships among the red algae. Now we present the results based on a multigene phylogeny using ten gene markers from 570 red algal species, and plastid genome data from 150 taxa that represent the phylogenetic (e.g., order- and family-level) breadth of red algae. Each of seven classes is well supported both in multigene and plastid genome data, however, inter-class relationships are still incongruent between the phylogenies based on different taxon-sampling and dataset. We speculate that there is more complex evolutionary history of the red algae than we conventionally thought.

## MS 01-2

### Systematics of green seaweeds (Ulvophyceae), recent progress and challenges

**Olivier De Clerck**[*1]
[1] *Biology, Phycology - Ghent University, Belgium*

Even though molecular systematics and application of large-scale barcoding initiatives have greatly improved our knowledge on green seaweeds (Ulvophyceae), several fundamental questions remain unanswered. On a most fundamental level, there is still considerable uncertainty on whether Ulvophyceae represent a natural group. Phylogenies which are nowadays commonly based on whole organelle genome datasets more often than not fail to confirm a monophyletic Ulvophyceae. Whether polyphyly of the Ulvophyceae is an artifact resulting from compositional heterogeneity and poor model fitting remains to be tested. In contrast, on order-, family- and genus-levels great progress has been made over the past years and phycologists are slowly progressing toward a stable classification. Care needs to be taken though that this classification also serves a utilitarian function. Last, on a species-level several problems remain. First, estimates of the global species diversity remain a worrying aspect. In most cases we have no idea on the diversity of many groups of green seaweeds. Second, linking diversity as unveiled by DNA-sequencing to formally published names remains difficult to the extent that phycologists increasingly refrain from formally naming species. Third, DNA-based species delineation (often based on a single marker) requires testing. It is not known if taxa which have been delineated based on a single gene, hold up under a truly multilocus dataset. In addition, whether DNA-based taxa are reproductively isolated is rarely tested. During the presentation, I will illustrate recent progress on all three levels of green seaweed systematics.

## MS 01-3

### Evolutionary relationships of heterokont algae based upon gene and genome phylogenies.

**Robert A. Andersen**[1*], Louis Graf[2], Hwan Su Yoon[3]
[1] *Friday Harbor Laboratories, University of Washington, USA*
[2] *Department of Biological Sciences, Sungkyunkwan University, Republic of Korea*
[3] *Department of Biological Sciences, Sungkyunkwan University, Republic of Korea*

Heterokont algae are characterized by an immature flagellum that bears tripartite tubular hairs and a mature flagellum lacking hairs (heterokont, stramenopile). The phylogeny of the many classes is difficult or even impossible to access based upon morphology (e.g. cannot compare cell walls, silica structures and naked protoplasts). As a consequence, the phylogenetic relationships of the heterokont classes has changed dramatically from the 1950s to date as molecular systematics developed. In this study, we used seven genes from 140 taxa and we used plastid genomes from 60 taxa. Phylogenetic trees had three large clades, SI, SII and SIII. Clade SI contains the predominantly attached brown algae, xanthophytes and several small classes as well as the predominately motile raphidophytes. We provide new data for several freshwater and marine lineages that help resolve Clade SI. Clade SII contains the chrysophytes, synchromophytes, pinguiophytes and eustigmatophytes, which are predominately unicellular organisms. Chloroplast genome data support the inclusion of the eustigmatophytes in Clade SII. Clade SIII contains the diatoms, the dictyochophytes and the pelagophytes. We discuss several new genera that help resolve the Pelagophyceae. We suggest the possible merger of some classes.

## MS 01-4

### Phylogenetic studies in brown algae with special reference to the early evolution of Laminariales and taxonomic revision of Ectocarpales

**Hiroshi Kawai**[*1]
[1] *Kobe University, Japan*

Since the finding of heteromorphic life histories in kelp species by Sauvageau (1915) and Kylin (1916), the phylogeny of brown algae in higher taxonomic ranks has been traditionally explained by the combination of thallus morphology and life history patterns. However, this basic idea was challenged by several researchers who found similarities among apparently distant lineages, such as the nature of sexual pheromones and thallus constructions. Later, molecular phylogenetic studies of macroalgae starting in 1980s have gradually unveiled the phylogenetic relationships between brown algal taxa in different taxonomic ranks. Furthermore, in spite of limited fossil records of brown algae, using chronograms based on multigene molecular phylogeny, it became possible to discuss the phylogeography of selected taxa. In the present talk, I would like to review the development of genetic studies in brown algal systematics and introduce some studies for elucidating overall phylogeny of brown algae, early evolution of Laminariales and taxonomic revision of selected chordariacean species.

## MS 02-1

## Biochemical conversions of seaweed for combined ethanol and feed ingredients production

**Trine Sofie Bladt**[*1], Anne-Belinda Bjerre[1], Ana Lopez Contreras[2], Nicolaj Ma[1], Adrian Macleod[3], Xiaoru Hou[1]

[1] *Center of Bioresources and Biorefinery, Danish Technological Institute, Denmark*
[2] *Bioconversion group, Wageningen Food and Biobased Research, Netherlands*
[3] *Blue economy research area, The Scottish Association for Marine Science, United Kingdom*

Seaweed has gained more and more attention as feedstock for bio-energy carriers and value-added products. A biorefinery concept has been developed and tested in pilot scale using brown seaweed *Saccharina latissima* cultivated in SAMS' farm (PORT A' BHUILTIN farm) in Scotland as substrate for ethanol and feed ingredients production.55.5 kg dried seaweed biomass was processed in 600 L pilot fermenter with 500 L working volume by enzymatic hydrolysis using commercial enzyme Cellic CTec2 (Novozymes). Additional seaweed laminarins were added to increase the algae sugar concentration without introducing inhibitors. After fermentation, the liquid fraction was distilled to fuel-grade ethanol for real engine test and the separated solid fraction was evaluated for feed ingredients by the content of proteins, fucoidans, alginate, antioxidants and salts. A biochemical process was optimized in a combined SHF-SSF fed batch fermentation. Whole-crop seaweed with addition of laminarin was initially enzymatically hydrolyzed and thereafter fully fermented (Separated Hydrolysis and Fermentation, SHF), after which purified laminarin was added for a sequential fermentation (Simultaneous Saccharificcation and Fermentation, SSF). No further enzyme addition was needed and a maximum ethanol yield of 70% of theoretical was achieved resulting in 8 L distilled (99% v/v) bio-ethanol. Proteins and unfermented algae constituents (fucoidans, alginate, antioxidants and salts) were concentrated in the solid fraction of the fermentation compared to the content in the raw material, making this fraction a potential protein-rich feed ingredient. This study demonstrated the process of producing liquid biofuels and feed ingredients from seaweed biomass using a combined SHF-SSF fed batch strategy, which highlighted the potential of producing biofuels from seaweed. Future technology/process development will further improve the recovery of other value-added products e.g. antioxidants, alginate and fucoidans in the solid residues.

# MS 02-2

## Economics and environmental sustainability of biological seaweed-to-fuel/energy conversion

**Jay Liu**[*1], Peyman Fasahati[2]

[1] *Chemical Engineering, Pukyong National University, Republic of Korea*
[2] *Chemical and Biological Engineering, University of Wisconsin-Madison, United States of America*

This study evaluates and compares economics and environmental footprints for biological conversion of seaweed to biofuel and bioenergy through (1) fermentation to ethanol, (2) anaerobic digestion to volatile fatty acids followed by hydrogenation to alcohols, and (3) anaerobic digestion to biogas for heat and power generation. Aspen Plus simulations and literature data were used to obtain energy and material balance during conversion, life cycle inventory of input/output data, and environmental emissions. The system boundary was considered from cradle-to-grave including cultivation, conversion at biorefinery, and consumption stages. SimaPro software incorporating SimaPro databases, ecoinvent, and other literature data was used to perform life cycle assessment (LCA) studies. Technoeconomic models were developed for each strategy to calculate minimum product selling prices and maximum seaweed purchase prices to reach a breakeven point after 30 years of plant life assuming 10% internal rate of return. Solid residues from fermentation in all three strategies were considered as a fertilizers in a local market. Results indicated that seaweed fermentation to ethanol has higher conversion energy efficiency and better economics compared to other strategies by having a smaller capital and operating costs. LCA results showed that seaweed drying after harvest should be avoided as it puts a large burden on overall life cycle profile. The best transportation scenario was identified as pumping grinded wet seaweed from collection point in the shore to the biorefinery through pipes. Furthermore, LCA results were used to measure the life cycle impact of each route, identify the bottlenecks, limitations, and potential to lower the environmental impacts. Results demonstrated that constructing seaweed cultivation sites in the sea imposes relatively large burden on the life cycle profile in each strategy. Furthermore, LCA results showed that, overall, production of liquid biofuels yields a better environmental profile compared to electricity generation by having larger avoided emissions.

# MS 02-3

## Offshore green algae seagriculture in Israel for biorefinery and bioeconomy

**Alexander Golberg**[*1]

[1] *Porter School of Environment and Earth Sciences, Tel Aviv University, Israel*

Current strategies for biochemicals, food production, and renewable bioenergy generation rely mostly on classic land-based agriculture. However, as indicated by the European Biorefinery Joint Strategic Research Roadmap for 2020: A key issue for biomass production in Europe is land availability. Multiple countries have the same problem of limited arable land, which could be used for energy crops cultivation. Furthermore, concerns over net-energy balance, land, potable water use, environmental hazards, and processing technologies question the terrestrial biomass to provide a sustainable answer to the coming food and energy challenges. At the same time, an expanding body of evidence has demonstrated that marine macroalgae, cultivated offshore, an emerging field which is called seagriculture, can provide a sustainable alternative source of biomass for sustainable food, biofuel, and chemicals generation. Among the several proposed as biorefinery species, the green seaweed *Ulva* is of particular interest because it is world-wide spread and rapid growth rates. Integrating climatological oceanographic data with a metabolism and growth rate model of the green marine macroalga from *Ulva* genus, we analyzed the potential of offshore biorefineries to provide for biomass, ethanol, butanol, acetone, methane, and protein, globally and in 13 newly defined offshore provinces. In addition, a macroalgae photobioreactor was developed and integrated into the building to provide initial feedstocks for offshore cultivation. Next, we determined the net annual primary productivity (NPP) for *Ulva* sp. , using a single layer cultivation in a shallow, coastal site in Israel and estimated the required territories for 1) substitution of transportation fuels in Israel with *Ulva* derived bioethanol and 2) reducing $CO_2$ emissions for 2030 following the 2015 Paris agreements.

# MS 02-4

## Replacing the fossil C-molecule

**Joost Wouters**[*1], Stefan Kraan[2]

[1] Management, The Seaweed Company, Netherlands
[2] Research & Development, The Seaweed Company, Ireland

The global demand for biofuels continues unabated. Driven by high prices, rising concerns over environmental pollution and global warming, and the movement to alternate fuels, the world bioethanol market is projected to reach 130 billion litres per annum by the year 2020. However, the demand for bioethanol needs to be balanced by the problems associated with the supply of the raw material feedstock. Corn and sugar cane are the major feed-stocks for the bioethanol industry, and the continued use of these crops will drive the food versus fuels debate even more as demand for ethanol increases. Not only does the large-scale production of corn and sugar damage the environment by the use of harmful pesticides, it uses two other valuable resources: arable land and enormous quantities of water. The challenge is to find a feed-stock which is abundant and carbohydrate-rich. Seaweed can be that feed stock and can be produced sustainable and uses less or no agricultural inputs (pesticides, fertiliser, land, water), and is not part of the human food chain. Aquaculture of seaweeds also brings additional benefits such as carbon, nitrate and phosphate removal which may be a very important benefit in the near future. Current seaweed cultivation technologies available will be examined and the economic aspects of using brown seaweeds for bio-ethanol production will be presented together with some personal views on the feasibility of biofuel production from seaweed and the direction (European) seaweed aquaculture will have to advance to make it a successful and competitive industry.

## MS 03-1

### Seaweed cultivation and breeding programs to adapt environmental changes in Korea

**Eun Kyoung Hwang**[*1], Dong Soo Ha[1], Chan Sun Park[2]

[1] Seaweed Research Center, National Institute of Fisheries Science, Republic of Korea
[2] Department of Marine and Fisheries Resources, Mokpo National University, Republic of Korea

In 2016, world seaweed production reached 30,139,389 t (Fresh Weight, FAO 2017). Korea was the fourth largest producer, contributing 1,351,258 t annually, behind China, Indonesia and the Philippines (FAO 2017). Among the economically important genera, *Pyropia, Undaria, Saccharina, Sargassum, Ulva, Codium* and *Gracilaria* are used mainly as human food, whereas species of *Gelidium, Pachymeniopsis* and *Ecklonia* are used as raw materials for phycocolloid industries. Export of *Pyropia* products reached 513 million in US$ in 2017 (KCS 2018). Breeding is an important part of the seaweed aquaculture industry. Since 2012, the Korean government has started to certify seaweed varieties. 15 seaweed varieties have been registered for right protection including 9 varieties of *Pyropia*, 5 varieties of *Undaria* and one variety of *Saccharina*. The direction of seaweed breeding is to improve production and product quality, to enhance content of certain functional ingredients, disease resistance and to increase environmental adaptability. It is because of the rapid development of various varieties that have met the demand for various products. For *Pyropia*, it is necessary to develop varieties with high amino acid content, improved disease resistance and environmental adaptability (high temperature tolerance, low nutrient requirement and low salt tolerance). For *Undaria* and *Saccharina*, the direction of breeding is to improve production quality, strengthen specific functional ingredients, secure genetic diversity, strengthen disease tolerance and to adapt to environmental change (such as high-temperature resistance).

## MS 03-2

### Current status and assignments of seaweed cultivation and breeding in Japan

**Norishige Yotsukura**[*1]

[1] Field Science Center for Northern Biosphere, Hokkaido University, Japan

In Japan, *Pyropia* spp. (P), *Undaria* spp. (U), *Saccharina* spp. (S), and *Cladosiphon* and *Nemacystus* spp. (CN) have been cultured on a large scale with catches of 300,683 t, 47,627 t, 27,068 t and 15,225 t (wet weights), respectively, in 2016. While these seaweeds have been stably produced using generally established technique, current problems include: bleaching from reduced nutrient concentrations in P; poor seedling growth due to increased water temperature in the seedling-raising season in U; and bud drop after seeding or before harvest in CN. Until now, various problems have been addressed by improving hardware and technical aspects. However, there is a limit to what can be done through these approaches and efforts have been made to breed new culture strains to improve environmental adaptability and productivity. These breeding efforts are still developing, and only a small number of cultivars have so far been registered. Conversely, independently created unregistered strains are being used locally, and it is necessary to understand their characteristics and sort and register these to promote the efficient use of diversity. The full-scale cultivation of kelp started in 1969 in Hokkaido, where *S. japonica* and its regional varieties have been cultured to supplement the decrease in natural catches. Previously, producers experienced various problems such as bud drop, spot disease, and feeding by phytal animals, whereas current challenges include the stable securement of mother algae and measures against damages caused by attached animals. In contrast, research institutions are currently developing environmentally tolerant strains, and with natural catching continuing to be the main pillar of fishery, the future issue is the coexistence of natural strains and bred strains in the sea.

## MS 03-3

### Seaweed farming in China has benefited from application of cultivars

**Shaojun Pang**[*1]

[1] Key Laboratory of Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China

In the year of 2017, totally 2,235,012 t of seaweeds was produced through farming in an area of 145,263 hectares along the coast, while 24,300 t was harvested from natural inhabit in China (China fishery statistical year book, 2018). Farming is almost the exclusive way of obtaining seaweed biomass in this country. Seven seaweed species are now grown in large scale from Liaoning province in the north to the subtropical Hainan island. Except Guangxi and Hebei provinces, all other coastal provinces have their independent seaweed farming industry with different species distributed. Applications of cultivars in all the farmed species have contributed significantly to the rapid improvement of production in the past few decades. In the talk, I will introduce the related history and present the technical layout of how these cultivars have been bred and the system to extend them to the producers.

## MS 03-4

### Micropropagation of selected *Kappaphycus* strains for the purpose of boosting the supply of much needed, new cultivars for commercial farming

**Anicia Hurtado**[*1], Majid Ali[2], Ma. Rovilla Luhan[3], Alan Critchley[4]

[1] *Consultancy, Integrated Services For The Development of Aquaculture and Fisheries (ISDA) Inc., The Philippines*
[2] *School of Mathematical Sciences, Universiti Sains Malaysia, Malaysia*
[3] *Aquaculture Department, SEAFDEC, The Philippines*
[4] *Verschuren Centre for Sustainability in Energy and the Environment,, Cape Breton University, Canada*

*Kappaphycus* is a genus of carrageenophyte which has been cultivated since the early 1970s in tropical waters of southeast Asia, particularly within the Coral Triangle. The industrial gel kappa carrageenan is extracted from cultivated *Kappaphycus* biomass. This phycocolloid demands relatively high prices in the global market due to its wide spectrum of applications in processed foods, cosmeceuticals and pharmaceuticals. However, the repeated vegetative propagation of *Kappaphycus*, since its first introduction as a marine agronomic crop, by commercial, extensive farming has resulted in the deterioration of the quality of those cultivars (i.e. loss of strain vigour). Consequently, in recent times, various, important *Kappaphycus* production areas have been vulnerable to pest and disease infestations, and the volume, quality properties and thus value of the crops to the farmers have declined. The micropropagation of selected *Kappaphycus* strains, in order to generate new and improved cultivars, has taken considerable investments in time and efforts, particularly since the early 1990s. Various assessments of the success of adopting seaweed micropropagation in the Philippines, Indonesia, Malaysia and Vietnam are on-going. However, the science of mass production of healthy seedlings for extensive cultivation has to be tested further at even larger commercial scales, in different geographies, so as to ensure a robust and sustainable supply of carrageenophytes to supply the increasing volume and quality demands of industrial-scale seaweed processors. Various biotechnologies involved in micropropagation and screening required to generate new and improved cultivars of *Kappaphycus* will be presented.

## MS 04-1

### Signaling pathways regulating photosynthesis in response to nutrient starvation and trophic regimes

Jacob Munz[1], Yuan Xiong[1], Moyan Jia[1], Jenny Lee[1], Sunjoo Joo[1], Jae-Hyeok Lee[1]

[1] *Department of Botany, University of British Columbia ,Canada*

Photosynthesis is an energy converting process that requires coordinated metabolic flow and thereby subjected to intense regulation under environmental stressors. A facultative phototroph, *Chlamydomonas reinhardtii* degrades select photosynthetic complexes under nutrient starvation but only when external acetate is available. To investigate the mechanisms that monitor starvation conditions and available carbon nutrients and withhold photosynthetic energy flow, we have explored different culture regimes and taken a genetic approach. First, we showed that arginine cultures constitutively turned on nitrogen (N) starvation-induced genes and increased lipid droplets during robust phototrophic growth. The diatom *Phaeodactylum tricornutum* also accumulated lipid droplets in arginine culture without growth impairment. Arginine culture, therefore, presents a system wherein N starvation responses are induced without compromising photosynthesis or growth. Second, we isolated two groups of insertional mutants showing defects in N-starvation-induced degradation of cyt-b6f complex that relays electrons between Photosystem I and II. The first group showing insensitivity to N starvation includes two subgroups: one showing gross N-starvation insensitivity and the other with defects in a subset of N-starvation phenotypes. The second group displaying specific defects in cyt-b6f degradation also impairs in mixotrophy-dependent suppression of photosynthesis under iron-limitation and sulfur-starvation, suggesting insensitivity to mixotrophy. Mutants in this second group showed comparable mixotrophic or heterotrophic growth to wild type, suggesting compromised mixotrophy signaling. Combining arginine cultures and those signaling mutants will distinguish the genetically programmed responses to nutrient starvation regimes from generic stress responses and reveal the signaling pathways that help the survival of phototrophs under ever-changing nutrient conditions.

## MS 04-2

### The bZIP1 transcription factor regulates lipid remodeling and contributes to ER stress management in *Chlamydomonas reinhardtii*

**Yasuyo Yamaoka**[*1], Seungjun Shin[1], Bae Young Choi[2], Hanul Kim[2], Sunghoon Jang[2], Masataka Kajikawa[3], Takashi Yamano[3], Fantao Kong[4], Bertrand Legéret[4], Hideya Fukuzawa[3], Yonghua Li-Beisson[4], Youngsook Lee[1,2]

[1] *Integrative Bioscience & Biotechnology, POSTECH, Republic of Korea*
[2] *Life Science, POSTECH, Republic of Korea*
[3] *Graduate School of Biostudies, Kyoto University, Japan*
[4] *Institut de Biologie Environnementale et Biotechnologie, CEA Cadarache, France*

The endoplasmic reticulum (ER) stress is caused by various stresses and induces the accumulation of unfolded proteins in ER. Upon ER stress, cells activate unfolded protein response (UPR), which includes multiple ways to alleviate the stress. The mechanism of UPR is not understood well in microalgae. We previously identified *Chlamydomonas* IRE1 (*CrIRE1*) as an ER stress sensor. Here, we identified and characterized an ER stress response effector *CrbZIP1* that works at the downstream of CrIRE1 in *Chlamydomonas reinhardtii*. First, we found that *CrIRE1* activated by ER stress spliced out a 32-nucleotide fragment from *CrbZIP1* mRNA, which induced the codon frame-shift in *CrbZIP1* and the translocation of *CrbZIP1* protein from ER to the nucleus. Thus, *CrIRE1*/*CrbZIP1* pathway can modulate gene expression levels under ER stress. We isolated mutants of *CrbZIP1* genes that highly upregulated under ER stress, and performed phenotypic observation and lipidomics analysis. Mutants deficient in *CrbZIP1* failed to induce the UPR genes, severely retarded in growth, and accumulated lipid droplets under ER stress. Furthermore, the contents of a major ER membrane lipid diacylglyceryltrimethylhomo-Ser (DGTS) and an ER membrane specific polyunsaturated fatty acid (pinolenic acid, 18:3Δ5,9,12) were increased only in the parental strains. The expression levels of a gene coding DGTS synthase *(BTA1)* and a desaturase necessary for pinolenic acid synthesis *(CrDES)* were directly activated by *CrbZIP1*. Moreover, two independent alleles of the crdes mutants were hypersensitive to ER stress. These results indicate that *CrIRE1*/*CrbZIP1* pathway is a critical component of ER stress response, and a mechanism of its action involves lipid remodeling under ER stress.

## MS 04-3

### Gene silencing in microalgae

**Eun Jeong Kim**[*1]

[1] *Department of life science, Chung-Ang university, Republic of Korea*

Microalgae exhibit enormous diversity and can potentially contribute to the production of biofuels and high-value compounds. However, for most species, our knowledge of their physiology, metabolism, and gene regulation is fairly limited. In eukaryotes, gene silencing mechanisms play important roles in the reversible repression of the gene. The recent sequencing of several algal genomes is providing insights into the complexity of gene silencing mechanisms in microalgae. Collectively, glaucophyte, red, and green microalgae contain the machinery involved in RNA interference. However, individual species often only have subsets of these gene silencing mechanisms. Moreover, current evidence suggests that algal silencing systems function in transgene repression but their role(s) in gene regulation or other cellular processes remains virtually unexplored, hindering rational genetic engineering efforts.

## MS 04-4

### Algae-microbe interaction – a new twist to biological nitrogen fixation

**Sowmyalakshmi Subramanian**[*1]

[1] *Department of Plant Sciences, McGill University, Canada*

Like land plants, sea plants (seaweeds) also harbour a rich and dynamic microbial population. Bacteria especially are found both on the surface and in the cytosol of the seaweeds they associate with, dictating various nutrient functions and microbial biofilms. Climate change is impacting the dynamic aquatic environment tremendously. Changes in water salinity, nutrient availability and temperature, are all disturbing the established residential microorganisms thereby causing changes in effective algae-microbe interactions. Nitrogen (N) is a naturally occurring vital element found in all organisms as a component of proteins and nucleic acids. It is one of the most important nutrient components of bio-geochemical cycle of the ecosystem. While the concept of terrestrial biological nitrogen fixation (BNF) as rhizobium-legume symbiosis is understood to a large extent, the same is not true for the BNF of rhizobium-algae symbiosis. Green and red seaweeds especially harbour nitrogen fixing bacteria that significantly influence seaweed growth. Some of the endosymbionts of green seaweeds such as those belonging to *Rhizobium*, *Azotobacter* and *Agrobacterium* group are capable of fixing atmospheric nitrogen using the *nifH* genes coding for nitrogenase. The objective of this study is to compare and contrast the commonalities and differences between the *nifH* genes of rhizobium-legume symbiosis and the rhizobium-algae symbiosis to understand the mechanisms biological nitrogen fixation both on land and sea. This study would highlight the potential for understanding the nitrogen fixing bacteria on land and in sea and the impact of plant evolutionary history in both these terrains.

## MS 05-1

### Annual periodic formation process for the world's largest *Ulva* blooms in the Yellow Sea

**Peimin He**[*1], Jianheng Zhang[1], Xinyu Kang[1], Jinlin Liu[1]

[1] *College of Marine Ecology and Envrionment, Shanghai Ocean University, China*

The world's largest trans-regional macroalgal blooms during 2008-2018 occurred in the Yellow Sea, China. In this paper, we described the regularity of annual periodic formation for the world's largest *Ulva* blooms in the Yellow Sea. Terrestrial investigation along the coastline of the Jiangsu Province showed that filamentous Ulvaceae algae were prevalent in various environments. Especially, *Pyropia* aquaculture area could provide approximately 2784 tons of *Ulva prolifera*, dominant species of the blooms, making itself the main source for the blooms. Besides, an accurate numerical model was used in this study, showing the origin of macroalgal blooms was traced to "Sansha" regions which accounted for almost 70% of the total *Pyropia* aquaculture area. In the Southern Yellow Sea, four transects of shipboard monitor was conducted, indicating that the individual or scattered floating *Ulva* macroalgae were observed in the coastal area of Rudong, which was considered as the source area of the blooms. Optimal hydrological and meteorological conditions contributed to the formation and transport of the massive bloom north into the coast of Qingdao, under the daily observation of satellite remote sensing. The stage of life history for the floating *Ulva prolifera* during the drifting process from the source area to the Qingdao area was determined, the results showed that all the floating *Ulva* were sporophytes, and the maturation period of sporophytes was more than 30 days, indicating that vegetative growth are mainly responsible for the rapid expansion of macroalgal blooms. We also found that *Ulva* microscopic propagules were widely distributed in the *Pyropia* aquaculture area in the coldest winter before the *Pyropia* harvest. They could easily attach on the infrastructures of *Pyropia* aquaculture, and became the source seed of the blooms. Those studies presented here contributed to increasing our understanding on the blooming mechanism for this annual disaster.

## MS 05-2

### Golden tide seaweeds in Korean waters: genetic and genomic comparisons between floating and benthic populations

**Hyuk Je Lee**[*1], Seo Yeon Byeon[1], Sangil Kim[2], Suk Hyun Yun[2], Hyun-Ju Oh[2], Sang Rul Park[3]

[1] *Biological Science, Sangji University, Republic of Korea*
[2] *Oceanic Climate and Ecology Research Division, National Institute of Fisheries Science, Republic of Korea*
[3] *Marine Life Sciences, Jeju National University, Republic of Korea*

Recently, brown seaweeds *Sargassum horneri* blooming on the eastern coast of China drifted in large biomass with oceanic currents (called "golden tide") and subsequently floated along the southern coastlines Korea. These floating populations posed a large threat to both the local economy and coastal ecosystems. We tracked genetic origins of the floating *S. horneri* populations and investigated the genetic structure between floating (N=14) and Korean benthic (N=5) populations using two genetic markers, such as mitochondria (mt) DNA cox3 and seven microsatellites. Results of genetic structure analysis clearly revealed two separate genetic clusters of each comprised of floating and benthic populations. Given a shared mtDNA haplotype and oceanic circulation systems, the floating populations may have been originated from the southeastern coast of China. However, our phylogeographic analysis showed that variation in mtDNA cox3 is not sufficiently enough to distinguish floating from Korean benthic populations. Therefore, we further analysed sequence polymorphisms in the whole organelle genomes of a Korean benthic sample in comparison to Chinese sample's genomes to trace genetic origins of floating biomass more precisely. We successfully mapped a mitochondrial genome of 34,620 bp and a chloroplast genome of 124,068 bp for the Korean benthic sample. We found that although the mt genome had a shorter length in size than the

chloroplast genome, it had considerably more variable sites. MtDNA cox2 gene showed the highest number of six Single Nucleotide Polymorphism (SNP) sites and an inter-genic region between nad7 and trnP genes showed a 14 bp insertion/deletion mutation (indel). We are currently testing those candidate markers on the mt genome for discriminating between floating and Korean benthic samples.

## MS 05-3

### Challenges and opportunities in relation to *Sargassum* blooms along the coast of the Mexican Caribbean

**Daniel Robledo**[*1], Erika Vazquez Delfin[1], Yolanda Freile Pelegrin[1], Adán Salazar Garibay[2]

[1] *Marine Resources, CINVESTAV, Mexico*
[2] *Remote Sensing Group, CONACYT - CentroGeo MERIDA, Mexico*

Macroalgal blooms are becoming more frequent events worldwide in response to several factors, some of which have not been proven as responsible for these common events. Reports in the scientific literature for the Atlantic and Pacific coast for Golden tides or blooms of the genus *Sargassum* have appeared recently. Past and recent (2011, 2015, 2018) blooms formed by *Sargassum* species along the Mexican Caribbean coast make us aware of the necessity to tackle these events not only locally, but at a Regional and Global scale. We have identified at least three pelagic species of *Sargassum*, which are dominant in the blooms occurring along the coast of the Mexican Caribbean. Monthly collections of this biomass derived in taxonomic and ecological information, in which other benthic species were also identified. The chemical characterization of the collected biomass will provide basic information for *Sargassum* valorization and exploitation. Moreover, based on satellite image analysis, we followed the event in order to quantify its pelagic volume and the possible impact in touristic areas and vulnerable ecosystems in nearby coastal area of Quintana Roo. Basic and applied information on *Sargassum* biomass may contribute to the understanding of these events and suggest management and possible solutions to their widespread occurrence worldwide.

## MS 05-4

### Speciation and identification of species in green tide forming *Ulva* species complex

**Masanori Hiraoka**[*1]

[1] *Usa Marine Biological Institute, Kochi University, Japan*

Current taxonomy of green tide causing *Ulva* spp. has progressed since DNA markers were introduced. However, it has been found that markers such as ITS and rbcL sequences commonly used cannot discern the causative species or strains from closely related ones. Speciation in *Ulva* seems to occur rapidly, and these markers have too low a sequence divergence to delimit *Ulva* species. To accurately identify bloom-forming *Ulva*, hybridization tests and analyses using more highly resolved DNA makers are required. Here I present two examples applying such identification to *Ulva* green tides in China and Japan. Floating *U. prolifera* has repeatedly caused huge green tides along the Chinese coast. Although the bloom-forming strains are potentially able to hybridize with the other strains growing as attached forms in brackish habitats, these two types of *U. prolifera* have been found to be different in genetic morphology and crossing ability to *U. linza* through combined studies of culturing, hybridization and phylogenetic analyses using the 5S rDNA spacer with a high sequence divergence. Consequently, the bloom-forming strains have been proposed to be a new subspecies designated *U. prolifera* subsp. qingdaoensis. In the other example, the combined work demonstrated replacement from *U. ohnoi* to *U. reticulata* is occurring in the type locality of *U. ohnoi*, which is Uranouchi Inlet in Tosa Bay, southwestern Japan. *Ulva reticulata* is very similar to *U. ohno*i in cellular morphology and ITS sequence of which their divergence is less than 1%. However, crossing tests revealed there is prezygotic and postzygotic reproductive isolation between *U. ohnoi* and *U. reticulata*. These results indicate that if DNA markers with an inadequate resolution are excessively relied upon as criteria to identify species, there is a risk of misunderstanding the ecophysiological characteristics of green tides due to the inability to differentiate the actual causative strains.

## MS 06-1

### The necessity of cheap and reliable gametophyte propagation as a bedrock for a thriving global kelp aquaculture.

**Alexander Ebbing**[*1], Klaas Timmermans[1]

[1] *Department Estuarine and Delta Systems, NIOZ Royal Netherlands Institute for Sea Research and University Utrecht, The Netherlands.*

Kelp aquaculture starts on land with the propagation of gametophyte cultures and a hatchery phase. Gametophytes are the seeds of kelp and a predictable performance of the kelp's seed bank is essential for future kelp breeders and farmers. However, propagating kelp gametophytes is still unpredictable and expensive for the majority of seaweed entrepreneurs. Culture maintenance needs to become cheaper and more reliable before it can aid large scale kelp aquaculture. Innovation in this field is essential and can act as a catalyst for both farming and the breeding of kelps. The scalability and cost effectiveness of the hatchery phase can also be questioned. Changing the concept of a hatchery phase could very well be crucial before large scale kelp aquaculture on a global scale is possible. Kelp aquaculture of this scale forces us to think laterally, resulting in the observation that diverging from the status quo is essential and that a kelp aquaculture without a hatchery phase lies in the realm of possibilities. How can we guarantee high quality kelp hatchlings, while reducing the price for gametophyte production at the same time? What are the bottlenecks and what are potential solutions for solving these problems? This talk will emphasize on these envisioned bottlenecks of mass producing kelp gametophytes and kelp hatchlings, using the novel implementation of the SeaCoRe bioreactor system as a case study.

## MS 06-2

### Innovative and sustainable ropes for seaweed cultivation

**Bert Groenendaal**[*1], Frederik Vroman[1]

[1] *R&D department, SIOEN Industries NV, Belgium*

Seaweeds are gaining general acceptance as being the feedstock of the future. Their potential for existing and new applications (i.e. food, feed, biomaterials, nutraceuticals, cosmetics, biofuels, etc.) is growing exponentially. However, there are a number of trends that will affect their use: (1) drastic elimination of wild seaweed harvest; (2) industrialization

and mechanization of seaweed cultivation (i.e. seeding, cleaning and harvesting); (3) integration of seaweed cultivation with other forms of aquaculture (i.e. IMTA), and with other marine activities (e.g. in wind energy parks); (4) more sustainable cultivation of seaweeds. This paper will present the development of the first generation of advanced biobased / biodegradable seaweed cultivation substrates. Starting from natural resources we have developed 1D (twines, ropes and ribbons) and 2D (sheets, nets, grids) substrates that can be applied for cultivating red, brown and green seaweeds via twine seeding, direct seeding and/or vegetative growth. These innovative developments will pave the road for more sustainable cultivation of seaweeds, which will not polute our seas and oceans with plastics.

## MS 06-3

### Seaweed biorefinery – scaling up low hanging fruits

**Olavur Gregersen**[*1], Anne-Belinda Bjerre[2]

[1] *Cultivation and Processing, Ocean Rainforest, FaroeIslands*
[2] *Agro-tech, Danish Technological Institute, Denmark*

The objective of the European project MACRO CASCADE is to prove the concept of the cascading marine macroalgal biorefinery. This is a production platform that covers the whole technological chain for processing sustainable cultivated seaweed to processed value added products. The project commenced in late 2016 and will end in 2020. Already know the project can present significant achievements within the following work packages (WP): WP1: Innovative and scalable cultivation systems for off- and nearshore conditions, mechanical harvesting, and increased biomass yield resulting in an overall reduction cost of 50-75%. WP2: Developed ensiling methodology for seaweed biomass preparation and storage stability. WP3: Developed patentable feed and food products with health promoting functionalities through innovative microbial refining methods of macroalgae in combination with rape seed. WP4: Developed scalable and sustainable extraction/separation methods for production of multiple products from brown and red seaweeds or seaweeds residues by enzyme aided physicochemical methods. Targeted intermediate products are alginate, fucoidan, mannitol and protein. WP5: Developed a variety of efficient and robust carbohydrate active enzymes, with a range of specificities of relevance for processing macroalgal polysaccharides. Target high value products for feed, food, pharmaceuticals, cosmetics and chemicals are enzymatic derivatives of alginate, laminarin and fucoidans. The project will continue to optimize strains of seaweeds with levels of target components in *Saccharina latissima* (sugar kelp, kombu) and *Palmaria palmata* (red seaweed, dulse), upscaling developed extraction methods in a conceptual biorefinery and study the economic viability of the seaweed cascading valorisation schemes. Furthermore, conduct a quantitative assessment of the sustainability of the seaweed-based value chains, and based on that develop sustainable business cases for a "Blue Print" of the cascading marine macroalgal biorefinery. The project has received funding from the Bio-Based Industries Joint Undertaking under the European Union Horizon 2020 research and innovation programme.

## MS 06-4

### Process and economics of large scale seaweed biorefineries.

**Jaap W. van Hal**[*1], Jan Wilco Dijkstra[1], Dick F. Meyer[1]

[1] *Biomass and Energy Efficiency, ECN part of TNO, Petten, The Netherlands*

The MacroFuels project (www.macrofuels.eu) aims to develop seaweed to biofuels processes. Part of this project is to develop process and economic models of the entire value chain from seaweed to fuels. This presentation presents the main results of the process simulations and as well as the relative contributions to the plant capital investments. Flowsheet models were developed describing each of the unit operations in the biorefinery, using laboratory data and expert input for seaweed composition and conversion yields. Mass and energy balances were calculated and an initial heat integration was performed. This was done for the following three cases: Seaweed to ethanol , Seaweed to acetone/butanol/ethanol (ABE), Seaweed to furanics based fuel. In all cases biogas is produced from the non-fermented components such as non-fermentable sugars, alginate and other organics. Biogas is partly combusted to cover the heat demand of the process. The model uses a yearly input of 1,200 ktonne of seaweed (dry weight bases), using two harvests per year. Using best available data we arrive at an annual production of 107 ktonne of ABE and 74 ktonne of ethanol respectively. The ABE system produces additionally a net amount of 124 ktonne of biogas and the ethanol produces 194 ktonne. Conditioning and storage represent about half to total process investments. For the furanics based fuel we arrive at 200 ktonne furanic fuel produced, blended with a biofuel stream. In this case, no net biogas is produced. For the processing of seaweed to biofuels, the largest investments are in the storage and hydrolysis of seaweeds. Significant mass flows are associated with the acidification and neutralisation in the production of sugars. Significant savings can be achieved by storing seaweed a different way than on land and by eliminating the hydrolysis all together.

## MS 07-1

### Metabolic engineering of microalgae via genome editing method to enhance the production of antioxidant-rich algal oil

**Eon Seon Jin**[*1], Kwangryul Baek[1], Inhwa Song[1]

[1] *Life Science, Hanynag Univesriy, Republic of Korea*

*C. reinhardtii* is a well-studied model green alga and has great potential for biotechnological applications. Continuous development and application of CRISPR/Cas9 for metabolic engineering would allow for a significant improvement of strain for possible utilization of commercial use. Macular pigments (lutein and zeaxanthin) are dietary carotenoids reported to be protective against age-related macular degeneration. We generated a knock-out mutant of the zeaxanthin epoxidase gene induced by preassembled DNA-free CRISPR-Cas9 ribonucleoproteins in *C. reinhardtii* to significantly improve the macular pigment contents with higher zeaxanthin content and productivity than the wild type. And we further generated a knockout mutant of the AGP4 gene coding for the small subunit of the ADP-glucose pyrophosphorylase (AGP) protein from the highly improved macular pigment strain of *C. reinhardtii* as a parental type. Consequently, the resulting strain displayed a decreased level of starch accumulation, but TAG content was approximately 2.3 times higher under nitrogen-limiting conditions with a higher amount of lutein and zeaxanthin. However, this non-DNA mediated CRISPR-Cas9 methods could not screen the mutants which do not have the observable phenotype. Hence, we also optimized the protocols for the CRISPR-Cas9 RNP-mediated knock-in through non-homologous end joining repair mechanism, this can improve the efficiency of targeted gene mutation up

to 36% among selected transformants. Thus, our technology can greatly extend the *C. reinhardtii* genome editing application in both basic and applied areas of algal research, which can also be widely applied to other microalgae.

## MS 07-2

### Progress and trends in the development of microalgae aquafeeds

**Qiang Hu**[*12]

[1] *Center for Microalgal Biotechnology & Biofuels, Institute of Hydrobiology, Chinese Academy of Sciences,China*
[2] *Microalgal Biotechnology Center, SDIC Biotech Investment Corporation, State Development & Investment Corporation, China*

Microalgae, which are the base of the aquatic food chain, provide food for the global capture fisheries production of over 90 million tons annually. Indigenous microalgae together with microalgae-fed protozoa and zooplankton as well as microalgae-associated bioflocs are biofeeds for the world aquaculture production of over 40 million tons of farmed aquatic animals annually. Cultivated microalgae by biotechnological means are preferred or obligatory live feeds in aquaculture hatcheries for larval and juvenile stages of many aquaculture species, particularly marine finfish, shellfish and shrimp. Cultivated microalgae are also used as functional ingredients in formulated aquafeeds to impart specific beneficial properties of high-value niche aquaculture species. With an ever increasing global aquaculture industry and a growing trend towards use of sustainable natural resources, the finite supplies of the key feedstuffs - fishmeal and fish oil can't meet the growing demand. This is creating a tremendous opportunity to expand the microalgal industry to supply bulk microalgae substitutes for fishmeal-/fish oil-based aquafeeds. In this presentation, the current status of microalgae used in aquaculture hatcheries and as functional ingredients in formulated aquafeeds will be overviewed. New and emerging microalgal species applicable to aquaculture will be introduced. The latest progress on the development and application of large-scale culture biotechnologies for mass production of microalgae will be presented. Recent trends towards the development of formulated larval feeds for early developmental stages of many aquaculture species and future outlook will be introduced. Finally, the path forward to development of advanced photobioreactors and culture processes for production of bulk microalgae feedstuffs for aquaculture will be introduced.

## MS 07-3

### Cultivation strategy for *Ettlia* sp. YC001 depending on the target materials

**Hee-Mock Oh**[*1]

[1] *Cell Factory Research Center, Korea Research Institute of Bioscience and Biotechnology, Republic of Korea*

Microalgae basically are known photoautotrophic microorganism which can grow without any organic carbon supply. But, some of them show heterotrophic growth with organic carbon sources and also mixotrophic growth with some wastewaters. *Ettlia* sp. YC001 which was isolated by us has already shown a high growth rate and lipid productivity under high $CO_2$ concentrations and is a highly settleable microalga. The strain was cultivated in autotrophic, heterotrophic and mixotrophic condition and their biomass and lipid productivities were compared. The continuous autotrophic cultivation system was operated in a chemostat under different $CO_2$ supplies, dilution rates, and light intensities for 143 days. The highest biomass and lipid productivities were 1.48 g $L^{-1}$ $d^{-1}$ and 291.4 mg $L^{-1}$ $d^{-1}$ with a pH of 6.5, dilution rate of 0.78 d-1, and light intensity of 1,500 µmol photons $m^{-2}$ $s^{-1}$. With a sufficient supply of $CO_2$ and nutrients, the light intensity was the main determinant of the photosynthetic rate. In the heterotrophic cultivation with 5-L scale-uped fermentation for 6 days, the biomass and lipid productivities were 7.21 g $L^{-1}$ $d^{-1}$ and 1.18 g $L^{-1}$ $d^{-1}$, respectively. Consequently, heterotrophic cultivation of *Ettlia* sp. provided much higher production of biomass and lipid than those of autotrophic cultivation. In the mixotrophic cultivation, *Ettlia* sp. was shown to be effective in removing nutrients and capturing suspended solids from eutrophic pond water. The chemostat cultivation showed the highest N and P removal rate at 32.4 mg $L^{-1}$ $d^{-1}$ and 1.83 mg $L^{-1}$ $d^{-1}$ , respectively, and highest biomass and lipid productivity at 0.432 g $L^{-1}$ $d^{-1}$ and 67.8 mg $L^{-1}$ $d^{-1}$ , respectively. The turbidity was also reduced by 98% in the chemostat cultivation. Consequently, the cultivation strategy of microalgae should be decided in consideration of all related factors such as features of the strain, target material to be produced, production cost, available facilities for microalgal cultivation, etc.

## MS 07-4

### *Dunaliella salina* beta-carotene: from the lab to commercialisation

**Michael Borowitzka**[*1]

[1] *Algae R&D Centre, Murdoch University, Australia*

The halophilic green flagellate alga, *Dunaliella salina*, can grow at salinities up to 5 M NaCl and can accumulate up to ~ 14% of dry weight of the carotenoid, beta-carotene. Beta-carotene was the first microalgal high value product commercialised. Starting from the basic research on osmoregulation in *D. salina* in the early 1970s the focus shifted to using *D. salina* as a source of beta-carotene with lab-scale research especially in Australia, Israel and the USA by the mid-1970s. This talk will focus on the commercial development in Australia (at Hutt Lagoon and at Whyalla) and in Israel (at Eilat). Pilot scale work commenced at the start of the 1980s and major production commenced by the mid 1980s. Currently these three plants with a total pond area exceeding 1500 ha in area produce over 90% of the worlds natural beta-carotene for the vitamin supplement, food colouring, health food and aquaculture industries.
The commercialisation stages at all three sites show great similarity and they are a good example of the challenges, pitfalls and eventual successes in the development of new technology and commercialisation of a new product. This talk will describe the process and the lessons learned.

## MS 08-1

### Endosymbiosis and environmental adaptation lead to foreign gene acquisition in algal lineages

**Debashish Bhattacharya**[*1], Hwan Su Yoon[2], Alessandro Rossoni[3], Andreas Weber[3], Fatima Foflonker[1], Dana Price[4]

[1] *Biochemistry and Microbiology, Rutgers University, United States of America*
[2] *Biological Sciences, Sungkyunkwan University, Republic of Korea*
[3] *Institute for Plant Biochemistry, Heinrich-Heine-University, Germany*

[4] Plant Biology, Rutgers University, United States of America

It is widely accepted that the origin of intracellular organelles, the plastid and mitochondrion, resulted in massive gene transfer to the nucleus from the captured, permanent endosymbiont, a process termed endosymbiotic gene transfer (EGT). More controversial is the hypothesis that horizontal gene transfer (HGT; i.e., independent of endosymbiosis) plays an important role in algal and seaweed evolution. The accumulation of high-quality algal genome data is allowing us to address this second issue. I will discuss recent collaborative work done in our lab that shows the small but crucial role that HGT plays in algal adaptation to fluctuating or extreme environments. Examples will include the bacterium-sized *Picochlorum* green alga that thrives in a wide range of salt and light conditions and the extremophilic red algae, Cyanidiales. Analysis of 10 new genomes from this latter lineage shows that HGT (giving rise to 1% of the gene inventory) provided some of the genetic resources that allowed this clade to survive in its hostile environment. HGT-impacted functions include metal and xenobiotic resistance/detoxification, cellular oxidant reduction, and osmotic resistance and salt tolerance. A major point I will make that is that the hologenome can extend beyond the multicellular organism to the environmental microbiome that both sustains, via provision of needed metabolites, as well as allows long-term change in algal lineages via prokaryote-derived HGT. This perspective, based on biotic interactions, can inform both model-based cell biology studies as well as commercial applications that require robust, fast-growing algal strains.

## MS 08-2

### Genomic Insights Into the virulence mechanisms used by bacterial pathogens of seaweeds

**Suhelen Egan**[*1], Jennifer Hudson[1], Melissa Gardiner[1], Vipra Kumar[1], Nandan Deshpande[1]

[1] BEES/ CMB, UNSW Sydney, Australia

Seaweeds (macroalgae) form a diverse and ubiquitous group of photosynthetic organisms that play an essential role in many aquatic ecosystems, yet till recently very little was understood with respect to their associated microbiota. While symbiotic interactions with marine microbes are essential for macroalgae, we now also know that microbes can be responsible for negative outcomes, such as disease of the host. A major challenge, however, is to link specific microbial pathogens to particular disease events or phenotypes. To overcome this challenge, we have used a combined approach of ecology, microbiology, -omics technology and classical molecular biology to understand the cause of a model disease, the bleaching of the red macroalga *Delisea pulchra*. This presentation will provide an overview of some of our recent work in this area, including the discovery of multiple pathogens that are capable of causing bleaching of *D. pulchra*. Genomic and transcript analysis of some of these bacterial pathogens has identified mechanisms for host interaction and virulence e.g. colonisation factors, extracellular enzymes and stress resistance. Moreover many of these virulence factors appear widespread in environmental bacteria and may respond to environmental change in a multitude of ways resulting in otherwise harmless microbial symbionts to become opportunistic pathogens and cause disease.

## MS 08-3

### Interrogating evolution for solutions to algal diseases

**Claire Gachon**[*1]

[1] The Scottish Association for Marine Science, Scottish Marine Institute, UK

Diseases and pests are an increasing source of concern to algal producers, linked with the expansion and intensification of cultivation worldwide. Pathogens are also key evolutionary drivers that have shaped the genomes and most likely current wild populations of algae. Therefore, it makes sense to probe algal populations and genomes for genotypes and traits selected by evolution, and applicable to disease management. My group combines -omics with laboratory-controlled experiments on several algal-pathogen systems to investigate the physiology of diseased algae and of algal pathogens, with the view to develop novel strategies for controlling diseases in aquaculture. I will report the identification of molecules from endophytic fungi that colonise kelps asymptomatically, and which block the development of several oomycete and phytomixid pathogens of red and brown algae. In a second part, I will introduce our strategy to deploy GWAS on the kelp *Saccharina latissima,* in order to identify loci involved in resistance against disease, and to inform future breeding programmes. Finally, I will replace these findings in an ecological context and highlight how this work can inform biosecurity and conservation policies.

## MS 08-4

### Understanding coral-dinoflagellate symbiosis using genomics and hologenomics

**Cheong Xin Chan**[*1], Raúl A. González-Pech[2], Timothy G. Stephens[2], Rémi Lagorce[2], Yibi Chen[1], Amin R. Mohamed[3], Yuanyuan Cheng[4], Christopher Wrona[2], Clarisse Louvard[2], Mark A. Ragan[2], Debashish Bhattacharya[5], -ReFuGe 2020 Consortium[6]

[1] Institute for Molecular Bioscience, and School of Chemistry and Molecular Biosciences, University of Queensland, Australia
[2] Institute for Molecular Bioscience, University of Queensland, Australia
[3] Commonwealth Scientific and Industrial Research Organisation, CSIRO, Australia
[4] UQ Genomics Initiative, University of Queensland, Australia
[5] Department of Biochemistry and Microbiology, Rutgers University, United States of America
[6] Reef Future Genomics 2020 Consortium, ReFuGe 2020, Australia

Dinoflagellates of family Symbiodiniaceae represent critical photosynthetic symbionts in corals and other coral reef animals. Genetic diversity of these dinoflagellates is highlighted by the recent systematic revision of Symbiodiniaceae and the high level of genome-sequence divergence among taxa from distinct clades/genera. We recently sequenced and generated draft de novo genomes from seven *Symbiodinium sensu stricto* (the most basal symbiodiniacean lineage; formerly clade A) isolates, and two *Polarella glacialis* isolates (the free-living outgroup). Our comparative analysis revealed a high level of genome-sequence divergence within *Symbiodinium* genus, and distinct genome features (e.g. size, repeat content, synteny) that relate to the different ecological niches (e.g. free-living, opportunistic, and symbiotic). We also identified thousands of dinoflagellate genes of unknown functions that are highly conserved and/or lineage-specific. Some gene functions related to coral symbiosis and to meiosis were found to be under adaptive selection among the symbiodiniacean lineages. To better understand symbiotic interactions that underpin a healthy coral holobiont, through Reef Future Genomics (ReFuGe) 2020 Consortium we generated the hologenome of the coral Porites *lutea,* comprising the genomes of (a) *P. lutea,* (b) the associated symbiont (the unculturable symbiodiniacean *Cladocopium* C15), and (b) 52 high-quality bacterial and archaeal metagenome-assembled populations. Comparing these genomes in an integrated approach, our results revealed how different biotic components contribute to a healthy coral holobiont;

this includes the supply of fixed carbon, B-vitamins and amino acids from bacteria and archaea to the eukaryotes. Our findings demonstrate the critical and specialised roles that dinoflagellates and other microbes play in sustaining coral holobionts.

## MS 09-1

### Korean initiatives working towards gender equality in STEM

**Heisook Lee**[*1]

[1]*GISTeR , Ewha Womans University,Korea*

STEM (Science, Technology, Engineering and mathematics) plays a crucial role for creating better world and so does the gender equality. Both men and women could contribute to the sustainable society through their talents and resources but there is still a big gender gap in STEM fields. As a result present science has more evidence for men than for women. Main objectives of gender equality in STEM can be summarized ① fostering equal opportunities and gender balance in the participation of higher education and RDI (Research, Development and Innovation), ② corroborating gender balance in decision making positions in RDI, ③ integrating sex and gender analysis in research and innovation contents to ensure better science for both men and women. The third objective is rather new but has an enormous potential for creating new value to science itself as well as to society and economy. Korea still has a big challenge toward the gender equality in STEM as the following data of women in STEM in the year of 2016 show; the percentage of women enrolled in STEM in colleges and universities is 28.7%, the percentage of women employed in R&D institutions is 19.3%, women account for 27% among new hires but women only account for 15.9% of all promotions, the labor force participation rate for women declines from 80.5% in their 20s to 61.0% in their 30s. Recruiting women into STEM is important but bigger challenge is retaining women in STEM. We share some achievements and remaining challenges of Korean policy initiatives towards gender equality in STEM based on the legal systems followed by the three 5 year Basic plans for fostering women in STEM. We then finally discuss the 4th Basic plan starting in 2019 for the gender inclusive innovation.

## MS 09-2

### Women in science- in seaweed and Denmark

**Susan Løvstad Holdt**[*1]

[1]*The National Food Institute (DTU Food), Technical University of Denmark, Denmark*

The equality is set to be very gender positive, low power distance and all possibilities attainable in the Danish scientific landscape. However, why is it then we have the same issues regarding the leaking pipeline as everybody else in the world? Students starting at The Technical University of Denmark (DTU) are 50% men and women, but the professors are respectively 80% and 20%, and men still have a higher salary than women. Forget the thought that "women choose family instead of academic career". Women scientist have organized ourselves as Women in Engineering Science (WiES) at DTU and arrange after work meetings to address many of the issues such as; what is the science behind the differences?, how do we get better in salary negotiation? This in order to keep focus on and discuss the issues, and hopefully this will make things better in the future. That is what science say. Women also tend to "keep themselves down" by impostor syndrome or having very hard "negotiations" with themselves, before they go to salary negotiations, or maybe "give up" before even trying. My near workplace, the National Food Institute and research group, are dominated by women and with women leaders, which gives me role models. But this is not typical. Therefore, when I hire colleagues I actually have a focus on getting men in as colleagues, for the diversity in our group. It is actually not important to have exactly 50/50 men and women, but to have the equal opportunity, and create the diversity that the mix of e.g. gender, nationality and working types give. Within the seaweed society, the International Seaweed Association (ISA) now have focus on equal women and men in the ISA Council and also speakers and keynotes at the International Seaweed Symposia (ISS).

## MS 09-3

### Women in algae science: Korean prospective

**Jin Ae Lee**[*1]

[1]*School of Environmental Science & Engineering, Inje University, Korea*

The report highlights key gender topics drawn from the membership data sources of the Korean Society of Phycology as of 2018. The data are analyzed with respect to the gender matter and employment of three sectors such as government, education, and business/industry. Women algae scientist constitutes 33% of total algae scientists in Korea. It is comparable to the recent national survey that the women in science and engineering constituted 24% of the total. At the level of college and graduate program, the ratio of women student member to men is 0.79, but at the level of employment the ratio of women to men drops down significantly to 0.30. Within the employment sector women are more likely than men to work in educational institutions (47% vs. 40%), and men are more likely than women to be employed in the business/industry (19% vs. 12%). The report will also provide the diversity and the trend of algae science topics mainly related to women scientists during the last four decades in the Korean Society of Phycology.

## MS 09-4

### Surviving and thriving: wisdom from the past and inspiration for the future (or how I have survived as a female phycologist)

**Juliet Brodie**[*1]

[1]*Department of Life Sciences, Natural History Museum, UK*

One of the intriguing and great things about phycology is that it is a field in which women have often played a dominant and crucial role, and been able to excel. Such women have been responsible for scientific discoveries that have had a great impact on the course of science and indeed changed the world. For example, Kathleen Drew, whose discovery of the life cycle of *Porphyra* was the basis of the modern nori industry, and who also had the vision to set up the British Phycological Society in 1952 which continues to thrive and serve the phycological community. But there have been other pioneering women before and after this time who have left a legacy on which we are still building today. The work of these women and the paths they took have often informed my own thinking and given me inspiration for my own research. In this talk, I will look to the influence of these women and review the science I have done as a consequence. I

will also give an overview of my life as a female scientist, including how to have the courage of one's convictions, getting new ideas published, tackling brick walls, unconscious bias and learning to be resilient and adaptable. For me, having an insatiable curiosity, a questioning and open mind and a vision for the future has enabled me to survive and thrive.

## MS 09-5

### Algae science and the gendered roles based on the 4th industrial revolution

**Mi-Kyung Kim**[*1]

[1] *Ecophycotech Co., Ltd , MCK Biotech Co., Ltd., Korea*

In order to produce biomass for the seaweed or microalgal application industry, it was labor-intensive, male dominated and representing the 3D industry in the past. However, the 4th Industrial Revolution by Big Data, artificial intelligence, machine learning and deep learning can be easier through more female dominated gender roles such as "communication", "collaboration", "critical thinking" and "creativity" for the successful business model of mass production facilities of smart aquaculture and smart microalgal farms. The emphasis is on the importance of women's flexibility and delicacy, which are considered necessary to cultivate talented individuals who are fit for gender equality in the 4th Industrial Revolution.

## MS 10-1

### Carbon budget in the seaweed farm, a life cycle analysis

**Put Ang, Jr.**[*1]

[1] *The Chinese University of Hong Kong, Shatin, China*

Seaweed farm has been considered to be a potential sink for carbon through its rapid turnover of biomass. We have provided a general life cycle of a seaweed farm before, and are now developing a more detailed life cycle analysis that covers the whole process of carbon production and utilization. It will include the whole life cycle from carbon production of the seaweed to the final utilization of such product. Carbon production will include the net storage of carbon in the seaweed biomass from seedling to harvestable crop, to the final industrial product. Carbon utilization will cover all carbon subsidies needed to produce such harvestable crop and the final industrial product. This will include utilization of petrol gas in small boat to plant, maintain and harvest the crop, the manpower involved, the delivery of such crop to the industry and the energy subsidy to produce the final product. There are uncertainties in such estimate, including the amount of biomass loss due to grazing, breakage and decay. Carbon from such processes will be lost to the general environment. Wastage in the production, and fate of the waste after production are also difficult to estimate. This life cycle analysis will use information from a tropical seaweed farm to demonstrate it utility. No doubt such analysis would need further fine tuning. Nevertheless, this represents an initial attempt to further this type of analysis, which is essential to address the role of seaweed farm in global carbon equation.

## MS 10-2

### Vulnerability and mitigation potential of temperate Australian seaweeds in a changing climate

**Alecia Bellgrove**[*1]

[1] *School of Life and Environmental Sciences, Centre for Integrative Ecology, Deakin University, Australia*

Australia is home so some of the most diverse and unique seaweeds on our planet, across more than 25,000 km of coastline and 30° latitude. The Great Southern Reef is an interconnected series of rocky reefs across 5 southern states, ~40° longitude and more than 8000 km of coastline, dominated by kelp forests subtidally and primarily the habitat-forming fucoid *Hormosira banksii* intertidally. These natural systems have enormous potential to store carbon, with conservative estimates of 109.9 TgC in living biomass. We have also demonstrated that these temperate macroalgae may be significant donors of recalcitrant carbon to coastal and deep-sea blue carbon sinks. Understanding the ecological effects of climate change on these biogenic macroalgal ecosystems and the adaptive capacity of the autogenic engineers that create them is essential to managing their ability to mitigate carbon emissions through biosequestration and maintaining the biodiversity that they support. I will present some results of temperature stress experiments and assessments of photo-protection chemistry of an important autogenic engineer in the Australian context. Moreover, I will introduce our work that is seeking to better understand the fate of the macroalgal carbon by quantifying contributions to blue carbon sinks; and opportunities for the development of seaweed aquaculture in an IMTA system in Australia to mitigate nutrients and carbon in a changing climate.

## MS 10-3

### Regeneration of ocean forests: the importance of seaweed

**Paal Bakken**[*1]

[1] *SeaForester, Portugal*

Climate change, loss of biodiversity, and uncertainty about future food supplies are real threats that need urgent action. Our Ocean is becoming more acidic, biodiversity is plummeting, and fish stocks are decreasing. It is happening right in front of us, in our blue front yard, where seaweed forests are disappearing at an alarming rate. Vegetation in the ocean is vital to its ability to sustain a healthy planet and replenish fish stocks. With no awareness and very little money directed to solving the problem, we are sleepwalking into a disaster. SeaForester is an initiative that aims to reverse the alarming disappearance of seaweed forests in the world. Its mission is simple: to restore the forgotten forests in our ocean. Seaforester intends to 1) encourage and participate in seaweed reforestation projects on a non-profit basis, 2) create a global network that aggregates funding for projects world-wide, 3) process data and implement common monitoring methodologies, and 4) be a major communicator and educator of the far-reaching benefits of marine vegetation on all continents' blue coastal front yard. Seaforestation can be a cheap, quick and decisive step to combat the two biggest challenges we now face – climate change and food security. If we measure the entire world's coastline with depths down to 30 meters where sunlight can penetrate and marine vegetation can grow, we are talking about an area the size of all of the world's tropical forests combined, bigger than Europe or the United States. For example, a kelp forest of just 0.03 percent of this area, or 5,000 square kilometers, could support 500,000 tons of fish while capturing carbon at a rate five times that of the rainforest. Projects are under way across the globe but much more needs to be done.

## MS 10-4

### Integrated multi-trophic aquaculture (IMTA): a critical analysis towards the use of seaweed for N and C mitigation

**Alejandro Buschmann**[*1], Pamela Fernández[1], Maria C. Hernández-González[1], Sandra Pereda[1], Carolina Camus[1]

[1] *Centro i-mar & CeBiB, Universidad de Los Lagos, Chile*

Global climate changes including ocean warming (OW) and acidification (OA), can have wide-ranging effects on marine organisms. In addition, eutrophication (E) of coastal waters can also affect marine biodiversity. It has been proposed that seaweed farming could be a tool for biomitigation, to sustain the health of coastal ecosystems. However, coastal marine ecosystems are highly variable and, on the other hand, the efficiency of C, N and P removal by algae can also be highly variable. In this paper we analyse the effectiveness for reducing C and N by IMTA culture systems. A literature review showed that the number of publications on IMTA has been increasing since 1990, and during 2018 over 200 papers were published. However, when searching for publications including the concept of IMTA that makes a direct link with N uptake, only 8 articles were published in 2018. The relation of IMTA with ocean acidification is also weaker, and only 16 records were found for the whole searched period, whereas only 5 articles linked IMTA and OA during the past 2018. There are some methodological restrictions towards the demonstration of the impact of IMTA on the mitigation on OA and E. We discuss some of them and we encourage that pilot scale demonstration facilities are required to determine the impacts that IMTA may have on nitrogen loads and CO2 incorporation on coastal systems.

## MS 11-1

### The host and the holobiome: a study of the carrageenophyte *Chondrus crispus*

**Georgia Ward**[*1], Stuart Ross[2], David Bass[1,2], Grant Stentiford[2], Juliet Brodie[1]

[1] *Life Sciences, Natural History Museum, United Kingdom*
[2] *Pathogens and Molecular Systematics, Centre for the Environment, Fisheries and Aquaculture Sciences, United Kingdom*

The red alga *Chondrus crispus*, known as Irish moss, is common along shorelines in Europe where it is a traditional source of carrageenan, a thickening agent used in foods, cosmetics and pharmaceuticals. The majority of commercial carrageenan production is now centred around *Kappaphycus* and *Eucheuma* spp. in the tropics, with the Philippines, Indonesia and Malaysia the most productive regions. The yield of these crops is known to be limited by outbreaks of epiphytes and a diseased state known as *ice-ice* , though the biotic and abiotic factors affecting these are poorly understood. Seaweeds are known to coexist with an associated community of bacteria, protists, fungi and other algae, with these organisms together comprising the holobiome. While the importance of the composition of the holobiome in influencing the health status of the host is becoming increasingly apparent, particularly the role of bacteria in modifying the host's interaction with grazers, epiphytes and abiotic factors, little is known about the complex interactions between these taxa, and how these vary in response to environmental conditions or in response to the host. In this study we use C. *crispus* as a model with which to investigate variation in the holobiome of *carrageenophyte* algae across seasons, and across different host conditions. We use high-throughput amplicon sequencing of prokaryotic and eukaryotic components of the holobiome, paired with light microscopy, to examine changes in composition across seasons, and across different individual host tissues of distinct life stages of C. *crispus* collected in Dorset, UK. This presentation will discuss the observed changes, as well as the importance of these methods for understanding the role of the holobiome in influencing the health and disease of carrageenophyte algae.

## MS 11-2

### Microbiome shifts in the agarophyte *Gracilaria* under high temperature and grazing events: understanding potential disease causative microbes in seaweed aquaculture

**Phaik-Eem Lim**[*1], Teck-Toh Tan[1,2], Sze-Looi Song[1], Sze-Wan Poong[1]

[1] *Institute of Ocean and Earth Sciences, University of Malaya, Malaysia*
[2] *Institute of Advanced Studies, University of Malaya, Malaysia*

The global seaweed aquaculture production has increased exponentially since 50 years ago due to their high demand as food and for various industrial applications. Among the global commercial seaweeds, *Gracilaria* ranks among the top producers of phycocolloid. However, environment related stressors such as temperature, diseases and pests are adversely affecting the seaweed production. Since the associated bacterial community is symbiotically important for seaweed growth, it is important to determine the changes in bacterial diversity in response to environmental perturbations and the ensuing impact on seaweed domestication. In this study, *Gracilaria* firma was collected from the eulittoral zone with water temperature at 32 °C (denoted as wild), acclimatised at 28 °C (denoted as control) and cultured at 35 °C for 25 days (denoted as high-temperature-treatment) to investigate the changes in microbiome diversity associated with the host using 16S rRNA gene (V3-V4 hypervariable region) sequencing. In addition, the microbiota of grazed *Gracilaria salicornia* was examined to explore microbial-host interactions during pest infestation. Proteobacteria was the predominant phyla (with relative abundance of ≥5% in at least one specimen) in wild *Gracilaria firma*, whereas Cyanobacteria/Melainabacteria was the predominant phyla in control and high-temperature-treated samples. Seaweed microbiomes were altered by elevated temperature, with a 161.56 folds increase in Proteobacteria which include a wide variety of pathogens and opportunistic bacteria and 1.33 folds decrease in predominant phyla Cyanobacteria/Melainabacteria. Crocosphaera watsonii (Cyanobacteria/Melainabacteria) was the predominant bacterial species in all samples. There was no difference in photosynthetic activity between the wild and control samples, but high-temperature-incubated sample showed gradual decline in photosynthetic performance. An improved understanding of the responses of seaweed associated microbes under elevated temperature and grazing pressures, is potentially useful for the management of seaweed aquaculture.

## MS 11-3

### Epiphytes susceptibility and sustainability of algae farms, the host point of view: population genetics of *Gracilaria chilensis* assessed using microsatellite and SNP data sets

**Marie-Laure Guillemin**[*1], Christophe Destombe[2], Sylvain Faugeron[2,3], Stéphane Mauger[2], Pablo Saenz[1,2], Vanessa Robitzch[1,2], Myriam Valero[2]

[1] *Los Rios, Universidad Austral de Chile, Chile*
[2] *UMI 3614, Evolutionary Biology and Ecology of Algae, CNRS, Sorbonne Université,*

Station Biologique de Roscoff, France
[3] Departamento de Ecología, Facultad de Ciencias Biológicas, Pontificia Universidad Católica de Chile, Chile

*Gracilaria chilensis* (recently renamed *Agarophyton chilensis*) is one of the few species of algae that has been domesticated. This haploid-diploid red alga is extensively cultivated in Chile where two kinds of populations coexist but differ in their habitat: sexual populations fixed on rocky shores and asexual populations free-floating or embedded in soft sandy substrate. Both kinds of populations host a wild array of epiphytes. In farms, human assisted propagation mimics natural propagation processes typical for floating populations. Thus, we propose that cultivation may have accelerated changes in life history traits otherwise naturally linked to shifts between habitats and reproductive modes in *G. chilensis*. In contrast to wild rocky populations composed of both haploid and diploid individuals, highly mature during the austral summer, farms are dominated by diploid individuals that show low investment in sexual reproduction. Exploring two different types of molecular markers, SNP's from ddRAD genotyping and microsatellites markers, we confirm high levels of clonality in most farms with widespread clones shared at a regional level. Furthermore, since hard and soft bottom habitats exhibit important differences in terms of turbidity, light intensity, desiccation at low tide, and level of burial and abrasion affecting the thalli, we hypothesized the presence of genetic differentiation associated to adaptive divergence between fixed and floating populations. However, out of over 1200 variable SNPs, only 35 outlier loci were detected among our Chilean samples. From these, six presented significant changes in allele frequency correlated with geographic distances among locations (North to South) while four were correlated with differences in habitat type. Nonetheless, regardless of the set of SNPs (all loci vs only outlier loci), genetic differentiation between sampling locations seems rather linked to the type of habitat (muddy estuaries vs rocky-platforms) and historical impacts, (earthquakes or human activities) instead of geographic isolation by distance.

## MS 11-4

### Host and pathogen autophagy are central to the inducible resistance of brown algae against intracellular parasitic water moulds

**Pedro Murua**[*1], Dieter G. Müller[2], Mohamad Etemadi[3,4], Pieter Van West[5], Claire M. M. Gachon[1]

[1] Science, The Scottish Asociation for Marine Science, United Kingdom
[2] Fachbereich Biologie, Universität Konstanz, Germany
[3] Institute of Microbiology, University of Innsbruck, Austria
[4] Department of Horticultural Science, School of Agriculture, Shiraz University, Iran
[5] Aberdeen Oomycete Laboratory, International Centre for Aquaculture Research and Development, University of Aberdeen, United Kingdom

Brown algae encompass key primary producers of temperate ecosystems. Their wild harvest cannot supply the current demand and their cultivation is growing exponentially worldwide, with a worsening disease incidence. Both pathogen spectrum and immunity are aspects broadly under-documented in Phaeophyceae, despite their importance to inform disease management in farms/natural populations and support the development of breeding programs. Here, we investigated the time-course of the interaction between the obligate oomycete pathogen *Anisolpidium ectocarpii* and the kelp *Macrocystis pyrifera*, using TEM and in vivo markers. We observed that pathogen lipid droplets are abundant in the onset of the infection but gradually deplete, suggesting that the pathogen undergoes starvation as the infection progress. In response to the progressive depletion of algal resources, some *A. ectocarpii* spore initials degenerate via autophagy, supporting the continued differentiation of the others. Over time however, *A. ectocarpii* thalli undergo targeted nucleophagy and become entirely abortive, indicative of the pathogen's starvation response being subverted towards kelp defense. Infected algal cells also become autophagic: chlorophagy-like processes and chloroplast size reduction were normally observed, thus quickly mobilizing the nutrients required to mount defenses, or even directly digesting the intruder via xenophagy. Pilot experiments with autophagy inhibitors reduced significantly autophagy in Anisolpidium, and also stops the propagation of infection to healthy hosts. We establish a working model where several lines of inducible autophagic responses may ultimately lead to acquired disease resistance.

## MS 11-5

### Challenges for the sustainabe *Pyropia* farming: newly arising diseases and changing environment

**Gwang Hoon Kim**[*1]

[1] Department of biology, Kongju National University, Republic of Korea

The seaweed industry is undergoing a rapid global expansion and currently accounts for over 49% of the total mariculture production and over 7 billion US$ of world market. Unabated exponential growth for several decades is now challenged by many new diseases and changing environment. Some challenges are caused by the growth of the industry itself. Nutrient depletion of seawater is becoming the most serious threat for the sustainability of the industry. *Pyropia* farming in Far Eastern countries offers a good model case to learn how the farmers have dealt with the challenges and what should the phycologists contribute to keep this industry sustainable. Oomycetes are one of the most serious pathogens that threaten global aquaculture industry, and they cause two out of four most common diseases in *Pyropia* farms. Recent studies revealed several new pathogens for these oomycete diseases and a PyroV1 virus causing serious green-spot disease. We hypothesized that a basic genetic profile of molecular defenses will be revealed by comparing and analyzing genetic response of *Pyropia* against above three pathogens, and developed a disease-resistant strain. *Pyropia* aquaculture case shows that improving biosecurity, disease detection and prevention measures are critical for the sustainable seaweed aquaculture, but it is also important for the phycologists to participate in policy decision and communication with the sea farmers.

## MS 11-6

### Seaweed industry trends in Tanzania: success and constraints

**Buriyo, A.S**[*1], Msuya F.E[1] and Halling, C[2].

[1] Botany Department, University of Dar es Salaam, Tanzania
[2] Department of Ecology, Environment and Plant Sciences, Stockholm University, Sweden

The history of seaweed industry in Tanzania is well document and indicates that coastal people have been engaged in the activity for about 7 decades now since the times of collection of *Eucheuma* and *Kappaphycus* species from natural stocks for export in 1930s. This paper reviews and presents seaweed industry trends in Tanzania from the 1930s where the industry depended on collection of seaweeds from the natural stocks, its first business boom in the mid 1950s when the

collection for export reached 500-800 tonnes dry weight per year (t dw/yr); the decline of the industry 1970s due to overexploitation to 150 t dw/yr and eventually collapsed. Moreover, the paper narrates the research efforts conducted at the University of Dar es Salaam on seaweed farming possibilities, introduction of commercial seaweed farming 1989, trends since then, recent challenges facing the industry, as well as ongoing work.

## MS 11-7

### Marine biosecurity frameworks for aquaculture

**Chad Hewitt**[*1], Marnie Campbell[1]

[1] *Harry Butler Institute, Murdoch University, Australia*

Increasing pressures on ocean resources for production of food, animal feedstock and pharmaceuticals has led to significant expansion of aquaculture activities across the globe. Already aquaculture production of animal and seaweed products have surpassed wild capture/collection activities. The use of established aquaculture species from other regions (non-native species) has been the primary mode of operation in order to minimise establishment costs and utilise pre-existing markets. Existing farming practices have limited protections against accidental release into these new environments, posing a direct introduction risk as has been observed with many of the top aquaculture species including Atlantic salmon, *Salmo salar*; Japanese Oyster, *Magallana gigas*; and the elkhorn sea moss, *Kappaphycus alvarezi*. Biosecurity protections (WTO, OIE, IPPC) exist to prevent the dissemination of pathogens, pests and weeds of agricultural systems that could severely compromise production capacity. These arrangements have some umbrella benefits for marine aquaculture; however, these primarily protect the economic production interests and largely ignore the "off-farm" risks. These "off-farm" risks can include use of non-native species as target stocks in aquaculture; the potential for introductions of hitchhiker (associate) species when importing new stocks; the use of non-native live, fresh or frozen feedstocks and the movement of aquaculture equipment. In contrast, the risks to aquaculture from marine bioinvasions from other sources (including other aquaculture operators) include pathogens, parasites, biofouling and harmful algal blooms. Marine Biosecurity frameworks have been developed over the last 30 years in several countries that explicitly address the protection of marine ecosystems. In general, the focus is heavily on accidental shipping related movements of organisms via ballast water and biofouling, but in some systems include aspects of "off-farm" exposure (eg ICES). We will discuss approaches taken, with specific examples drawn from Australia and New Zealand, to illustrate the key considerations for implementation.

## MS 11-8

### Diversified aquaculture production and markets-seaweeds and sustainable development goals

**Nidhi Nagabhatla**[*1,2], Yeojin Kim[1,3], Elizabeth Cottier-Cook[4], Sarah Alegretti[4]

[1] *United Nations University, Canada*
[2] *The School of Geography & Earth Sciences (SGES), McMaster University, Canada*
[3] *International Environmental Research Institute (IERI), Gwangju Institute of Science and Technology (GIST), Republic of Korea*
[4] *The Scottish Association for Marine Science, SAMS, United Kingdom*

Expansion in aquaculture production worldwide present a potential towards managing food and nutrition needs, while providing livelihood and income opportunities for individual and communities. Seaweed industry is increasingly gaining attention center stage in this equation, with its fair share of challenges in the production-consumption loop viz., disease or pest's outbreaks, impact of climate change, lack of technical and financial capacity to adopt smart farm management practices and often lack of institutional and policy support. This study encompasses multiple facets: a) inter linkage analysis of seaweeds and Sustainable Development Goals, more so, SDG 14 (sustainable use of coastal and marine resources), 12 (responsible production and consumption); 5(focus on gender) 16 (strong institutions) 17 (effective partnerships, collaborations and knowledge transfer) and others; b) assessment of socioeconomic, water and food security context, markets and policy structures and mechanism in South Koreas, to reflect upon Integrated Coastal Zone Management, climate change adaptation and marine resource management polices to addresses seaweeds production and ensure long term sustainability of the sector; c) within the focus on 'GCRF GlobalSeaweedSTAR' (www.globalseaweed.org) programme objectives and reference to its geographical focus- a 10-point agenda /guideline that builds upon the measures' ecosystem services approach endorsed by The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) will be presented for discussion and d) overview of international projects and programs, that focus on Seaweeds-while presenting a narrative of existing threats and opportunities for future investment in the sector. The concluding remarks will be drawn on the future of the seaweed sector in context of SDG agenda, conceptual underpinnings of the food and water security frameworks proposed by international development agencies, including the United Nations.

## MS 12-1

### Structural diversity and bioactive potential of halogenated secondary metabolites from four major species of red algae Genus *Laurencia* in Sulu-Sulawesi Coral Triangle region (Malaysia)

**Charles Santhanaraju Vairappan**[*1], Takashi Kamada[2], Minoru Suzuki[3]

[1] *Institute Tropical Biology and Conservation, Universiti Malaysia Sabah, Malaysia*
[2] *Department of Materials and Life Scieneces, Faculty of Sciences and Technology, Shizuoka Institute of Science and Technology, Japan*
[3] *Coastal Branch of Natural History Museum and Institute,, Natural History Museum and Institute Chiba, Japan*

Red algae genus *Laurencia* is a predominant seaweed, particularly in the Bornean Sulu Sulawesi Coral Triangle region. It is well represented by 15 species, with at least eight halogenated compound producing species. In the last 10 years, we have isolated total of 110 halogenated compounds from *Laurencia snackeyi* (Weber-van Bosse) Masuda, *Laurencia majuscula* Harvey (Lucas), *Laurencia nangii* Masuda, and *Laurencia similis* Nam Saito. There are also another 6 undescribed species that produces halogenated compounds. Their structural diversity is unique and consist of sesquiterpenes, diterpenes, triterpenes, C15 acetogenin and C15 bromoallenes. A total of 13 skeletone types was identified, and statistical analysis revealed that *L. majuscula* and *L. nangii* has the highest structural diversity and it varies with population and collection sites, while *L. similis* and *L. snackeyi* produced less diversed halogenated metabolites. These metabolites were subjected to anti-inflammation and anti-cancer assay since chronic inflammatory response plays an important role in the inhibition of cancer development, progression, metastasis, and resistance to chemotherapy. In addition, we also investigated the mechanism of action in inflammatory cancer to better understand the complex crosstalk network between oncogenic and pro-inflammatory genes. Compound's anti-inflammatory potential and mechanism of action was evaluated using RAW 264.7 macrophages. In addition, PGE2, TNF-, IL-1 and IL-6, iNOS,

and COX2 response towards the tested compounds, were evaluated. Cancer cell bioassay was concluded using HL60 and MCF7 cell lines, with normal cell controls. Apoptosis mechanism was evaluated using Sub-G1 proportion, microscopic technique, Bax, Bcl-xl, Cleaved Capcase 3 and -actin. In addition microarray gene expression of MRNA for cells treated with these compounds were concluded.

## MS 12-2

### The effects of marine algal natural products on skeletal muscle growth and inflammatory myopathy

**You-Jin Jeon**[*1], Seo-Young Kim[1]

[1] *Marine Life Sciences, Jeju National University, Republic of Korea*

Skeletal muscle is an important tissue in energy metabolism and athletic performance. The use of effective synthetic supplements and drugs to promote muscle growth is limited by various side effects. Moreover, their use is prohibited by anti-doping agencies; hence, natural alternatives are needed. Therefore, we evaluated the skeletal muscle growth effect of substance that can act like synthetic supplements from edible seaweed. First, we evaluated the effects of $C_2C_{12}$ myoblasts proliferation and differentiation using diverse phlorotannins isolated from an edible brown alga, Ecklonia cava. Of the different phlorotanin isolates evaluated, dieckol (DK) and 2,7″-phloroglucinol-6.6′-bieckol (PHB) induced the highest degree of $C_2C_{12}$ myoblasts proliferation. In addition, DK and PHB regulated myogenesis through down-regulating the Smad signaling, a negative regulator, and up-regulating the insulin-like growth factor-1 (IGF-1) signaling, a positive regulator. Interestingly, DK and PHB bind strongly to myostatin, which is an inhibitor of myoblast proliferation, while also binding to IGF-1 receptors. Moreover, they bind to IGF-1 receptor. Another algal polyphenol, Diphlorethohydroxycarmalol (DPHC) from Ishige okamurae suppressed the NO production and the mRNA expression levels of pro-inflammatory cytokines in $C_2C_{12}$ differentiated cells. In addition, DPHC down-regulated MuRF-1 and MAFbx/Atrogin-1, which are the key proteins of myopathy via NF-κB and MAPKs signaling pathways in TNF-α or $H_2O_2$-stimulated $C_2C_{12}$ myocytes and zebrafish in vivo model. These results suggest that marine algal polyphenols induce sarcopenia and skeletal muscle myotubes exposed to inflammation.

## MS 12-3

### Fucoidan as an Integrative therapy

**Damien Stringer**[*1], Monika Corban[2], Nuri Guven[2], Mark Ambrose[2], Raj Eri[2], Ah Young Park[1], J. Helen Fitton[1], Sam Karpiniec[1]

[1] *R&D, Marinova Pty Ltd, Australia*
[2] *Pharmacy, University of Tasmania, Australia*

Fucoidans are high molecular weight fucose-based sulfated polysaccharides from brown macroalgae. Fucoidans are noted to cause cell cycle arrest and apoptosis in cancer cells and may increase the effects of some chemotherapy drugs. The mechanisms of these activities are unclear. How does fucoidan act to induce these effects?
We assessed 'fucoidan-gene' interactions using a systematic screen of the entire set of 4,733 haploid Saccharomyces cerevisiae gene deletion strains. Some of the findings were confirmed using cell cycle analysis and DNA damage detection in both normal human dermal fibroblasts and human colon cancer cells. We found global effects of fucoidan on a wide range of eukaryotic cellular processes, including RNA metabolism, protein synthesis, sorting, targeting and transport, carbohydrate metabolism, mitochondrial maintenance, cell cycle regulation, and DNA damage repair-related pathways. Fucoidan induced DNA damage and G1-arrest in colon cancer cells, while these effects were not observed in normal human fibroblasts. Conclusion: Fucoidan has global effects on diverse cellular processes in eukaryotic cells, which selectively affect cancer cells.

## MS 12-4

### Potential antioxidant and antiobesity effect of purified polysaccharide from *Sargassum thunbergii* extract

**Hyo Geun Lee**[*1], Min-Cheol Kang[2], You Jin Jeon[1]

[1] *Marine life science, Jeju National University, Republic of Korea*
[2] *Research Group of Process Engineering, Korea Food Research Institute, Republic of Korea*

*Sagassum thunbergii* is a known invasive species of brown algae. Due to the interference, they are regularly removed in the cultivations of *Sargassum fusiforme*. Recent studies have shown its nutraceutical values including In the present study, the antioxidant and antiobesity effects of polysaccharide from *Sagassum thunbergii* have been studied. The antioxidant effect of purified polysaccharides from *Sargassum thunbergii* were evaluated in vero cells and zebrafish embryos. In order to evaluate the antioxidant effect of *Sargassum thunbergii* polysaccharides 4 (STC-PS4), we measured the cell viability and ROS generation against $H_2O_2$ treatment and we further confirm the antioxidant effect using zebrafish model. In vivo study, we measured the cell death, ROS generation and lipid peroxidation against H2O2 treatment. The antiobesity effect of *sargassum thunbergii* polysaccharides 3 (STC-PS3) was evaluated on 3T3 cells. To determine wheather STC-PS3 have antiobesity activity, we measured the lipid contents in 3T3 cells. The lipid contents were measured by oil red o staining dye. The animal study was carried out on high fat diet (HFD) induced obese mice, divided into 5 groups of 10 mice in each groups. During the animal study, the body weight were measured every weeks and the serum lipid profile, insulin, adiponectin, fat tissue weight, histological analysis of liver and epithelial fat was analyzed.
The antioxidant and antiobesity activity of *Sargassum thunbergii* were demonstrated that the treatment of STC-PS4 increased the cell viability and decrease the ROS generation and lipid peroxidation against $H_2O_2$ treatment. Furthermore STC-PS3 decreased the lipid accumulation in 3T3 cells and oral administration of STC-PS3 reduced the body weight, fat tissue weight, serum triglyceride, cholesterol, insulin and adiponectin levels. Taken together, our finding suggest that *Sargassum thunbergii* can be use for the Recent studies have showed development of antioxidant and antiobesity functional food products.

## MS 12-5

### Isolation of secondary metabolites from marine cyanobacteria and their biosurfactant activity

**Jakia Jerin Mehjabin**[*1], Julie Gabrielle Petitbois[1], Liang Wei[1], Tatsufumi Okino[2]

[1] *Graduate School of Environmental Science, Hokkaido University, Japan*
[2] *Faculty of Environmental Earth Science, Hokkaido University, Japan*

Biosurfactants are promising amphipathic compounds derived from microorganisms and can exhibit a large number of bioactivities including

anticancer, antimicrobial, antiadhesive and anti-biofilm activity against human pathogens. The high structural diversity and bioactivities of cyanobacterial secondary metabolites present them as potential candidates for biosurfactants. This research aims to identify and isolate biosurfactants from cyanobacteria. Cyanobacteria samples were collected by SCUBA near Kota Kinabalu, Malaysia, identified by 16S rRNA gene sequencing analysis using cyanobacteria specific primers and cultured in SWBG-11 medium. The structure elucidations of isolated compounds were done by different techniques of NMR and mass spectroscopy analysis. The biosurfactant test was conducted by oil displacement assay and Du Noüy ring method and cytotoxicities were checked by *in vitro* MTT assay against MCF7 breast cancer cell line. The chemical profiling of the potent cyanobacterial extracts leading to the isolation of four new compounds (1-4) from *Moorea bouillonii* and cultured *Leptolyngbya* sp. The NMR spectra of 1-3 showed the characteristic signals of an acetoxy carbonyl, two olefinic methines, N-methyl, O-methyl and chlorinated methine. The NMR spectra of 4 revealed a long methylene chain, olefinic methine, carbonyl and a methoxy group which indicated the similarities with the compound synthesized by Fabienne in 2011, however, this is the first report of its isolation from natural product. Compound 4 showed biosurfactant activity exhibiting the CMC value of 60 mg/L with minimum surface tension 46 mN/m whereas compound 1 and 4 showed weak cytotoxicity. On the other hand fatty acid amide serinolamide C isolated from *Okeania* sp. was able to reduce the surface tension 30 mN/m with CMC value 277 mg/L. In summary, four new compounds were isolated from marine cyanobacteria whereas, compound 4 and serinolamide C showed biosurfactant activity. Investigations of bioactivities of other compounds are in progress.

## MS 12-6

### Proteomic insights on fucoxanthin biosynthesis regulation in microalgae *Phaeodactylum tricornutum* under light limitation.

**Manoj Kumar**[*1]

[1] *Climate Change Cluster, University of Technology Sydney (UTS), Australia*

Fucoxanthin is a natural pigment in algae with anti-inflammatory, anti-tumor, and anti-obesity activity in humans. In recent years, there has been a growing demand in fucoxanthin based nutraceutical and cosmetic products. The global fucoxanthin market is projected to grow at a CAGR of 3.2% through 2022 and estimated nearly 700 tons annually. Compared to seaweeds, microalgae including *Phaeodactylum tricornutum* has shown high economic potential due to its high content of fucoxanthin. Recent studies have evident the increased fucoxanthin production under nutrient and light limitation in microalgae, however, the underlying regulatory divers for enhanced fucoxanthin production are unknown. This study integrates photobiology, physiology, and proteomics to identify the key regulatory pathways influencing fucoxanthin production in microalgae *Phaeodactylum tricornutum* (marine diatom) explored to 100 µmol photon $m^{-2}s^{-1}$ (control) and light limitation [25 µmol photon $m^{-2}s^{-1}$ (low light; LL), 10 µmol photon $m^{-2}s^{-1}$ (very low light; VLL)] condition for 9 days. The light limitation did not influence the maximum quantum yield as indicated by no change in non-photochemical quenching (NPQ) under tested experimental conditions. Further, a significant high level of fucoxanthin together with the variation violaxanthin and diatoxanthin cycle pigments in light limiting condition indicate the regulation of xanthophyll cycle. These results are well integrated with the proteomics study wherein a range of proteins including, photosynthetic proteins especially fucoxanthin chlorophyll *a/c* binding proteins (FCPs), light harvesting proteins (LHCs-Lhcr, Lhcx, and Lhcf), proteins of violaxanthin-diadinoxanthin cycle, various proteins of glycolysis, pentose phosphate pathways, glutamate/glutamine synthesis, lipid metabolism, antioxidant system and genetic information processing were found upregulated. This study provides valuable insights on the fucoxanthin regulation and identifies key metabolic pathways to potentially engineer the microalgae for enhancement of fucoxanthin production efficiency for industrial purposes.

## MS 12-7

### Squalene-derived polyethers, inhibiting adult T-cell Leukemia cell, isolated from the red alga, *Chondria armata*

**Toshiyuki Hamada**[*1], Kazushi Kobayashi[1], Naomichi Arima[2], Fumito Tani[3], Charles S Vairappan[4], Satoaki Onitsuka[1], Hiroaki Okamura[1]

[1] *Graduate School of Science and Engineering, Kagoshima University, Japan*
[2] *Graduate School of Medical and Dental Sciences, Kagoshima University, Japan*
[3] *Institute for Material Chemistry and Engineering, Kyushu University, Japan*
[4] *Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Malaysia*

*Chondria armata* is a red alga belonging to the family Rhodomelaceae. The alga grows mainly in the rocks of the intertidal zone in tropical and sub-tropical regions, according to AlgaeBase (http://www.algaebase.org/). Since the discovery of an anthelmintic domoic acid, many kinds of bioactive compounds have been isolated; caulerpin and armatols from the Indian Ocean and aplysiols from the Orpheus Island, Australia. Discovery of new compounds from the alga is expected in new drug development. Adult T-cell leukemia (ATL) is an aggressive malignant disease caused by the human T-cell lymphotropic virus type I. It is recognized to be a rare form of leukemia, and an effective treatment is still under development. Through bioassay-guided isolation, three new compounds with growth inhibitory activity on S1T, an ATL cell line, were isolated from the crude methanol extract of *C. armata*. The detail of the structure elucidation of three compound will be addressed in this presentation. Biological Materials: The plant samples were collected several times by hand during the summer of 2013 and 2014 Minami-kyushu City and Yaku-shima, Kagoshima, Japan. Extraction and Isolation: The MeOH extract of *C. armata* was partitioned with dichloromethane and 50% MeOH aq, successively. The dichloromethane-soluble portion was repeatedly subjected to silica gel, gel filtration, and semipreparative RP-HPLC to afford two new triperpenoids, compounds 1, 2, and 3. Cytotoxic assay: The assay was performed according to previously described procedures. In our search of bioactive substances from marine resources, the red alga *C. armata* collected off the coast of Kagoshima, Japan, has led to the isolation of three new triterpenoids. Those structures were determined mainly by spectroscopic NMR techniques. All three compounds showed cytotoxic activities against on S1T, an ATL cell line.

## MS 12-8

### Brown algal extracts for gut health applications

**Ah Young Park**[*1], Raj Eri[2], Damien Stringer[1], Sam Karpiniec[1], Helen Fitton[1], Nuri Guven[2]

[1] *R&D, Marinova, Australia*
[2] *Pharmacy, University of Tasmania, Australia*

Fucoidans are a class of bioactive sulfated polysaccharides derived from edible brown marine macroalgae such as *Fucus vesiculosus*. Polyphenols can be co-extracted with fucoidan from *Fucus vesiculosus*, resulting in an extract with multiple biological activities. Fucoidans and marine polyphenols have an attractive array of bioactivities and potential in human health applications including immune modulation, anti-cancer, gut health, and pathogen inhibition. Orally delivered fucoidan-polyphenol or fucoidan only preparations significantly reduced the inflammatory pathology associated with dextran sulphate-induced colitis in a mouse model. There was a highly significant reduction in the levels of cytokines stimulated by dextran sulphate, in addition to reductions in damage as assessed by histology. The macrophages in inflamed colitis tissues tend to be classically activated (Th1) M1 type macrophages as opposed to 'wound healing' M2 macrophage type (Th2). Building on the earlier study, we examined the differences in M1 and M2 macrophage distribution in the colitis model, both with and without fucoidan, using novel markers of M1 and M2 subtype macrophages to perform immunohistochemistry on formalin fixed, paraffin embedded sections. Anti-iNOS was used as an M1 marker and both anti-Arginase 1 and anti-Mannose receptor as M2 markers. The results demonstrate a greater expression of M2 and lesser expression of M1 macrophages where fucoidan was administered. This is the first demonstration of a mechanism involving macrophages by which fucoidan reduces inflammation in the gut.

## MS 13-1

### Genetic diversity exploitation of *Saccharina latissima* for innovative macro-algal biorefinery in Europe.

**Philippe Potin**[*1], Zofia Nehr[1], Paolo Ruggeri[1], Komlan Avia[1], Stéphane Mauger[2], Bertrand Jacquemin[3], Lucie Jaugeon[2], Aurélien Baud[2], Emilie Gouhier[2], Delphine Scornet[1], Jérôme Coudret[2], Stéphane Loisel[2], Susana M Coelho[1], Christophe Destombe[2], Myriam Valero[2], J Mark Cock[1]

[1] *Integrative Biology of Marine Models UMR 8227, CNRS Station Biologique de Roscoff, France*
[2] *Evolutionary Biology and Ecology of Algae UMI 3614, CNRS Sorbonne Université Station Biologique de Roscoff, France*
[3] *CEVA, Centre d'Etudes et de Valorisation des Algues Pleubian, France*

In Europe, the sugar kelp *Saccharina latissima* has become the flagship species for the development of large scale seaweed cultivation providing affordable biomass feedstock for the production of a range of existing and novel products. Within the European Union-funded project GENIALG, crop production is based on the local genetic resources, taking into account regional specificities. GENIALG is developing new genetic approaches based on next generation DNA sequencing techniques to accelerate breeding programs. Three main types of genetic analysis are underway for *S. latissima* : 1) genetic crosses to evaluate effects of in/outbreeding depression, 2) QTL detection and 3) a genome-wide association study (GWAS). The first approach carried out three types of cross from individuals collected in five populations in in Brittany: selfings, within-population crosses and between-populations crosses and the sporophyte progeny were grown on long lines in seaweed farms. Preliminary analysis of this experiment indicates different levels of inbreeding depression. Genotyping and phenotyping are underway. For the QTL analysis, a segregating family of 129 F2 progeny derived from a cross between two Breton parents was produced by growing sporophytes on open-water ropes over two subsequent years (F1 and F2). ddRAD-seq genotyping data has been obtained and is currently being analysed to build a genetic map and detect QTLs. For the GWAS, pools of male and female gametophytes derived from each of 283 *S. latissima* isolates were used to set-up a common garden experiment using in-bred sporophyte descendants of each isolate obtained by carrying out bulk self-fertilisations using the gametophyte pools. The sporophytes harvested in the autumn are now used for genotyping and phenotyping. These germplasm lines will constitute the genetic basis that can be used by breeders to efficient and environmentally sound targeted genome-based selection.

## MS 13-2

### Fine scale population genetics of sugar kelp in the North Atlantic for a selective breeding program

**Simona Augyte**[*1], Charles Yarish[1], Schery Umanzor[1], Michael Marty-Rivera[1], Scott Lindell[2], Jean-Luc Jannink[3], Kelly Robbins[3], Xiaowei Mao[3]

[1] *Ecology and Evolutionary Biology, University of Connecticut, United States of America*
[2] *Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institute, United States of America*
[3] *Plant Breeding and Genetics, Cornell University, United States of America*

Currently, advancements in yield and productivity are being made in the domestication of *Saccharina latissima* for the production of food, feed and biofuel. Large morphological variation is observed throughout the range of this taxon, but it is still unclear how this variation translates to producing vigorous cultivars in open-water aquaculture farms. To better understand natural population structure and gene flow in the western North Atlantic, we compiled genome sequence data of populations from this region sampled from brood stock collections being used to initiate a breeding program for kelp cultivar improvement. DNA was extracted and sequenced at the Diversity Arrays Technology Laboratory in Australia producing over 20,248 SNPs that were filtered for the analyses. Our preliminary results reveal the majority of variation (68%) is found within populations (defined as a single sampling location) while the minority is found among populations (11%) with some variation (21%) found between geographical regions in the western North Atlantic. High levels of within population diversity suggests that sugar kelp is resilient to changing environmental conditions. Although kelp meiospores do not disperse very far (<1km), gene flow is evident throughout the Gulf of Maine region. Our results also indicate that the Cape Cod peninsula creates a physical barrier between the Gulf of Maine and Southern New England regions, leading to two distinct populations in this region. Thus, a population just north of Cape Cod clusters with Gulf of Maine populations, while one just south of the peninsula clusters with Southern New England. Our results will be placed into a larger context with other populations from the Pacific and Atlantic coasts. Currently, research is underway to apply genomic selection to increase strain fitness and assess hybridization of cultivars. This research aims to identify and isolate biosurfactants from cyanobacteria. Cyanobacteria samples were collected by SCUBA near Kota Kinabalu, Malaysia, identified by 16S rRNA gene sequencing analysis using cyanobacteria specific

## MS 13-3

### Kelp seed banks and sterilization procedures

**Sergey Nuzhdin**[*1]

[1] *Molecular Computation Biology, Univ. Southern California, United States of America*

A rapidly rising human population coupled with the damaging effects of climate change pose a paramount challenge to produce more resources

in a harsher climate. As the agricultural "Green Revolution" provided the foundational resources for the worldwide population increases of the 20th century by focusing on superior breeds of crops and innovative farming technology, a similar marine "Blue Revolution" is the potential key to satiate an increasing global demand in a changing environment. The "Green Revolution" relied on crop gene banks, which captured the genetic diversity of terrestrial crops and are now mined for useful alleles that can be applied in breeder programs. However, these forward-thinking gene banks have concentrated on terrestrial crops, neglecting other targets, including marine species. Ocean ecosystems are especially susceptible to biodiversity collapse due to globally increasing water temperature and ocean acidification. The loss of marine biodiversity will have a globally catastrophic impact through the loss of commercially and ecologically important species, including red, brown, and green macroalgae. . While the macroalgae-based aquaculture industry has grown explosively, averaging 11% growth a year over the last two decades, most farmed macroalgae has yet to benefit from the science-based breeding that was fundamental to the Green Revolution's success. Implementing a rigorous, environmentally-friendly and genomics-based domestication and seed production program is an essential missing piece at the forefront of aquaculture research and development. Establishing aquacultural seedbanks for macroalgae addresses both ecological and commercial concerns caused by worsening climate change, providing the foundation for a 21st century "Blue Revolution". Further, developing sterilization techniques will enable permitting procedures and regulations for optimizing aquaculture practices.

## MS 13-4

### Breeding *Macrocystis pyrifera*: what have we learned?

**Carolina Camus**[*1], Alejandro H. Buschmann[1]

[1] *Centro i-mar & CeBiB, Universidad de Los Lagos, Chile*

The worldwide demand for *Macrocystis pyrifera* biomass is increasing as new uses are discovered, couple with the interest for production of bioenergy. In this context, there is an urgent need to move towards the development of sustainable aquaculture that incorporate genetic breeding programs. In the southeastern Pacific coast (SEP), the technical and economic feasibility of the farming of *M. pyrifera* has been demonstrated at pre-commercial scale, revealing that 124 wet ton/ha can be achieved using wild individuals. Also, procedure for cultivation at hatchery and open sea has been established together with the production of bioethanol at a pilot scale under a biorefinery approach. The actual challenge for the giant kelp farming involves the establishment of a breeding program for the domestication of the species. This study investigates the spatial variation of the genetic and phenotypic diversities in natural populations of the giant kelp in the SEP, and evaluates the potential for modifying agronomic traits through controlled breeding. Nine microsatellites and 12 morphological traits were used to describe the distribution of diversity present along the SEP coast. Crossing experiments were made to assess the heritability of specific traits and evaluate the performance of the F1 generation in the laboratory and in open sea cultivation, respectively. Results revealed four genetic clusters along the latitudinal distribution of the species, tightly correlated with the existence of major environmental discontinuities. These cluster matched cluster of morphological diversity, suggesting that both morphological and genetic diversities responded to the same environmental drivers. In crossing experiments, no significant differences were detected between selfed and outbred F1, in morphology, growth and chemical components, but a high variability among all different crosses was observed, revealing a high degree of heritable phenotypic variance.

## MS 14-1

### The freshwater algae culture collection (FACHB-collection): algal resources for fundamental and applied research in China

**Lirong Song**[*1], Qi Zhang[1], Lingling Zheng[1], Tianli Li[1]

[1] *Center for Algal Biology and Applied Research, Institute of Hydrobiology, the Chinese Academy of Sciences, China*

The Freshwater Algae Culture Collection (FACHB-collection) is affiliated to National Freshwater Biological Resource Center, located in the Institute of Hydrobiology, the Chinese Academy of Sciences. The FACHB-collection was a member of World Data Centre for Microorganisms (WDCM, http://www.wdcm.org/) in 2004 (WDCM No. 873) and founding member of the Network of Asia Oceania Algae Culture Collections (AOACC, http://mcc.nies.go.jp/AOACC/Home.html) in 2004. The mission of the FACHB includes 1. Collection, isolation & purification of algal species; 2. Maintenance & preservation of the algal species; 3. Development of techniques relating to preservation, cultivation, etc.; 4. Development of database of algal strains with economical & environmental importance; 5. Provide services to scientific & industrial communities. The FACHB-collection currently holds more than 3000 strains, belonging to over 150 genera, 8 phyla. As the main algal culture collection in China, the FACHB-collection dispatched approximately 2000 strains to users every year. In recent years, it is estimated that Microcystis, *Chlorella* and *Scenedesmus* were among the best-selling genera. About 40% of all orders per year were used for water environmental research and bioremediation; meanwhile, about 30% of all orders per year were used for bioenergy, biofuel or applied research. In China, freshwater algal resource-related researches and application have gradually expanded due to the interests of regionally and internationally. In the era of ever-increasing demanding both for high-valued living algal strains and expertise of algal cultivation and related knowledge, which are being pushed by research and industry, algal culture collections are playing active roles in the exploitation of utility of algae as an important bio-resource

## MS 14-2

### 'Industrial development of microalgal cultures and seaweeds' filamentous tissue cultures for pharmaceutical and nutraceutical source material

**Hong-Nong Chou**[*1]

[1] *Institute of Fisheries Science, National Taiwan University, Taiwan*

Both micro- and macro-algal species in the Algal Culture Collection Center of National Taiwan University have been studied extensively for their low-cost production of various bioactive compounds. From the clones of Prorocentrum lima, okadaic acid (OA), a potent inhibitor of protein phosphatase 1 and 2A, also a possible anticancer agent has been found to be constantly excreted into the culture medium, especially in the stationary phase of growth. Thus, a concentrate population in the vessel of culture system was developed accordingly for the continuous releasing of OA. Recovery of the extracellular OA was done by the application of an adsorbent. Pure and valuable chemicals were then desorbed and separated by the subsequent chromatography. In addition

to OA, many other microalgal toxins, such as brevetoxins, microcystins, and gonyautoxins were isolated from the lab cultures of red tide species. The toxins are distributed as standards for seafood and drinking water monitoring. They are also supporting to the research needs as probes for their different bioactivities. Phycocyanin, one of the biliproteins of *Bangia atropurpurea* (Ba-PC) showed the effective modulation of immune response in a mammal system for treating allergic disease both in vivo and in vitro experiments. A diploid filamentous (Conchocelis) phase of the species was manipulated for mass culture and applied as source material for extraction and purification. The richest fluorescent pigment, phycoerythrin, of the filamentous phase of this algae and relevant species, and filamentous tissue cultures of many other red algal species, that can be applied as the fluoro-tags in flow-cytometry for medical diagnosis. The pigment can be utilized as color additive and functional agent in food and cosmetics. The filaments have many advantages in extraction of valuable bioactive components, comparing with their thalloid forms.

## MS 14-3

### A new thin-film microfluidic platform for continuous flow biodiesel production from wet microalgae

**Wei Zhang**[*1], Eko Kornelius Sitepu[1], Colin Raston[2]

[1] *Centre for Marine Bioproducts Development, Flinders University, Australia*
[2] *Institute for NanoScale Science and Technology, Flinders University, Australia*

Dewatering and lipid extraction process contribute to the dominant energy penalty and cost in the production of biodiesel from microalgae. A novel biodiesel production platform based on two thin-film microfluidic device (vortex fluidic device (VFD) and Turbo-thin film device (T2FD))-assisted direct transesterification (DT) of wet microalgal biomass of *Chloroparva pannonica* was developed and evaluated. VFD-intensified DT of microalgal biomass is a novel method for one step biodiesel production directly from wet microalgae biomass at room temperature. No significant impact of catalyst, parameter setting, or mode of operation was detected for fatty acid extraction or conversion to FAME efficiencies. Average extraction efficiencies of extractable fatty acids 41 mol% which was low because C18:2 did not extract. Continuous flow-operated VFD achieved a 96% conversion efficiency for fresh biomass (67% water content) at a residence time of 2 min.

The continuous flow turbo-thin film device (T2FD) is also effective in rapidly producing biodiesel directly from wet biomass of the microalgae *Chloroparva pannonica*. The maximum biodiesel conversion yield of 96.6% ± 0.7 was obtained at room temperature and atmospheric pressure with a short residence time (< 1 min). The results establish that the high shear processing in the T2FD is effective in enhancing DT of microalgae biomass even for a relatively high concentration of water, with the amount of methanol present playing a key role in the DT process. This VFD- and T2FD-mediated DT of wet biomass offers a novel and efficient way of producing biodiesel. Moreover, the rapid high conversion yield of direct biodiesel production at room temperature opens the possibility of economically feasible production of biodiesel.

## MS 14-4

### Microalgal biotechnology and industries in China: construction of both new innovation mode and driving force

**Song Qin**[*1], Baosheng Ge[2], Yulin Cui[1]

[1] *Cas, Institute of Yantai Coastal Zone, China*
[2] *College of Chemical Engineering, China University of Petroleum, China*

Due to depletion of fossil fuels and serious climate changes, the main challenge in the present scenario is to meet energy demand as well as reducing the impact of greenhouse gases on the environment. Microalgae shows a substantial part in meeting the energy demand carbon dioxide fixation and also function as the most important feedstock for sustainable products. However, the development of microalgal industry is still greatly hampered due to the limitations such as low biomass productivity, high cultivation cost and few fundamental studies on precision functions of microalgae. To address these issues, this report mainly focused on recent development of microalgal industry in China and its potential applications in health food, nutraceuticals and services, such as $CO_2$ fixation and wastewater treatment. Also, we will discuss the main challenges and opportunities of microalgal industry not only in China but also in worldwide ranges, and try to propose a systematic solution aiming at crossovering the above neckbottles.

## MS 15-1

### Fucoidan, health benefits and implications for gut health

**Stefan Kraan**[*1]

[1] *Hatchery R&D, The Seaweed Company, Ireland*

Fucoidans, a group of brown algal polysaccharides are widely found in the cell walls of brown seaweed, but not in other algae or higher plants. Fucoidan is considered as a cell wall reinforcing molecule and seems to be associated with protection against the effects of desiccation when seaweed is exposed at low-tide. Several companies notably in Ireland have isolated fucoidans from a range of species (species-specific), and can provide characterized fractions for either investigational research or as ingredients for nutraceutical and cosmetic applications. Different therapeutic profiles are primarily due to the molecular structure. Fucoidans are known to possess numerous biological properties with human health applications. With a strongly growing seaweed-food products market in US and Europe of close to 30% increase last year, coupled to recent advances in improvements in processing and extraction technology there are big- and so-far largely underdeveloped opportunities for new seaweed food product and ingredients like fucoidan. Our health strongly depends on our gut flora, but since the start of processed foods and fast food coupled to high sugar intake this gut environment is under threat. This intestinal population of microbes collectively referred to as the gut microbiome have a vital function not only for digestion. Recently it has been discovered that communication between the gut microbiota and the brain (Gut-Brain axis) and a lack of diversity in the gut flora has been linked with several psychological disorders and other (mental) health issues. Fucoidan as a pre-biotic can have a positive impact on gut-biota and its interactions will be evaluated.

## MS 15-2

### Seaweed legislation and standards in Europe

**Susan Løvstad Holdt**[*1]

[1] *The National Food Institute (DTU Food), Technical University of Denmark, Denmark*

Food regulation and legislation are in place in Europe, but when it comes to seaweed specifically, this is at the early stage. Companies within seaweed for human consumption need to comply with legislation like novel food list and threshold levels within contaminants regulated only on food supplements, but the legislations are inadequate for inclusion of seaweed to the market. The aim of this presentation is to introduce the legislation and challenges in EU with respect to seaweed, and briefly introduce the ongoing algal standardization work. The novel food catalogue include some seaweed species that is recognized as food, this since they have been documented as commonly eaten before May 15 1997 in the EU, but many more species are sold "illegal" as food in Europe. If compounds are extracted from the "accepted food seaweeds", these specific compounds also need to undergo authorization under the Novel Food Regulation. Legislation on contaminants and threshold values is based on seaweed as food supplement and not as food. This is at present considered in an EU working group. Recommendations for algal standards are under development on e.g. identification, methods for analyses and fact sheets for e.g. food, feed and cosmetics (CEN/TC 454 Standards on Algae and algae products ), so we at least know what we are selling and purchasing. The standardization work is initiated by a mandate from the European Commission in order to support the future European algal market, and this together with a legislation update would most likely enhance the European seaweed market.

## MS 15-3

### The case for whole dietary seaweeds

**Jane Teas**[*1]

[1] *Cooper Library, University of South Carolina, United States of America*

In many parts of East Asia, in particular, Korea, Japan, and China, seaweed is officially recognized as a healthy food; elsewhere it is largely ignored. Currently, daily intake of seaweed in seaweed-consuming countries, reported as whole dried seaweeds, is 5 g (about a tablespoon)/day. This literature review identified benefits recorded in observational epidemiologic studies, clinical trials, and laboratory research. Benefits reported ranged from increased overall longevity, possibly by improved immunity and decreased gut transit time, to lower rates of obesity, cancer, stroke, heart disease, viral infections, and diabetes. Clinical trials have tested the effects of whole seaweeds on specific health issues, including osteoarthritis, skin aging, biomarkers of cancer risk and progression, goiter, and obesity. Using cell culture and animal studies, specific bioactive agents responsible for many of these health benefits have been identified, including fucoidan, fucoxanthin, laminarin, carrageenan, sesquiterpenes, iodine, and alginates. Dietary seaweed and their constituents also have been shown to enhance the health of the gut microbiota. Seaweeds selectively increase beneficial colonic bacterial populations that produce short-chain fatty acids, contributing to improved human health. Several clinical studies have identified seaweeds as helper foods that act synergistically to decrease the harmful effects of other foods and even toxic drugs. Possible negative side effects of consuming seaweed, such as high iodine, arsenic, and even cadmium, have been studied in isolation; however, the effects of these toxic elements are likely mitigated by traditional cooking methods and consumption of whole seaweed. People do not eat a single bioactive, nor do they usually worry about a single health challenge. Consumption of red, brown and green whole seaweeds, in the proportions eaten in Asia, may combat a myriad of major chronic health problems and improve quality of life and longevity

## MS 15-4

### Dietary *Sargassum fusiforme* improves memory and reduces amyloid plaque load in an alzheimer's disease mouse model

**Monique Mulder**[*1], Jeroen Bogie[2], Yupyn Chintapakorn[3], Hong-Bing Liu[4], Bart Staels[5], Albert Groen[6], Dieter Lutjohann[7], Tim Vanmierlo[2]

[1] *Internal medicine, Erasmus university medical center, Netherlands*
[2] *Department of Immunology and Biochemistry, Hasselt University, Belgium*
[3] *Chemistry, Center of Excellence in Environment and Plant Physiology, Thailand*
[4] *Key Laboratory of Marine Drugs, Ocean University of China, China*
[5] *University of Lille - EGID, Inserm, France*
[6] *Medical biochemistry, University of Amsterdam, Netherlands*
[7] *Institute for Clinical Chemistry and Clinical Pharmacology, University of Bonn, Germany*

Activation of liver X receptors (LXRs) by synthetic agonists was found to improve cognition in Alzheimer's disease (AD) mice. However, these LXR agonists induce hypertriglyceridemia and hepatic steatosis, hampering their use in the clinic. We hypothesized that phytosterols as LXR agonists enhance cognition in AD without affecting plasma and hepatic triglycerides. Phytosterols previously reported to activate LXRs were tested in a luciferase-based LXR reporter assay. Using this assay, we found that phytosterols commonly present in a Western type diet in physiological concentrations do not activate LXRs. However, a lipid extract of the 24(S)-Saringosterol-containing seaweed *Sargassum fusiforme* did potently activate LXRβ. Dietary supplementation of crude *Sargassum fusiforme* or a *Sargassum fusiforme*-derived lipid extract to AD mice significantly improved short-term memory and reduced hippocampal Aβ plaque load by 81%. Notably, none of the side effects typically induced by full synthetic LXR agonists were observed. In contrast, administration of the synthetic LXRα activator, AZ876, did not improve cognition and resulted in the accumulation of lipid droplets in the liver. Administration of *Sargassum fusiforme*-derived 24(S)-Saringosterol to cultured neurons reduced the secretion of Aβ42. Moreover, conditioned medium from 24(S)-Saringosterol-treated astrocytes added to microglia increased phagocytosis of Aβ. Our data show that *Sargassum fusiforme* improves cognition and alleviates AD pathology. This may be explained at least partly by 24(S)-Saringosterol-mediated LXRβ activation.

## MS 16-1

### The ecology of non-geniculate coralline red algae

**Gavin Maneveldt**[*1]

[1] *Biodiversity and Conservation Biology, University of the Western Cape, South Africa*

Within the marine benthos, space is an absolute requirement that is often in short or limited supply. This is because it is a non-renewable resource that only ever becomes available when an organism dies or relinquishes it. On rocky shores, non-geniculate (encrusting) corallines in particular, constitute an ecologically important group of marine organisms that cover much of the primary space. This is despite the fact that they are extremely slow growing, having very low accretion and marginal extension rates. As a first line of defence, non-geniculate corallines have both mechanical antifouling mechanisms, but also induce and rely strongly on herbivore-coralline associations to prevent or limit surface fouling. Additionally, encrusting algae generally exhibit a two dimensional mode of growth in which success at overgrowth is largely dependent on: 1) the thallus thickness at the leading edge/margin; and 2) the degree of marginal adherence to the substrate. With a few notable exceptions, encrusting algae with thicker thalli and those with raised margins generally overgrow

encrusting algae with thinner thalli and those with more adherent margins respectively. Overgrowth competition is usually strongly hierarchical and should result in the exclusion of inferior species. However, competitive exclusion is seldom observed and we are more like to find competitively inferior species (in terms of overgrowth competition) coexisting alongside their superior competitors. The results of ecological studies on non-geniculate coralline algae have demonstrated a strong interplay, and an inverse relationship, between interference and exploitation competition in which species that are typically always overgrown (poor interference competitors), maintain their existence largely because they are better at exploiting the available limited space.

## MS 16-2

### Effects of water temperature, light and nitrate on the growth of sporelings of the nongeniculate coralline alga *Lithophyllum okamurae* (Corallinales, Rhodophyceae)

**Aki Kato**[*1], Sakie Yoshioka[1], Kazuhiko Koike[2], Noboru Murase[3], Masasuke Baba[4]

[1] *Takehara Fisheries Research Station, Setouchi Field Science Center, Graduate School of Biosphere Science, Hiroshima University, Japan*
[2] *Graduate School of Biosphere Science, Hiroshima University, Japan*
[3] *Department of Applied Aquabiology, National Fisheries University, Japan*
[4] *Central Laboratory, Marine Ecology Research Institute, Japan*

Recently, degradation of seaweed beds and concomitant expansion of barren grounds have been reported along the Japanese coasts as the coastal water temperature rises. Coralline algae are dominant on such barren grounds as well as on substrates under canopy-forming seaweeds. Most coralline algal study have elucidated the effects of global warming and ocean acidification, but only few have examined the optimal growth conditions or range of viable conditions for individual species, compared to rich information from temperate brown algae such as *Sargassum* and *Ecklonia*. Therefore, we investigated the effects of water temperature, light, and nitrate levels on the growth of sporelings of *Lithophyllum okamurae* which is commonly found in the temperate Western Pacific. Mature plants of *L. okamurae* were collected from the lower intertidal zone in Hiroshima, Japan, and sporelings were established from released spores in the laboratory. Relative growth rate (RGR) was then evaluated by measuring the area occupied by the sporelings. We found that the optimal growth temperature of the sporelings was similar to that of temperate brown algae. However, RGR of the sporelings saturated at a photon-flux density of approximately 120 µmol photon $m^{-2}s^{-1}$, with photoinhibition observed at a greater intensity, indicating that sporelings of *L. okamurae* are intolerant to higher light level than temperate brown algae. This saturation irradiance level was similar to that of other coralline algae grown in shade conditions, indicating that *L. okamurae* had adapted to such conditions. The initial slope of the growth rate versus nitrate concentration (Vmax/Ks) of the sporelings was lower than that of other coralline species, but was similar to values for other macroalgae. These results indicate that *L. okamurae* is not more tolerant than other macroalgae under these mentioned growth conditions; hence, this species might respond similarly as other macroalgae against future environmental changes.

## MS 16-3

### Corallinapetrales: a new order of coralline algae including a new family with *Corallinapetra gabrieli* comb. nov.

**So Young Jeong**[*1], Wendy A. Nelson[2,3], Boo Yeon Won[1], Viviana Peña[4], Line Le Gall[5], Tae Oh Cho[1]

[1] *Dept. of Life Science, Chosun University, Republic of Korea*
[2] *National Institute of Water and Atmospheric Research, New Zealand*
[3] *School of Biological Sciences, University of Auckland, New Zealand*
[4] *Grupo BioCost, Departamento de Bioloxía, Universidade da Coruña, Spain*
[5] *Institut Systématique Evolution Biodiversité (ISYEB), Muséum National d'Histoire Naturelle, CNRS, Sorbonne Université, France*

*Corallinapetra* is a coralline algal genus that was monospecific when described, based on the species *C. novaezelandiae*, based on a single collection from northeastern New Zealand. It was recognised as being distinct, based on its phylogenetic placement and morphological observations. However, *Corallinapetra* was excluded from all currently recognized families and orders within the Corallinophycidae by multi-gene phylogenetic analyses. *Corallinapetra* was characterized by having crustose thalli, flared epithallial cells, cell fusions between contiguous cells, multiporate conceptacles, sporophytic phase with individual compartments grouped in shallow depressions, and stalk cells. Nelson et al. (2015) did not erect higher taxonomic ranks for *Corallinapetra* given the paucity of material available for study. In this study, we analyzed DNA sequence data from the holotype of *Lithothamnion gabrieli*, which is recognized as a heterotypic synonym of *Lithothamnion muelleri,* using *psbA, psaA, rbcL,* nSSU, and COI-5P genes. We also obtained sequence data from an unidentified sample from Stewart Island in New Zealand. Our phylogenetic analyses show that *L. gabrieli* and the sample from New Zealand belonged to the same clade of *Corallinapetra*, and they formed a distinct clade from other families and orders in Corallinophycidae. We also observed detailed morphological characters using scanning microscope and light microscope. They were distinguishable from other families and orders in Corallinophycidae by each tetra/bisporangium being surrounded by remnant vegetative elongated cells, like compartments in multiporate tetra/bisporangial conceptacles and zonately divided tetrasporangia. In light of our results, we discuss the taxonomic changes that should be undertaken toward a classification reflecting the natural order among which we suggest that *Corallinapetra* should be elevated to higher taxonomic rank (family and order) and *Lithothamnion gabrieli* should be assigned to *Corallinapetra*.

## MS 16-4

### The role of crustose calcifying red algae in phase transitions on tropical pacific reefs

**Tom Schils**[*1], Matthew Mills[1]

[1] *Marine Laboratory, University of Guam, Guam*

Recent taxonomic investigations of Crustose Calcifying Red Algae (CCRA) in Guam (Mariana Islands, Western Pacific) have revealed a high degree of cryptic diversity of CCRA belonging to the Corallinales, Hapalidiales, Sporolithales, Peyssonneliales, and Gigartinales. DNA barcoding is used to assess the diversity of CCRA in tropical reef communities. Traditional surveys and multispectral imaging are used to contrast the abundance of CCRA taxa between semi-pristine sites and sites characterized by a significant decline in scleractinian corals. Like many other molecularly-assisted alpha taxonomic studies on algae, CCRA displayed high levels of endemism at island, archipelago, and ecoregion scales. In addition, CCRA were found to be major protagonists of benthic community change on coral reefs.

## MS 17-1

### The SAG culture collection of microalgae: a traditional bioresource serves modern science

**Thomas Friedl**[*1], Maike Lorenz[1], Tatyana Darienko[1], Anastasiia Kryvenda[1], Rudolf Tischner[1], Nataliya Rybalka[1], Matthias Blanke[1]

[1] *Experimental Phycology and Culture Collection of Algae, University of Goettingen, Germany*

With over 60 years expertise in the maintenance of yet more than 2200 live culture strains of microalgae incl. cyanobacteria the Algal Culture Collection at Goettingen University (SAG) is providing services to the world-wide public. As an active member within a European network of culture collections, SAG's research is into three directions, i.e. the improvement of algal strain maintenance, algal biotechnology, as well as molecular phylogeny and assessment of algal diversity in various terrestrial habitats. Currently, about one third of the SAG strains have been cryopreserved using a standard two-step protocol. However, about 13% of the holdings are still recalcitrant to standard cryopreservation. To further investigate this, cellular ATP concentrations and viability measurements were successfully used to monitor features of live cells during exposure to ultralow temperatures. A significant positive correlation of cellular ATP content and viability in cryosensitive model microalgal strains was found. In cryotolerant strains ATP levels of actively growing cells were generally higher. Decline in ATP level during exposure to ultralow temperatures in the cryotolerant strains was, however, similar to their cryosensitive counterparts. New productive strains from the Eustigmatophyceae and Dinophyceae rich in PUFAs (EPA) were revealed by a screening of SAG strains. Strains still productive under highly elevated $CO_2$ concentrations revealed fatty acid and carotenoid contents promising for biotechnological exploitation. With support from ITS2 sequences of SAG reference strains group-targeted metabarcoding revealed about 10% of cosmopolitan species in soils of Antarctica. While the algal soil biodiversity in Antarctica exceeded by far that of a temperate exemplar site, the majority of algal OTUs remained unidentified. It is important to further progress with sequencing of high resolution molecular markers for defined reference culture strains as well as to establish new isolates from terrestrial habitats world-wide.

## MS 17-2

### An Australian perspective on managing a biodiversity collection for research Impact

**Ian Jameson**[*1], Anusuya Willis[1], Cathy Johnston[1], Ros Watson[1]

[1] *National Research Collections Australia, CSIRO, Australia*

The Australian National Algae Culture Collection, ANACC, has accessioned strains, freshwater to hypersaline from the tropics to the poles, since inception in the late 1960's with a focus solely on microalgae and cyanobacteria, and with representatives from most established taxonomic classes. Particular species of beneficial or deleterious environmental, social and economic consequences have been studied in more detail and as a result have a deeper biogeographic replication and coverage. In Jan 2019 ANACC accessioned its first tranche of a well curated macroalgae collection from the University of Melbourne - a strategic move into macroalgae. ANACC supplies cultures to academia and industry in over 70 countries through the Australian National Algae Supply Service (ANASS). The broad diversity of ANACC has necessitated a polyphasic approach to strain characterization, including morphological and life-history documentation being more recently joined by genomic typification (single and concatenated barcode genes, 16S, 18S, LSU, COI, rbcL, ITS), and in a limited number of species (cyanobacteria) by whole genome sequencing. Beyond identity, logistics and research goals dictate priority of broader phenotype analyses that match species to their expected amplified traits; e.g. filamentous freshwater cyanobacteria screened for toxins and toxin gene expression but only opportunistically for essential polyunsaturated fatty acids. Examples of the polyphasic approach will include the Eustigmatophyte Nannochloropsis, the Trebouxiophyte *Botryococcus braunii* and evident genome drift in a model strain of the cyanobacterium *Raphidiopsis raciborskii* (Cylindrospermopsis). Examples will be given of core contributions by ANACC to wider CSIRO initiatives to optimize strain selection for targeted microalgae bioproducts. As a living biorepository open for exploitation there is now a deep layer of regulatory compliance and, through CSIRO, ANACC is attempting to clarify its position with respect to the Nagoya Protocol and equitable sharing of genetic resources.

## MS 17-3

### Diversity, conservation and utilization of freshwater bioresources

**Jee Hwan Kim**[*1]

[1] *Nakdonggang National Institute of Biological Resources, Korea*

The Freshwater Bioresources Culture Collection (FBCC) of Nakdonggang National Institute of Biological Resources (NNIBR) is a project to secure the diversity of freshwater bioresources cultures such as freshwater algae, bacteria, fungi, and to provide living cultures to scientists, students, and industry throughout Korea through stable conservation. The FBCC also provides a deposit service for freshwater biological resources obtained from research results. The FBCC essentially conducts 1) taxonomic research of freshwater algae, bacteria, and fungi, 2) excavation and characteristic study of useful freshwater resources, and 3) cryopreservation study of freshwater algae for efficient conservation and management. In addition, the FBCC intends to contribute to the sustainable utilization of useful bioresources by continuously producing and sharing useful information that meet the needs of the biological industry

## MS 17-4

### The Korean marine microalgae biobank: in the formation process

**Ji Won Hong**[*1], Nam Seon Kang[1], Eun Song Kim[1], Jung A Lee[1]

[1] *Department of Taxonomy and Systematics, Marine Biodiversity Institute of Korea, Republic of Korea*

The Marine Biodiversity Institute of Korea (MABIK) was established under the Ministry of Oceans and Fisheries (MOF) in 2015 for preservation of marine organisms in accordance with the Nagoya Protocol. Based on the Act on Securing, Management, Use, etc. of Maritime and Fisheries Genetic Resources, the Korean Marine Microalgae Biobank (KMMB) was formed as a part of the MABIK in 2017. In response to the Government's key policy objectives and priorities for the promotion of marine bio-industries in Korea, we have collected information on Korean marine microalgae that can biosynthesize valuable biocompounds by searching scientific reports and patents. The geographic origins of the species were confirmed to

ensure that only microalgae that are truly from Korea are listed. In total, we retrieved 34 microalgae species with potential applications in 8 main fields and we aim to focus on collecting and maintaining these particular species of interest. We aim to establish and document morphological, molecular, physiological, and chemotaxonomical characteristics of the cultures in order to provide this information available on the Marine Bio-Resource Information System (MBRIS, https://mbris.kr/pub/main/publicMainPage.do). At present, 110 microalgal strains are available at KMMB representing 73 species and all of which were originated from Korea. We are planning to start official pilot operations in 2020 and our eventual goal is to develop the KMMB into a service collection that provides high quality marine microalgae cultures and technical advice to industry as well as academia and research sector within next 5 years.

## MS 18-1

### Marine forest reforestation project of Korea Fisheries Resources Agency (FIRA)

**Jin Woo Kang**[*1], Jun-Chul Jang[1], Tae-Sik Kim1, Ki-Yeal Park[1]

[1] *Project Management Division, East Sea Branch, Korea Fisheries Resources Agency (FIRA)*

The barren ground areas is extending that this phenomenon occurs as a result of several factors such as herbivore, over coastal development, and climate change(seawater temperature rising, ocean acidification). To protect coastal ecosystem in Korea, Korea Fisheries Resources Agency (FIRA) was established 2011. FIRA has a main mission, which is contributing to the national economy by establishing a foundation for sustainable use of fisheries resources. Especially, in part of the marine forest project, the goal is greening 75% of the all coastal areas. We conducted marine forest enhancement that the areas of marine forest were over 18,360 ha until 2018. For marine forest reforestation project, we used the artificial-reef after selection of appropriate site. We conducted several methods for marine forest such as longline, spore bag, and catch the herbivore in the selection sites for the project. In addition to, we investigated the development of technologies for climate change responses and strategic for future growth. We will try to set-up 54,000 ha of marine forests to 2030 that marine forests could provide habitat for marine organisms and reduces greenhouse gases and so on.

## MS 18-2

### Restoration of artificial eelgrass seabed using industrial byproducts

**Kyunghoi Kim**[*1], Yoshinori Koshikawa[2], Tadashi Hibino[3] and Jong-Ryol Kim[4]

[1] *Dept. of Ocean Engineering, Pukyong National University, Korea*
[2] *Kajima Technical Research Institute Chofu, Japan*
[3] *Graduate School of Engineering, Hiroshima University, Japan*
[4] *Korea Fisheries Resources Agency(FIRA), Technology Development Division*

In order to evaluate byproduct (coal ash) as a material for sea beds for transplant of eelgrass (*Zostera marina*), a pilot scale experiment was carried out at Kaita bay of Japan where the natural eelgrass bed was disappeared after reclamation. Artificial seabed was made of Granulated Coal Ash(GCA) and then eelgrass was transplanted to on the artificial bed. Successful settlement of the eelgrass was observed with the exponential increase of eelgrass density. An increase of biodiversity was achieved in and around the artificial sea beds after the transplant. From the results of this experiment, it is concluded that the GCA can be a suitable material for creating eelgrass beds.

## MS 18-3

### Enhanced $CO_2$ uptake by planted sea forest counteracts ocean acidification in costal environments

**Kitack Lee**[*1], Miok Kim[1], Byunghee Jeon[2], Yejin Hyeon[2]

[1] *Division of Environmental Sciences and Engineering, Pohang University of Science and Technology, Republic of Korea*
[2] *Korea Fisheries Resources Agency (FIRA), Technology Development Division, Republic of Korea*

The diel and seasonal dynamics of carbonate chemistry associated with a sea forest were investigated in coastal waters of Korea using continuous measurements of seawater carbon parameters (i.e. partial pressure of $CO_2$, total alkalinity, total dissolved inorganic carbon and pH) from January 2019 to April 2019. Analysis of carbonate data revealed that organic carbon production by the sea forest (photosynthesis) dominates over inorganic carbon production (calcification) in the study area. The changes in surface $pCO_2$ associated with photosynthesis of the sea forest were comparable to a magnitude of the alteration due to temperature variation, indicating that net impacts of ocean acidification and global warming can be mitigated by organic matter production by the sea forest in the coastal marine ecosystem.

## MS 18-4

### New construction technique of marine forest using artificial floating structures

**Han Gil Choi**[*1], Sung Kyu Son[2], Seong-Ho Shu[2], Nam Gil Kim[3], Bong Kyun Shin[4], and Sung Il Hwang[4]

[1] *Faculty of Biological Science, Wonkwang University*
[2] *Korea Fisheries Resources Agency (FIRA), Technology Development Division*
[3] *Department of Marine Biology and Aquaculture, Gyeongsang National University*
[4] *Underwater Ecology Institute*

Three dimensional marine forest will be established using artificial floating structure, which is different from previous marine forest construction method. Marine seaweed aquaculture is very popular in area and production with various cultivation species. In particular floating cultivation techniques for commercial kelp (*Undaria pinnatifida, Saccharia japonica*, and *Ecklonia cava*) and *Sargassum* species (*Sargassum fulvellum, S. fusiformis*) are well developed. Also, recently, new cultivation techniques for kelp species (*Ecklonia stolonifera, Eisenia bicyclis*) and *Sargassum* species (*Sargassum macrocarpum, Myagropsis myagroides*) were established to restore barren grounds using cultivation ropes of the species. In the present study, artificial floating structures were designed based on current seaweed aquaculture system and recently developed off-shore seaweed aquaculture structures. Culturing seaweed species in the floating structure were selected in terms of habitat evaluation procedure (HEP) and habitat suitability index (HSI). Newly developed floating marine forest system can be applied in the coastal barren area to supply propagules from parents established in the floating system and it can provide nursery and feeding grounds of many marine animals, itself.

## MS 19-1

### Japan's nationwide long-term monitoring survey of seaweed communities known as the "monitoring sites 1000": ten-year overview and future perspectives

**Ryuta Terada**[*1]

[1] *United Graduate School of Agricultural Sciences, Kagoshima University, Japan*

*"Monitoring Sites 1000"* – Japan's long-term monitoring survey was established in 2003, based on the Japanese Government policy for the conservation of biodiversity. Ecological surveys have been conducted on various types of ecosystems at approximately 1,000 sites in Japan for 15 years now, and is planned to be carried out for 100 years. Since 2008, seaweed communities have been monitored at six sites, featuring the typical kelp (e.g. *Saccharina* and *Ecklonia;* Laminariales) and *Sargassum* (Fucales) communities in the cold-water and temperate regions of Japan. Annual surveys are carried out during the most abundant season of these canopy-forming seaweeds. Quadrat non-destructive sampling method, applied along transects perpendicular to the shoreline, is used to determine species composition, coverage, and vertical distribution of seaweeds at these sites; while destructive sampling is done every five years to determine biomass. The occurrence of canopy-forming species *Saccharina japonica* and *Ecklonia cava* seemed stable at Muroran (southwestern part of Hokkaido) and Shimoda (Pacific coast of middle Honshu) sites, respectively; whereas the occurrence of *Ecklonia radicosa (= Eckloniopsis radicosa)* community at Satsuma-Nagashima site in southern part of Kyushu Island has been unstable until its sudden disappearance from the habitat in 2016. *E. radicosa* lost most of their blades by browsing of herbivorous fish, and so may be considered one of the potential causes of its decline. A shift in the community structure and population gap dynamics related to environmental changes has also been observed at some other sites. Pre- and post-disaster data revealed the impact of the 2011 earthquake and tsunami disasters, including a shift of the vertical distribution of *Ecklonia bicyclis (= Eisenia bicyclis)* to shallower depths at Shizugawa site in the Pacific coast of northern Honshu Island, due to seafloor subsidence.

## MS 19-2

### *Ecklonia* kelp forests – globally significant habitats under pressure

**Thomas Wernberg**[*1]

[1] *UWA Oceans Institute & School of Biological Sciences, University of Western Australia, Australia*

*Ecklonia* forests are the most widespread laminarian kelp forests globally, dominating temperate reefs at low latitudes in both hemispheres, where they provide valuable resources, habitat, and services for coastal communities. Despite being tolerant to a wide range of abiotic conditions, recent environmental change has caused direct and indirect loss of *Ecklonia* forests, with extensive areas transitioning to turf and urchin barrens. These changes have significant impacts on marine biodiversity and ecosystem functioning because *Ecklonia* is a foundation species which supports a plethora of habitat-associated plants and animals, many of which are socio-economically important. With ongoing climate change impacts will intensify, and this may require application of multi-faceted and novel strategies to increase resistance and resilience to future conditions. Some forms of management have been effective in restoring kelp forests, however in many cases the threats facing kelp forests in the future greatly exceed local conservation strategies, necessitating novel conservation solutions to protect and conserve these ecosystems. Although the diversity of changes to kelp forest globally make it challenging to generalize about their future, it seems almost certain that many kelp forests a few decades from now will differ substantially from what they are today.

## MS 19-3

### Drifted *Sargassum horneri* in the Yellow Sea: its origin, life cycle and fate

**Shaojun Pang**[*1], Tifeng Shan[1], Li Su[1], Jing Li[1]

[1] *Institute of Oceanology, Chinese Academy of Sciences,China*

Drifted *Sargassum horneri* in the Yellow Sea has been observed and studied for more than a decade. Up to today, the original niches of the benthic populations from which the drifted ones are derived from still remain unknown. *S. horneri* has been believed to be benthic, living on solid substratum like rock or large boulders and possesses an annual life cycle in the northern hemisphere. Drifted individuals of *S. horneri* in the Yellow Sea are ideal places for many marine animals including some precious fishes to lay eggs and to nurture their offspring. Drifted *S. horneri* has become a very welcomed seaweed food in China recently and the amount to be needed is continuously growing up, calling for effort to grow them in open sea. Branches of *S. horneri* that bears receptacles has been a rare and nutritional seaweed food in the Japanese market and the need has never been met. From ecological, scientific and economic points of view, *S. horneri* that has been drifted in the Yellow Sea over years needs to be investigated comprehensively.

## MS 19-4

### Biogeography and seascape genetics of the Bull Kelp, *Nereocystis luetkeana*

**Alberto, Filipe**[*1], Gierke, L.[1]

[1] *University of Wisconsin-Milwaukee, USA*

We present the first study on the population genetics of the Bull Kelp, *Nereocystis luetkeana*. We used 10 microsatellite markers and ddRAD SNP variants to genotype a over 1,000 samples distributed from over 47 sites along the species distribution range, with particular focus in the Salish Sea region. Within the Salish Sea and adjacent North East Pacific coast we used a landscape genetics approach to study which factors drive genetic differentiation. Accordingly, we tested the relative importance of spatial, oceanographic and environmental distances between sample sites. Four clusters of genetic co-ancestry resulted from our analysis, the extent of some of these suggest long distance dispersal is possible. Genetic diversity was the highest at the Southern limits of species range in Central California, although the levels at the northernmost samples in Alaska were also high suggesting multiple refugia during the last glacial maximum. The lowest levels of genetic diversity were observed inside the Salish sea in accordance with increasing isolation of kelp beds. Oceanographic distance explained the best the patterns of genetic differentiation, although there was some support for isolation by environment associated with Summer sea surface temperature and light penetration in the water. Anthropogenic impact in the Salish Sea has been associated with

decreasing kelp cover in areas close to large urban centers. The study of genetic differentiation can shed light on the demographic connectivity between disjunct populations in this system and identify areas of concern.

## MS 20-1

### Climate-driven declines in kelp forests and the global rise of turfs

**Thomas Wernberg**[*1]

[1] *UWA Oceans Institute & School of Biological Sciences, University of Western Australia, Australia*

Kelp forests provide valuable ecological services along a quarter of the world's coastlines. Unfortunately, the majority of kelp forests around the world have been in decline over the past 4-5 decades, and are being replaced by turf algae in many places. Climate-driven changes play a critical role in mediating the transitions from kelp to turfs through geographically disparate abiotic (warming and marine heatwaves) and biotic (herbivory and epiphytism) drivers of kelp loss. Characterising turf algae communities from collapsed kelp forests around the world clearly show how the transition of kelp forests to turf reefs represent a flattening of temperate reef seascapes. Evidence that environmental conditions are becoming less favourable for kelps, combined with a lack of observed recovery, raises concern that these changes represent persistent regime shifts. Possible soluitons will be discussed.

## MS 20-2

### Cryptic loss of genetic diversity and directional selection in marine forests following an extreme climatic event

**Melinda Coleman**[*1], Thomas Wernberg[2], Olga Camacho[3], Carlos Frederico Deluqui Gurgel[3]

[1] *Fisheries, NSW Department of Primary Industries, Australia*
[2] *Oceans Institute, University of Western Australia, Australia*
[3] *Departamento de Botânica, Universidade de Santa Catarina, Brazil*

Extreme climatic events have precipitated profound impacts on marine communities including range contractions and loss of entire ecosystems. Underlying patterns of genetic diversity may both mediate response to such extreme events, as well as subsequent adaptive capacity to further change. Empirical demonstration, however, of how extreme events impact genetic diversity are rare. Here, we demonstrate significant loss of genetic diversity across ~800km of marine forests following an unprecedented marine heatwave that completely extirpated populations of some species, but left others seemingly intact. The marine heatwave was associated with widespread loss of haplotype and nucleotide diversity in 2 forest-forming species. Scytothalia dorycarpa lost 33-61% of nucleotide diversity and 12-100% of haplotype diversity following the heatwave. Similarly, *Sargassum fallax* lost 15-31% of nucleotide diversity and 9-100% of haplotype diversity. Strikingly, genetic diversity declined even where there was no detectable impact on species abundances indicating that extreme events can have widespread and cryptic impacts on natural populations. Overall, both species become dominated by single haplotypes after the heatwave suggestive of strong directional selection. Prior latitudinal patterns in population genetic structure were wiped out as all sites genetically diverged. We provide one of the first empirical demonstrations of how an extreme event can cause widespread loss of genetic diversity and strong selection. Predicting the vulnerability of marine systems to extreme climatic events relies on understanding how the interplay between genetic diversity, adaptive capacity and population demography confers resilience to future change.

## MS 20-3

### Redistribution of macroalgae and herbivores by climate change in Japan

**Daisuke Fujita**[*1]

[1] *Marine Biosciences, Tokyo University of Marine Science and Technology, Japan*

Reduction of macroalgal beds have been one of the largest concerns along the Japanese coasts because decrease of kelp and agarophytes as well as the related shellfish have extensively affected the economy of fishing villages. It was on the east side of Izu Peninsula (influenced by Kuroshio), central Pacific coast of Honshu that unexpected decrease of *Gelidium* and/or *Ecklonia* beds were called 'isoyake' as early as late 19th century. Now the word is used to indicate decrease of a variety of canopy-forming species. In these decades, macroalgal beds are likely to fail in recovery, while they were previously resilient to the temporal decrease. This is due to the recent climatic changes represented by elevation of sea surface temperatures (SST). This seems to precede changes in sea level, wave height and precipitation. Meteorological Agency demonstrated that elevation in average annual SST around the country is +1.11°C/100 years, which is much larger than that of the global average (+0.54°C/100 years). Although the rate of elevation differs from area to area, redistribution of macroalgae and/or herbivores have been reported from almost all over the country. In subtropical to warm temperate coasts, alteration from algal to coral community or perennial to annual canopy and decrease of ecklonian kelp (including mass dislodgement) have been reported along with the increase of herbivorous fishes (including *Siganus* and *Kyphosus*) and/or sea urchins (including *Diadema* and *Heliocidaris*). In cold temperate coasts, saccharian kelp have decreased and urchin barrens dominated by the sea urchin *Mesocentrotus* increased. Among herbivores, *Messocentrotus, Diadema* and *Siganus* experienced mass mortalities at episodic higher or lower SST. Recent monitoring and caging show that macroalgae decrease because of grazing by herbivores or dislodgement by storms before withering at thermal death point. Therefore, control of herbivore density should be primarily targeted for algal restoration.

## MS 20-4

### Tropicalisation of temperate reefs: implications for ecosystem functions and management actions

**Adriana Verges**[*1], Erin McCosker[1], Mariana Mayer-Pinto[1,2], Melinda Coleman[3,4], Thomas Wernberg[5,6], Tracy Ainsworth[1,2], Peter Steinberg[1,7,2]

[1] *School of BEES, UNSW Sydney, Australia*
[2] *SIMS, Sydney Institute of Marine Sciences, Australia*
[3] *New South Wales Fisheries, Department of Primary Industries, Australia*
[4] *National Marine Science Centre, Southern Cross University, Australia*
[5] *UWA Oceans Institute, University of Western Australia, Australia*
[6] *Department of Science and Environment, Roskilde University, Denmark*
[7] *Singapore Centre for Environmental Life Sciences Engineering, Nanyang Technical University, Singapore*

Temperate reefs from around the world are becoming tropicalised, as warm-water species shift their distribution towards the poles in response to warming. This is already causing profound shifts in dominant foundation species and associated ecological communities as canopy

seaweeds such as kelp are replaced by tropical species including corals. Here, we consider the cascading consequences of this tropicalisation for the ecosystem properties and functions of warming temperate reefs, and what that means for the management of our marine environment. We put forward three potential trajectories of tropicalisation that differ in whether seaweed, turf or corals end up dominating the seafloor, and discuss expected changes in biodiversity, productivity and nutrient cycling. We outline management practices that may either mitigate predicted structural and functional changes or make the most of potential new opportunities in tropicalised reefs. These include marine protected areas, assisted evolution and the development of new fisheries. Finally, we highlight the ecological and ethical challenges associated with developing novel management approaches, which may need to become increasingly interventionist.

## MS 21-1

### Assessing the methane yields of whole and residue *Ulva* spp. following anaerobic digestion of samples prepared from varied long-term storage arrangements

**Jessica Adams**[1*], Angelos Photiades[1], Andrew Woolmer[2]

[1] *IBERS, Aberystwyth University, UK.*
[2] *GreenSeas Resources, Pembroke Dock, UK*

In recent years *Ulva* spp. blooms are becoming more frequent and larger as waterways suffer increasing eutrophication caused by growing farming intensification and land run-off. In some waterways these algae are low in contaminants and are suitable for alternative utilisation. In this study, industrial collaborator GreenSeas Resources are producing liquid fertiliser from the *Ulva* spp. growing in the Milford Haven estuary (south Wales, UK). They have conducted trials on different preservation methods including freezing, ensiling and drying but do not yet have a downstream process for the residues generated. Anaerobic digestion is proposed as a viable process for these residues, especially as the algae are collected whilst in an estuarine environment with low quantities of silt rather than harvested with sand from the coastal shores. Samples of *Ulva* spp. had previously been frozen; dried; pressed, then dried; ensiled; and rapidly aerobically digested and dried. For all long-term storage methods, batch anaerobic digestions were conducted on sub-samples which were either 'as is' or as residues after soaking and pressing at different temperatures whilst producing liquid fertilisers. All anaerobic digestions were conducted in triplicate with controls to enable methane yields for each preparation to be assessed within a regularly monitored 30-day trial. The highest cumulative methane yields and initial rate values of both whole stored *Ulva* and related residues following processing will be determined. Findings from this study will inform on preferred long-term storage methods for *Ulva* spp. prior to bioconversion and optimal extraction temperatures regarding anaerobic digestion. Preliminary findings from a complementary fertiliser trial will also be presented. This is a novel study, demonstrating the versatility of anaerobic digestion, capable of generating additional products from residue feedstocks. Findings will provide new data on both the long-term storage of *Ulva* spp. for downstream processing and a comparison of methane yields from *Ulva* residues and whole seaweeds.

## MS 21-2

### Opportunities for production of bioenergy from macroalgae by integration of hydrothermal carbonisation and anaerobic digestion

**Ross, A.B.** [*1], Brown, A[1], Camargo-Valero, M[2]., Finnerty[1], G.

[1] *School of Chemical and Process Engineering, University of Leeds, UK.*
[2] *School of Civil Engineering, University of Leeds, UK.*

The use of macroalgae for the production of bioenergy is continuing to attract interest. Processing macroalgae by hydrothermal carbonisation has been demonstrated to produce a solid bio-coal with improved combustion properties and an aqueous process water rich in solubilised organic and inorganic compounds [1]. Previous reports have predicted significant energy recovery from the process water by anaerobic digestion [1] but validation is required using experimental data. Biological methane potential (BMP) of the aqueous stream has been performed using batch mesophilic (37°C) digestions using an Automatic Methane Potential Test System (AMPTS II). Hydrothermal treatment was performed for three macroalgae (*Saccharina latissimi, Fucus serratus* and *Laminaria digitata*) and two model compounds (alginate and mannitol) in a high pressure reactor in the temperature range 150-250°C (1 hour at a 10 wt% solid loading). The levels of bio-methane generated from process waters are discussed in terms of process water composition and the presence of potential inhibitors. Barriers to implementation and opportunities for co-processing of macroalgae with additional feedstocks have also been investigated. The conversion of macroalgae derived process waters are lower than those predicted by theoretical calculations with typical methane yields reaching 150 ml $CH_4$ /g COD. Co-processing of macroalgae with other feedstocks produces higher quality bio-coal however this also effects the composition of process waters effecting methane yields. Inhibition is a potential barrier and approaches for reducing inhibition are proposed as well as discussion of alternative strategies for conversion of aqueous streams such as dark fermentation to produce bio-hydrogen.

## MS 21-3

### Outcomes of the three-year SEAGAS project: advancing the anaerobic digestion of *Saccharina latissima* for biomethane

Michelle Morrison[1], Elisa Capuzzo[2], Gary Caldwell[3], Karen Mooney[4], **Philip Kerrison**[*5], Alex Adrian[6]

[1] *The Centre for Process Innovation (CPI), UK*
[2] *Centre for Environment, Fisheries and Aquaculture (CEFAS), UK*
[3] *Newcastle University, UK*
[4] *Queen's University Belfast, UK*
[5] *The Scottish Association for Marine Science (SAMS), UK*
[6] *Crown Estate Scotland, UK*

This talk will present outcomes from the three-year SEAGAS project funded by InnovateUK. SEAGAS advanced the anaerobic digestion (AD) process for *Saccharina latissima*, currently an undeveloped, sustainable resource in Europe. The project focused on six areas:

1) Cultivation and harvesting methodologies were developed at two farm sites.
2) We verified the suitability of seaweed storage by ensilage to ensure a year-round supply for continual AD plant operation. We assessed both the biochemical and microbial composition.
3) Biomethane production and AD operational parameters were investigated through a series of 5-litre reactors. This culminated in a pilot scale test of two 800-litre AD reactor vessels for 12 months. The microbial composition was also assessed.
4) Environmental and socio-economic effects of seaweed cultivation and site selection were assessed. This included modelling changes in nutrient load,

environmental sampling for local environmental effects and social acceptability.
5) The value of AD digestate as a fertiliser was determined.
6) Finally, a financial model was developed to assess the feasibility of seaweed AD in the UK.

The consortium of six was led by the Centre for Process Innovation (CPI) for AD process development and digestate utilisation, subcontracted to Eunomia (UK SME). Academic partners are SAMS for development of the seaweed storage system, Queen's University Belfast for environmental and socio-economic impact studies and Newcastle University for microbiological analysis. Cefas (UK Public Sector) models the potential environmental effects of seaweed farms and provides knowledge to apply industry best practice. Crown Estate Scotland (UK Public Sector) join as advisors who wish to support aquaculture development.

## MS 21-4

### Towards macro algae bioprocessing: dark fermentation of algal components to biohydrogen and high-value chemicals

**Sean M. Scully**[*1]

[1] *University of Akureyri , Iceland*

Macro algae species are a promising feedstock for the production of biofuels such as biohydrogen. Thermophilic Clostridia are well-established candidates for the production of biofuels such as biohydrogen from complex biomass while investigations into their ability to deconstruct and ferment specific algal compounds has been limited. Recent work has examined the metabolic capacity of *Thermoanaerobacterium, Thermoanaerobacter,* and *Caldicellulisiruptor* strains to degrade macro algal components such as major polysaccharides and their constituents to useful products. Strains within the genus of *Caldicellulosiruptor* have demonstrated the ability to produce biohydrogen from macro algae and partial hydrolysates thereof. The capabilities of strains to degrade laminarin, alginate, agarose, fucoidan has been investigated with a number of strains showing potential for β-1,3-glucosidase activity. Monomeric components including uronic acids, methylpentoses, and mannitol have also been investigated. Mannitol is fermented to ethanol and hydrogen/acetate while methylpentoses such as L-fucose and L-rhamnose are converted to (S)-1,2-propanediol. Current work on the fermentation of macro algae fractions from *L. digitata* and *A. nodosum* will be presented along with thoughts on the integration of thermophilic Clostridia into macro algae processing.

## MS 22-1

### Eavesdropping seaweed - bacteria cross-talk

**Mahasweta Saha**[*1], Jutta Weise[2], Martin Rempt[3], Stephanie Stratil[1], Katharina Grosser[3], Björn Gebser[3], Jan Grüneberg[3], Michael Steinke[4], Georg Pohnert[3], Martin Wahl[1], Florian Weinberger[1]

[1] *Benthic Ecology, GEOMAR, Germany*
[2] *Microbiology, GEOMAR, Germany*
[3] *Instrumentelle Analytik/Bioorganische Analytik, University of Jena, Germany*
[4] *School of Biological Sciences, University of Essex, United Kingdom*

Biofilms, composed mainly of bacteria, are paramount in the marine environment colonising both non-living and living surfaces like macroalgae. Intense bacterial colonization and further colonisation by micro and macro-organisms can be potentially detrimental influencing fitness of the seaweed host. However, many seaweeds like the brown alga *Fucus vesciculosus* are known to chemically modify such bacterial colonisation via the use of polar and non-polar surface associated defence chemicals like fucoxanthin, DMSP. We found than an apparent shaping of distinct bacterial community on the surface of *Fucus* is exerted by such defence chemicals. Such chemically mediated interactions were also found to fluctuate with space and time positively correlating with the fouling pressure. While defence was found to be controlled by *Fucus*, we found that such control capacity can undergo rapid chemical defence adaptation during the process of biological invasion for the red *macroalgae Gracilaria vermiculophylla*. These results provided the first evidence that confrontation by new bacterial colonisers can trigger a rapid defence adaptation of aquatic weeds, which could be necessary for algal invasiveness. Although *Gracilaria* is a tough invader it is usually affected by tip bleaching disease caused by bacterial pathogens which were identified in a follow up study, followed by the identification of protective bacterial strains preventing such bleaching. In this context we could verify the concept of microbial 'gardening' as the surface metabolites originating from *Gracilaria* specifically deterred the identified pathogens while attracting the beneficial ones. Seaweeds are also known to be prolific producers of volatile compounds influencing atmospheric chemistry. However, their ecological roles in mediating interactions with bacteria are not known. Thus, in a follow up study we tested the efficiency of seaweed volatiles for mediating bacterial colonization and also how these volatiles can influence human behavior during beach wrack process.

## MS 22-2

### Bacteria in algal growth and stress response: a metabolic point of view

**Simon Dittami**[*1], Hetty KleinJan[1], Bertille Burgunter-Delamare[1], Clemence Frioux[2], Meziane Aite[2], Gianmaria Califano[3], Thomas Wichard[3], Erwan Corre[4], Elham Karimi[1], Anne Siegel[2], Catherine Boyen[1]

[1] *LBI2M, CNRS / Station Biologique de Roscoff, France*
[2] *Dyliss, IRISA-CNRS, France*
[3] *Institute for Inorganic and Analytical Chemistry, Friedrich Schiller University, Jena, Germany*
[4] *FR2424, CNRS / Station Biologique de Roscoff, France*

Brown algae form key marine ecosystems and live in association with bacteria that are essential for their growth and development. *Ectocarpus siliculosus* is a genetic and genomic model organism for brown algae. Here we used this model to start disentangling the complex interactions that may occur within brown algal holobionts. In a first experiment, whole genome sequences of both the algal host and cultivable symbiotic bacteria were used to predict the metabolic capacities of each individual organism and to identify metabolic complementarities between them. Co-culture experiments were performed to assess the usefulness of the latter as a predictor of beneficial interactions. In a second experiment, we sought to elucidate the role of the microbiota during the acclimation of *Ectocarpus* to low salinities. In this case, the cultivable microbiome did not have significant impacts on algal acclimation and we therefore attempted to expand our approach to non-cultivable microbes using metagenomics and metatranscriptomics. Algal cultures inoculated with metabolically complementary bacterial communities exhibited increased growth rates and, in several cases, were shown to produce new metabolites in accordance with the metabolic predictions. In the context of acclimation to low salinities, we found for instance the bacterial production of selenoamino acids to be specifically related to cultures that successfully acclimated, while bacterial quorum sensing pathways were activated in

cultures that did not adjust well to a decrease in salinity. Although further methodological developments will be necessary to better control alga-associated microbiota, metabolic complementarity is likely a good indicator for beneficial interactions. Furthermore, the framework of metabolic networks has proven useful to analyze complex omics datasets and to generate hypotheses on the metabolic interactions between different members of holobiont communities in response to an external stressor.

## MS 22-3

### Chemical mediators in algae-bacteria interactions: novel functions of thallusin as algal morphogenesis inducer for the green seaweed *Ulva* (Chlorophyta)

**Thomas Wichard**[*1]

[1] *Institute for Inorganic and Analytical Chemistry, Friedrich Schiller University Jena, Germany*

There is a growing interest in the occurrence and diversity of metabolites used as chemical mediators in cross-kingdom interactions within aquatic systems. Bacteria produce metabolites to protect and influence the growth and life cycle of their eukaryotic hosts. In turn, the host provides a nutrient-enriched environment for the bacteria. Here, I discuss the role of waterborne chemical mediators that are responsible for such interactions in *Ulva* and its associated bacteria. Growth and morphogenesis of the marine green tide-forming sea lettuce *Ulva* (Chlorophyta) depend on associated bacteria which release morphogenetic compounds that induce cell division and differentiation. Under axenic conditions, the model organism *Ulva mutabilis* develops into a callus-like-phenotype with cell wall protrusions. The combination of two bacteria, *Roseovarius* sp. MS2 and *Maribacter* sp. MS6 recovers the morphogenesis completely. Using bioassay-guided fractionation and solid phase extractions, morphogens were determined in aquacultures of *Ulva*. Besides unknown compounds, thallusin, an algal morphogenesis inducer, was determined for the first time in the chemosphere of *Ulva* by mass spectrometry. Here, Maribacter strains were identified as the source of thallusin which can replace the bacterium regulating processes such as cell wall and rhizoid formation at a low concentration of 100 fmol $L^{-1}$. Thallusin was initially found in bacteria associated with the green macroalgae *Monostroma*, triggering blade formation. Thallusin, an essential chemical mediator for algal growth, possesses thus distinct functions in algal development depending on the receiver, similar to plant hormones.

## MS 22-4

### Metatranscriptomic differentiation in microbiome composition and function across *Ectocarpus siliculosus* strains and cell types

**Aschwin H. Engelen**[*1], Simon Dittami[2], Denis Saint-Marcoux[3], Bernard Billoud[2], Elodie Rolland[2], Jane Langdale[3], Bénédicte Charrier[2]

[1] *CCMAR, Univ. do Algarve, Campus de Gambelas,Portugal*
[2] *CNRS, Sorbonne Université, Laboratory Integrative Biology of Marine Models, France*
[3] *Department of Plant Sciences, University of Oxford ,UK*

Microbiome research of macroalgae has focused mainly on associated bacterial communities based on amplicon sequencing of the 16S rRNA gene and shown spatial differentiation from large geographical scales to different thallus tissues. Studies on *Ulva* have demonstrated the importance of specific bacteriome members for the morphogenesis of spores at the single cell level. Here, we present metatranscriptomic based microbiome differentiation among wildtype and two mutants of *Ectocarpus* sp., namely etoile and *knacki.* Here, we use laser-capture microdissection followed by single cell type metatranscriptomics to provide insights into the composition and functioning of microbiomes at a microscale (~ 200µm) along the filament of the early sporophytes grown in controlled conditions. We link this microbiome pattern to the different cell types formerly identified in this organism, namely the apical, elongated, intermediate, round and branching cells. In general, the cultivated *Ectocarpus* strains showed a bacterial dominated microbiome in which Gamma- and to a lesser extent *Alphaproteobacteria* and *Bacteroidetes* are most abundant. Ascomycota were also quite well represented. The *Ectocarpus* wildtype had a more diverse microbiome with a distinct composition. At phylum level differences among all *Ectocarpus* strains were mainly driven by abundance differences in *Proteobacteria, Bacteroidetes,* and *Ascomycota. Bacteroidetes (Croceibacter)* members were especially well represented in the *knacki* mutant strain, whereas *Marinobacter* and *Alteromonas* (both *Gammaproteobacteria*) in the wildtype and etoile mutant, respectively. Microbiome differentiation among cell types along the algal filament was far less pronounced than among *Ectocarpus* strains and only detected for a limited number of microbial members of the microbiome. Compositional differentiations in microbiome corresponded to functional differences in gene expression patterns and will be presented. Our metatranscriptomic data provide new insights into the *Ectocarpus* microbiome composition and function and highlight the importance of this approach in future algal-microbiome studies also at unprecedented cell type levels.

## SS 1-1

### Kelp aquaculture in Northeast America: opportunities, challenges and future directions

**Charles Yarish**[*1], Jang Kim[2], Scott Lindell[3], Michael Stekoll[4], Simona Augyte[1], Schery Umanzör[1], Michael Marty-Rivera[1], David Bailey[3], Jean-Luc Jannink[5], Xiaowei Mao[5], Kelly Robbins[5], Loretta Roberson[6], Clifford Goudey[7]

[1] *Ecology and Evolutionary Biology, University of Connecticut, United States of America*
[2] *Department of Marine Science, Incheon National University, Republic of Korea*
[3] *Applied Ocean Physics & Engineering, Woods Hole Oceanographic Institution, United States of America*
[4] *Department of Natural Sciences, University of Alaska, United States of America*
[5] *Dept. of Plant Breeding and Genetics, Cornell University, United States of America*
[6] *The Bell Center, Marine Biological Laboratory, United States of America*
[7] *Ocean Engineering, C.A. Goudey & Associates, United States of America*

After more than 30 years of effort by scientists, industry, state and federal agencies, kelp aquaculture is now considered an environmentally responsible practice and offers new opportunities for expansion in US coastal waters. With the nursery technologies developed at the University of Connecticut, *Saccharina latissima* and other kelp species have been successfully cultivated in open water farms in the Northeast and The Pacific Northwest. After out-planting juvenile kelp (< 1mm), we have found that our kelp cultivated on longlines grew up to 7.0 m in length and yielded up to 24 kg FW per meter of longline length after 6 months in Long Island Sound (LIS) and the Gulf of Maine. The harvests from the northeast US kelp farms have been processed using a mobile kelp-processing machine for human consumption. Kelp aquaculture provides ecosystem services by removing excess nutrients (carbon and nitrogen) from ecosystems and thereby improves water quality, potentially reducing ocean acidification. This practice is now called 'nutrient bioextraction.' The kelp aquaculture in LIS and other regions of the Northeast America can remove up to 180 kg N $ha^{-1}$ $yr^{-1}$, and 1,700 kg C $ha^{-1}$, respectively. Kelp aquaculture now offers other new opportunities for producing biofuels in the US Exclusive Economic Zone under the ARPA-E (US DOE) MARINER Program. There are now unique opportunities for seaweed farmers to work with phycologists, ocean engineers, plant geneticists and others to develop and apply advanced breeding technologies that will increase growth and improve thermal tolerance for open water farm systems.

## SS 1-2

### Growing *Ulva* (Chlorophyta) in commercial integrated systems with abalone in South Africa for feed and bioremediation: an update.

**John Bolton**[*1], Brett Macey[1,2], Mark Cyrus[1,2], Kristin De Jager[1], Joseph De Prisco[1], Teejaswani Bachoo[1]

[1] *Biological Sciences, University of Cape Town, South Africa*
[2] *Aquaculture Research and Development, Department of Agriculture, Forestry and Fisheries, South Africa*

The green seaweed *Ulva* has been cultivated on land-based abalone farms in South Africa for more than 15 years. It is a two-phase, fully commercial example of a successful IMTA system. A decade ago it was recognised that the main threats to the continuance of these operations were economic (is it cost-effective to grow *Ulva*?), and a perceived threat of disease spread through the components of the system. This presentation summarises commercial development, and presents new scientific data on some of the benefits and challenges. Around 2000t of *Ulva* is grown annually, mostly on four abalone farms, all used as feed. On two newer farms the *Ulva* is used to biofilter abalone effluent water to enable 50% water recirculation, having a considerable economic benefit. At 50% recirculation ammonia build up is minimal, with little pH change. Preliminary data suggest that 75% recirculation is feasible with little adverse effect, and demonstrates the potential to increase to 100% recirculation for short periods. This could avoid effects of Harmful Algal Blooms, which are a major threat to local abalone cultivation. Microbiome studies demonstrated that *Ulva* has a strong inhibitory effect on *Vibrio* spp. in the integrated systems. These findings were supported by NextGen amplicon sequencing data revealing significant differences in the microbial community profile of *Ulva* and seawater within and between systems. This demonstrates a selectiveness of *Ulva* for preferred bacterial taxa, and potential health and environmental benefits for the use of *Ulva* in integrated systems. The production of *Ulva* on South African abalone farms continues to expand. A major challenge involves the need for proper *Ulva* identification and strain selection. This is hampered by the lack of an accepted species concept for *Ulva*, with considerable morphological variation within a large *Ulva rigida* complex.

## SS 1-3

### A day in the life of a future tropical seaweed farmer

**Iain Neish**[*1]

[1] *Seaweed Farming, Sea6 Energy Indonesia, Indonesia*

Tropical seaweed farming is undergoing step-changes in agronomy and value-chain dynamics. The present paper describes evolving production practices from the perspective of a village-based seaweed farmer who is progressing from the labor-intensive, risky and inefficient methods of the past to more rewarding methods that are now under development. From that farmer's perspective we can see how mechanization; expanding knowledge of agronomy; secure contract farming systems; drone-facilitated crop-logging systems; and holistic village ecoscape management are among the technologies trending toward sustainable prosperity for tropical seaweed farmers now and into the future.

*Ecklonia cava*

*Ecklonia cava*

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# Oral Session

## OR 01-1

### Manipulating sporophyte morphology towards an enhanced productivity of *Macrocystis pyrifera* (Ochrophyta)

**Alejandro Buschmann**[*1], Sandra Pereda[1], Karina Villegas[1], José Luis Kappes[1], Maria C Hernández-González[1], Robinson Altamirano[1], Carolina Camus[1], Felix Lopéz-Figueroa[2]

[1] *Centro i-mar & CeBiB, Universidad de Los Lagos, Chile*
[2] *Departamento de Ecología y Geología, Universidad de Málaga, Spain*

The giant kelp *Macrocystis pyrifera* has a plastic morphology, physiology and life history, allowing a wide distribution, including both hemispheres. Due to the farming interest of this species it is relevant to develop techniques to enhance its productivity. On one side, it is relevant to understand the relevance of genetics towards the selection of high productive strains; but, on the other hand, how to manage the morphology plasticity seems also a way to achieve this goal. In this study we summarized three years of research, seeking to understand the role of morphological plasticity on productivity, as a strategy to cope with environmental changing conditions. We encompassed field work, mesocosm (adult sporophytes) and laboratory experiments (juvenile sporophytes), to include population and individual approaches. Therefore, we characterized the morphology of *Macrocystis*, along the Chilean coastline (4 locations ranging 33°21´S to 53°35´S), to relate it to their photosynthetic potential. Also, by using a bioreactor experimental system (partial control on environmental factors), we carried out an experiment to determine primary productivity of individual sporophytes with differential allocation of biomass into the canopy and subcanopy (high C:SC ratio versus low C:SC ratio). Likewise, juvenile sporophytes were produced in floating culture systems making possible to have multiple and low number of fronds to run factorial experiments controlling temperature and nutrient availability, and to compare growth under grow-out conditions. Our results showed that morphology variations (differential allocation of the biomass for higher photosynthetic surface) can allow for a better light use by increasing the biomass and photosynthetic area, hence increasing plant productivity. Our main conclusion indicate that it is also possible to manipulate the morphotype controlling the environmental condition of the initial stages (e.g. fertility) to increment biomass production. Finally, we discuss the importance of genetic background and morphological manipulation to increase productivity of kelp.

## OR 01-2

### The development of seaweed farming in Europe - environmental impacts and prioritizing key knowledge gaps

**Adrian Macleod**[*1], Iona Campbell[1], Arlene Ditchfield[1], Christian Sahlmann[2], Luiza Neves[3], Jon Funderud[3], Margareth Øverland[2], Adam Hughes[1], Michele Stanley[1]

[1] *The blue economy research area, Scottish Association for Marine Science, United Kingdom*
[2] *Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, Norway*
[3] *Environment, Seaweed Energy Solutions, Norway*

Cultivation of kelp has been well established throughout Asia, and there is now growing interest in establishing cultivation of this kind in Europe to meet future resource needs. If this industry is to become established, consideration of the environmental changes associated with cultivation in Europe will be necessary to ensure the carrying capacity of the receiving environments are not exceeded and local conservation objects are not undermined. Data collected from experimental farms in Scotland are presented alongside a systematic review of the ecosystem changes likely to be associated with an expanding seaweed aquaculture industry to highlight current knowledge gaps and research priorities to address them. Whilst 'small-medium' scale cultivation projects (0-50 x 200m lines) pose less risk, an expansion of the industry that includes 'large-scale' cultivation projects (>50 x 200m lines) will necessitate a more complete understanding of the scale dependent changes in order to fully assess and manage risks. Environmental changes of greatest concern were identified to include: facilitation of disease, alteration of population genetics and wider alterations to the local physio-chemical environment. To better understand the relationship between environmental impact at different scales, a process for standardizing the scale of production is proposed, and would allow for comparisons between sites of different cultivation practices during the consultation process. Finally, recommended monitoring options are given in order to facilitate informed decision making which will be required to establish 'large-scale' cultivation projects whilst minimising environmental impacts.

## OR 01-3

### Latitudinal and seasonal variations of growth and chemical content of the sugar kelp *Saccharina latissima* along the Norwegian coast

**Silje Forbord**[*1], Guri Brodahl[2], Sanna Matsson[3], Jorunn Skjermo[4], Ole Jacob Broch[4], Kristine Steinhovden[4], Saifullah Saifullah[2], Malin Kleppe[5], Arne Duinker[5], Yngvar Olsen[2], Aleksander Handå[4]

[1] *Biology/Environment and New Resources, NTNU/SINTEF Ocean, Norway*
[2] *Biology, NTNU, Norway*
[3] *Aquaculture, Akvaplan niva, Norway*
[4] *Environment and New Resources, SINTEF Ocean, Norway*
[5] *Contaminants and Biohazards, Institute of Marine Research, Norway*

To investigate possible geographical and seasonal differences in growth and chemical composition of cultivated *Saccharina latissima* along the Norwegian coast, nine different locations from south (58°N) to north (70°N) were compared. Seedlings were produced simultaneously with similar environmental conditions before deployment on vertical droppers at 1-2 and 8-9 m depth in February 2017. In the period April to September 2017, registrations were made every second to fourth week. Growth measurements (length, width, density, weight), morphological and biofouling studies were done together with sampling of biomass for chemical analyses of amino acids, internal nitrate, CN, carbohydrates and heavy metals. The biomass production peaked first in Mid-Norway (63°N) in early July (14 kg/m at 1-2 m depth) before large portions of the biomass was lost due to heavy biofouling during summer. In Northern-Norway, the biofouling settled later and biomass production peaked in September (14 kg/m at 1-2 m depth). The locations in Southern-Norway did not reach their potential growth maximum before the settling of biofouling in May, and had a maximum biomass of 1.6-3.3 kg/m. The protein content varied from 2-11% of DW with no latitudinal trend between the stations after 12-16 weeks of cultivation in sea (before settlement of biofouling), with the highest content at 8-9 m depth for all stations. The protein content declined from April towards the summer, followed by an increase up to 20% of DW after settlement of biofouling. Both cadmium, inorganic arsenic and iodine showed significant differences among the different sites. However, only for cadmium there seemed to be a consistent latitudinal trend with increase towards the northern sites. The results suggest good possibilities for seaweed cultivation along the Norwegian coast, with a prolonged

production season in Northern-Norway, but with large geographical variations that need to be considered before upscaling the biomass production.

## OR 01-4

### Challenges in scaling up to massive self-sustaining seaweed farms

**Nelson Vadassery**[*1], Srideep Chatterjee[1], Siddharth Koppal[1], Hrishikesh Ranjalkar[1], Jiju Thomas[1], Jaikumar Muthuchami[1], Karthick Perumal[1], Rajesh Reddy Katreddy[1], Chaitanya Praveen[1], Suresh M R[1], Bhajuram Prajapathi[1], Shrikumar Suryanarayan[1], Iain C Neish[2], Agus Sastra Wiguna[2], Gigih Nur Ahmed[2]

[1] *Engineering, Sea6 Energy, India*
[2] *Engineering, PT Sea Six Energy Indonesia, Indonesia*

In order to be a credible replacement for fossil fuels, plastics , food and feed - seaweed farm sizes will need to be scaled up from a few hectares to several hundred square kilometres. As we scale up our seaweed farms in this fashion we need to address three aspects 1. Mechanization of offshore seaweed farmingTo cultivate at scale, it is essential that we develop the ability to cultivate seaweeds in the open ocean. Sea6 Energy has made significant strides in increasing the productivity of vegetatively propagated tropical red seaweeds - using our SeaCombine technology, enabling their cultivation in rougher offshore waters. 2. Solving the nutrient limitation issueIt is clear that as the farms grow in size, the amount of nutrients flowing through the farms need to be increased proportionately. We propose to do this using a combination of approaches. One is to bring in solar powered offshore upwelling systems to pump in fertile deep sea water onto the farms. Secondly, process the biomass offshore such that the hydrocarbons can be extracted, leaving behind the essential nutrients which can be dispersed among the farm for better growth. Thirdly, increase the nitrogen fixing ability within the farm ecosystem. 3. Offshore farm monitoring We plan to use of Drones and image processing technologies to visualize sea-farm cover, and extrapolate almost real time growth rates on different regions of the farm allowing us to focus on regions which need the most attention. Floating wireless data monitoring stations will also help beam data regarding farm conditions to common console from different regions from a farm into the cloud - enabling us to understand farm health from anywhere on the planet. We describe the approaches we are taking to address each of these, to truly enable large-scale seaweed farming.

## OR 01-5

### Biamass allocation of the brown alga *Sargassum fusiforme* and its relationship with modules

**Jingyu Li**[*1], Yingchao Liu[1], Yan Liu[1], Qiaohan Wang[1], Qingli Gong[1]

[1] *Fisheries College, Ocean University of China, China*

Biomass allocation and its relationship with modules have extensively reported on terrestrial plants, but rarely on seaweeds. The brown alga *Sargassum fusiforme* is an important commercial species in China, Japan and Korea, with highly differentiated modules. Biomass allocation and its relationship with modules have a major impact on the quality of *S. fusiforme*. Therefore, we selected the cultivated population from Dongtou, Zhejiang Province and the wild population from Rongcheng, Shandong Province as experimental materials. Algal samples of were collected monthly from December 2014 to August 2015 for wild population, and from October 2014 to May 2015 for cultivated population. The seasonal changes in biomass of each module, the proportion of biomass of each module, and the relationship between biomass allocation and modules were examined and analyzed. Seasonal variations in biomass of modules were found on both cultivated and wild populations. For wild population, the biomass of blades, pneumathodes and receptacles accounted for more than 60% of algal biomass. The largest proportion of biomass was observed on blades from December 2014 to May 2015, on pneumathodes in June and July 2015, and on receptacles in August 2015. For cultivated population, the biomass of blades and pneumathodes accounted for more than 60% biomass. The largest proportion of biomass was observed on blades from October and December 2014, and on pneumathodes from January to May 2015. The proportions of biomass in holdfast and receptacles of the wild population were significantly higher than those of the cultivated population. The correlation between algal biomass and number of pneumathodes of the cultivated population was higher than that of the wild population. Differences in biomass allocation and its relationship with algal modules between the cultivated and wild population of S. fusiforme may caused by environmental factors and growth mode.

## OR 01-6

### Effect of vector and direct seeding on growth of sugar kelp *Saccharina latissima* at sea

**Jorunn Skjermo**[*1], Silje Forbord[2], Kristine Braathen Steinhovden[1], Aleksander Handå[1]

[1] *Environment and new resources, SINTEF Ocean, Norway*
[2] *Department of Biology, NTNU, Norway*

Sugar kelp *Saccharina latissima* is interesting for cultivation at the Atlantic coasts in Northern Europe and many farmers are now starting up production of this species. There is a need to optimize the production technology to reduce cultivation costs, and one important step is to increase the quality and predictability in the seedlings production. In this study we evaluated the biomass production potential from seedlings of different age at the time of deployment, at the coast off Central-Norway. For vector seeding, spores and gametophytes were seeded and pre-cultivated on twine for periods of up to 6 weeks in hatchery before twisting on to carrier ropes at deployment in sea, in total 7 different treatments. For direct seeding fertile gametophytes and juvenile sporophytes pre-cultivated in tumbling cultures were seeded directly on cultivation ropes using a glue at the day of deployment, in total 4 different treatments. All 11 treatments were deployed at the same day in February and the growth registered after 3 (May) and 4 (June) months. The biomass yield peaked at 7,22±0,14 kg wet weight pr meter in June for vector seeding of ropes with spores 6 weeks prior to deployment, whereas direct seeding gave 1/3 of the maximum biomass. The sporophyte density on the ropes in June were similar for these two conditions but the individual weight of the direct seeded sporophytes was only 32% of the vector seeded sporophytes, suggesting that the direct seeded gametophytes or juvenile sporophytes used much of the spring to develop holdfast and start growing instead of immediate fast growth and biomass production. The results further show that twine seeding with spores or gametophytes and a hatchery period of 2-4 weeks gave a biomass yield of 45-58% of the maximum yield.

## OR 02-1

## Biofertilizing effect of the cyanobateria *Fischerella* sp. encapsulated in alginate-chitosane in the growth of radish

**Gustavo Hernández**[*1], Maurico Muñoz-Ochoa[1], Mauricio Contreras-Olguín[1], Cristine J. Band-Schmidt[1], Claudia Hernández-Guerrero[1]

[1] *Nstituto politécnico nacional, CICIMAR, Mexico*

The objective was to produce and assess the biofertilizer effect of the cyanobacteria *Fischerella* sp., encapsulated in alginate and/or chitosan. The cyanobacteria were reactivated, and cultured under environmental conditions up to a volume of 20 L (2500 beads / L). A culture of radish was used to test four types of encapsulation: Ca-alginate beads and Ca-alginate (A) / chitosan beads (AQ), both without (AC and AQC) and with (AFE and AQFE) cyanobacteria. Triple 17 (NPK), powder alginate (AP), chitosan powder (QP), *Fischerella* (FF) and control = Water (T) were used as controls. Weight, length, bulb diameters and chlorophyll a concentration in the radishes were measured weekly in a culture with 40 plants per treatment (three replicates). Statistical analysis showed significant differences. The bioencapsulated AFE, AQFE, and T17 promoted the growth and development of radish plants. From the experimental treatments, *Fischerella* encapsulated was chosen in Ca-alginate (AFE) to perform another experiment, combining the bioencapsulated developed with different proportions of fertilizer (T17). The results showed that the combination of 40% of bioencapsulated and 60% of fertilizer, produced a significantly higher growth and longer leafs (21 cm), polar diameter (3.2 cm), equatorial bulb (1.8 cm), higher fresh weight of leaves (9.5 g), fresh bulb weight (5.6 g) and chlorophyll "a" content (0.9 mg g -1). Proximal chemical analysis showed no significant differences in ash, fat, fiber, and protein among radish plants. The physicochemical evaluation of the substrate showed significant differences between treatments. The content of nitrogen (0.1%), phosphorus (70%) and water retention capacity (10%) increased compared to the initial conditions. Concluding that the Ca-alginate- *Fischerella* encapsulated is an efficient biological fertilization alternative that contributes to providing the nitrogen required for by the plant and allows to reduce the amount of chemical fertilizer by up to 40%.

## OR 02-2

## TPG clade crytomonads as a new microalgal group to enrich zooplankters for marine larviculture

**Wonho Yih**[*1], Hyung Seop Kim[2], Soo-Gun Jo[3], Yeong Du Yoo[4]

[1] *Department of Marine Biotechnology, Kunsan National University, Republic of Korea*
[2] *Department of Marine Biotechnology, Kunsan National University, Republic of Korea*
[3] *Department of Marine Biotechnology, Kunsan National University, Republic of Korea*
[4] *Department of Marine Biotechnology, Kunsan National University, Republic of Korea*

Marine crytpophytes are of great importance for their crucial niche in the history of endosymbiotic plastid evolution, functional roles in marine ecosystems, and biotechnological applicability. In the field of aquaculture many strains of "RHO(*Rhodomonas/Rhinomonas/Storeatula*) clade" cryptomonads have been frequently used to enrich the prey zooplankton for larviculture of fish and bivalves owing to their high content of quality nutrients. Recently "TPG(*Teleaulax/Plagioselmis/Geminigera*) clade" species including strains of *Teleaulax* genus with particularly high EPA contents were suggested to be excellent food for the enrichment of prey zooplankton [1]. Here we report on the enrichment effect of a TPG clade cryptophyte strain, CR-MAL08-2 (*Teleaulax amphioxeia*) isolated from Gimje Korea, for a rotifer strain Brachionus plicatilis (provided by Laboratory of Live Food Organisms for Aquaculture, Gangneung-Wonju National University) following the routine growth with a commercially available Chlorella concentrate (Daesang Co., Korea). Relative composition of total lipid of *T. amphioxeia* and Chlorella sp. were 11.2 and 10.2% of all the 3 major nutrients, respectively. By contrasts the relative composition of unsaturated FA (fatty acid) was 22 times greater in *T. amphioxeia* than in *Chlorella* sp. strain while relative composition of essential amino acid was 1.3 times higher in *T. amphioxeia* strain. Following the enrichment feeding on *T. amphioxeia* culture for 3 hrs the rotifer exhibited rather similar amino acid composition to control. Composition of total FA, n-3 HUFA, and n-6 HUFA (highly unsaturated FA) were all enhanced in the rotifer treated with *T. amphioxeia* strain by 3.1, 23.1, and 13.8 %, respectively. Thus, some strains of TPG clade crytomonads like *T. amphioxeia* may be useful as novel high-quality enriching food items to rear and produce the prey zooplankton for marine larviculture.

[1]Peltomaa, E., Johnson, M.D. & Taipale, S.J. 2018. Marine cryptophytes are great sources of EPA and DHA. Mar. Drugs 16:3

## OR 02-3

## Marine algae in French Polynesia: from traditions to innovation

**Mayalen Zubia**[*1]

[1] *UMR-EIO, Université de Polynésie française, France*

In the South Pacific Islands, seaweeds have long been used as food, medicines and ceremonial objects. Throughout the region, human consumption of seaweeds is widespread (mainly *Caulerpa*) and, nowadays, few species have been cultivated for phycocolloid industry (*Eucheuma, Gracilaria, Kappaphycus*). These tropical seaweeds also contain an extremely important chemodiversity (mainly terpenes, alkaloids, halogenated and phenolic compounds) representing an original and innovative resource that is not exploited until now. In French Polynesia, several research programs are conducted to explore the diversity of marine algae as a source of biotechnological applications. Extracts from 30 marine macroalgae species (10 Chlorophyta, 11 Phaeophyceae, and 9 Rhodophyta) and 10 benthic cyanobacteria from French Polynesia were evaluated for several biological activities. Some species could be used in cosmetic products for their potent antioxidant activities (*Amansia rhodantha, Sargassum pacificum*), other could be used in aquaculture for their strong antimicrobial activities against two pathogens *Tenacibaculum maritimum* and *Vibrio harveyi* (*Dictyota bartayresiana*). Furthermore, the French Polynesia politics aims for several years to develop insular rural seaweed farming (mainly *Caulerpa* and *Gracilaria*), and some co-culture projects (shrimps/seaweeds or fish/seaweeds) are emerging. These researches could offer interesting socio-economic opportunities for French Polynesia in the cosmetic, food, agricultural and aquaculture industries.

## OR 02-4

## Development of koji on nori *Pyropia yezoensis* and application to nori sauce manufacture

**Motoharu Uchida**[*1], Nobuo Hideshima[2], Toshiyoshi Araki[3]

[1] *National Research Institute of Fisheries and Environment of Inland Sea, Fisheries Research and Education Agency, Japan*

[2] General Counsel, Maruhide Shoyu Co., Ltd., Japan
[3] Community-University Research Cooperation Center, Mie University, Japan

Koji is a traditional fermentation culture product which is commonly used in the manufacture process of Japanese fermented products such as soy sauce, miso and sake, and promote enzymatic degradation. Koji is usually prepared by culturing a mold on cereals such as wheat flour, soybean, or rice, but that cultured on seaweeds has not been developed yet. This study prepared the koji by culturing a mold on seaweed nori (*Pyropia yezoensis*), and, then, characterized on this nori koji. Six kilograms of nori was added with 0.84 g of the seed culture *Aspergillus oryzae* and six liters of water, incubated for three days at 30.5℃ and >90% humidity, and obtained nori koji. The nori koji was characterized for mold content and enzyme activities. Furthermore, nori sauce fermentation test was conducted with and without addition of the nori koji to examine the effect of nori koji addition. The nori koji contained 4.0 mg N-acetylglucosamine, estimated as 28.6 mg mold cells, per gram dry matter and showed various kind of enzymatic activities in glycosidase, protease, and phosphatase as well as traditional soy sauce koji and rice koji. After 167 days of culture, the fermentation tank with the nori koji showed over 74% recovery of supernatant while that without the nori koji had less than 57% recovery. The supernatant of culture mashes contained more than two times larger quantity of total nitrogen compounds in nori koji test group against control group. The present study prepared koji on seaweed nori for the first time and demonstrated its advantages to promote degradation and increase taste value in nori sauce manufacture. Development of seaweed koji enables a method to prepare cereal allergen free fermented sauces from seaweeds. This work was supported by the NARO Bio-oriented Technology Research Advancement Institution.

## OR 02-5

### Anti-parkinson's effects and mechanism of oligosaccharides derived from *Pyropia yezoensis*

**Quanbin Zhang**[*1], Yingjuan Liu[1], Lihua Geng[1], Jing Wang[1]
[1] Key Lab of Experimental Marine Biology, Instititute of Oceanlolgy, Chinese Academy of Sciences, China

Parkinson's disease (PD) is a neurodegenerative movement disorder that is caused by a selective loss of dopaminergic neurons. Oligo-porphyran (OP) was prepared from porphyran through acidolysis reaction with a linear backbone of alternating 3-linked β-D-galactose and 4-linked α-L-galactose-6-sulfate. Its neuroprotective effects was investigated in this study. In a 6-OHDA-damaged PC12 cells, OP significantly ameliorated cell loss and attenuated the LDH release lesioned by 6-OHDA, restrained the overproduction of reactive oxygen species (ROS) and improved the antioxidant system. OP also alleviated the mitochondrial membrane potential (MMP) loss and showed effective role on the increase of anti-apoptotic Bcl-2 proteins and the suppression of pro-apoptotic Bax proteins. Additionally, OP repressed the activity of caspase-3 and caspase-9. Tunel staining presented that OP inhibited apoptosis of PC12 cells. In a MPTP induced PD mice model, the behavioral deficits in spontaneous motor activity, latency to descend in a pole test, and suspension in a traction test were ameliorated, and excessive dopamine (DA) metabolism was suppressed after OP treatment. OP also protected dopaminergic neurons by preventing MPTP-induced decreases in dopaminergic transporter and tyrosine hydroxylase protein levels. OP increased the phosphorylation of PI3K/Akt/GSK-3 and inhibited the activation of caspase-3 and poly (ADP-ribose) polymerase,with changes in the Bax/Bcl-2 ratio. These results showed that OP might promote DA neuron survival by regulating the PI3K/Akt/Bcl-2 pathway, thereby ameliorating the neurobehavioral deficits in a PD mouse model and suggesting OP as a neuroprotective treatment for PD.

## OR 02-6

### R-phycoerythrin: new advances on extraction and characterization. impact of the enzymatic assisted extraction

**Justine Dumay**[*1], Michèle Morançais[1], Cécile Le Guillard[1], Huu Phuoc Trang Nguyen[1], Mathilde Munier[1], Yoran Le Strat[1], Paul Déléris[1], Joël Fleurence[1]
[1] MMS laboratory, University of Nantes, France

Phycobiliproteins are the main light-harvesting pigments in Rhodophyta. In most of species, the phycobiliprotein content can reach up to 20% of dry algal material. In addition to its color, phycoerythrin emits yellow fluorescence. Applications of R-PE as a bioactive compound, depending on its purity, range from food colorant to moiety in fluorescent energy transfer, fluorescent labels, tags, tracers, and markers. Recently, R-PE biological activities have been found such as antitumoral, antioxidant, immunosuppressive, or hypertensive.Our recent works deals with new information about R-PE, from extraction procedure using enzymatic assisted extraction (EAE) to characterization of isoforms of R-PE. Different methods for R-PE extraction have been studied. We investigate EAE using mostly glycosidases to improve the extraction yields. Optimisation using mathematical experimental design have been used. When necessary, ultrasounds could be applied by the mean of an innovative tubular probe. Finally chromatographic analyses (gel filtration, ion exchange) have been used to characterize and separate and purify the different forms of pigments. Main results led to significant improve of R-PE extraction yield by the mean of EAE (from 2 to 67 times compare to classical extraction according to the species studied). It appears that methodology has to be completely readapted when biotic parameters changed (species, cycle of life). We highlighted for the first time that R-PE could possess two shapes, with similar spectral properties, which could be find differential applications. This presentation deals with a synthetic summary of the work realized in the laboratory for a decade. We pinpoint that EAE is a novel and extremely accurate process for R-PE extraction. Moreover, the lack of adaptability of such procedure led us to investigate other sources of enzymes, mimic the nature considering chemical ecology. New perspectives of our current work will close this presentation.

## OR 03-1

### Monitoring and management of the drifting *Sargassum horneri* golden tide in Korea

**Sangil Kim**[*1], Seok-Hyun Youn[1], Hyun-Ju Oh[1]
[1] Ocean Climate & Ecology Research Division, National Institute of Fisheries Science, Republic of Korea

Jeju Island and southwestern coasts of Korea have been being inundated by unprecedented huge amounts of drifting *Sargassum*, known as golden tides, since 2015, the resulting has caused a lot of economic and environmental damages. Hence, predicting this event is vital for field monitoring and management decisions, as well as fisheries, tourism and other related businesses. We have organized the drifting *Sargassum* monitoring system, which processes diverse data collected from satellite,

drone photographs, aerial and cruise survey, numerical model and many local monitors. This monitoring system gives people and decision makers timely information on the drifting *Sargassum* location and scale. We issue a *Sargassum* bloom forecast for potential beach event if necessary. Government and agencies associated with this monitoring system do proper actions to cope with incoming drifting *Sargassum* according to the forecast. Fishermen and travelers can use it in their own plans, like a weather forecast. Ecological monitoring has been incorporated in long-term plans for the monitoring system. To manage drifting *Sargassum* bloom will not only require biological and ecological understanding, but will also need to assess their ecological roles and impacts on the coastal ecosystem and fisheries industry. These should provide valuable information to make a management policy for drifting *Sargassum* bloom.

## OR 03-2

### Golden tides in the Yellow Sea and East China Sea: formation and managment

**Jianheng Zhang**[*1], Chuner Cai[1], Xiaowei Ding[1], Minmin Zhuang[1], Peimin He[1]

[1] *College of Marine Ecology and Environment, Shanghai Ocean University, China*

A new hazard of golden tides caused by floating brown macroalgae are on the rapid rise in the Yellow Sea and East China Sea, resulting in tremendous economic loss due to the destruction of marine ecosystems and damage to ecological service functions. Especially in 2017, an economic loss of 0.5 billion CNY (about 73 million USD) was estimated due to damaged seaweed aquaculture in the Jiangsu Shoal, China. Satellite remote sensing were used to retrieve the drifting path of the floating brown macroalgae, indicating that the blooms were traced to two sources, one is from the coast of Shandong peninsula in Northern Yellow Sea during October to next January, the other is from the Zhejiang coast of East China Sea during March to June. The floating brown macroalgae collected in the Yellow Sea and East China Sea were all identified as *Sargassum horneri* with the molecular markers of ITS2 and cox3. Seasonal variation of attached *S. horneri* in mussel culture area near Gouqi Island of East China Sea were investigated, the results showed that a large amount of attached *S. horneri* on the infrastructure will be detached in April under the driven of water currents and human impacts. With the structure of air sacs, they could keep floating and provided the formation of the blooms. How to control this fouling macroalgae is the key problem that marine scientists and managers should do right now. In this study, *S. horneri* as a potential cosmetic ingredient was also conducted, indicating that polysaccharide, algae ooze and powder extracted from *S. horneri* showed a high ability on moisture retention and absorption, anti-oxidation, and anti-radiation. Also as a traditional economic seaweed, resource utilization of floating *Sargassum* should be a priority.

## OR 03-3

### The development of bioactives from blooming seaweeds in Normandy, France: the Enteromorphe and Snotra projects

**Benoit Queguineur**[*1], Jeremy Brébion[1], Marine Dehail[1], Coralie Delaunay[2], Véronique Lavatine[3], Vanessa Reynier[3], Sebastien Pien[2], Franck Hennequart[1]

[1] *Research and Development, ALGAIA, France*
[2] *Pôle Environnement, SMEL, France*
[3] *Actalia innovation, Actalia, France*

ALGAIA is the main processor of brown seaweeds in France, producing and commercializing alginates and other bioactive ingredients for the global market. ALGAIA is also providing R&D services on macro- and micro-algae to many companies in the world in order to sustain novel extract development for further valorization of algal wild stocks or cultivated resources.With its R&D facilities located in Normandy, France, ALGAIA aims at adding value to local seaweeds with local stakeholders using the strength of their industries (oyster and mussel farming) and turning threats of algal blooms into opportunities. After a previous project investigating the standing stocks of *Sargassum muticum* (Yendo) blooms, harvesting techniques and harvesting license implementation, the SNOTRA project has generated extracts and targeted bioactivities in cosmetics such as anti-inflammatory, antioxidant (IC50 of 1 to 1,5mg/ml) and antiaging (40% inhibition at 1 mg/ml) and as biostimulant in agriculture applications. The initial lab extracts have now been upscaled to pilot scale production. Various sites have been monitored and the harvesting potential is around 20,000 t FW.On the other hand, the Enteromorphe project is dealing with the opportunistic *Ulva* sp. (Linnaeus), growing on oyster tables, affecting the growth of oysters. The project tested various conservation methodology, developed polysaccharide extracts, and assessed the antiviral properties of the latter. One extract showed antiviral activity with an EC50 of 74,25 µg/ml. Besides, specific food products have also been developed on the basis of the high concentration of Magnesium in the seaweed, and its role in muscular tonicity. ALGAIA is developing extracts at laboratory and pilot scale, with bio activity assays to bring added value to local seaweeds and support the industry.

## OR 03-4

### Seasonal population dynamics of the 'golden tides' seaweed, *Sargassum horneri* on the southern coast of Korea: the extent and formation of golden tides

**Sang Rul Park**[*1], Sangil Kim[2], Hyuk Je Lee[3]

[1] *Department of Marine Life Sciences, Jeju National University, Republic of Korea*
[2] *Ocean Climate & Ecology Research Division, National Institute of Fisheries Science, Republic of Korea*
[3] *Department of Biological Sciences, Sangji University, Republic of Korea*

Large scale floating *Sargassum* biomass, known as golden tides, have been regularly reported since the 2000s worldwide. Since 2015, excessive masses of floating *Sargassum* biomass, represented by *Sargassum horneri*, have been introduced through via ocean currents and winds to southern coastline of Korea, including Jeju Island. This massive mat caused considerable damage to in aquaculture industry, tourism and marine ecosystem. Until recently, most researches of this species have highlighted cultivation, development of gene marker and photosynthetic activity. However, the available data on population dynamics of *S. horneri* is still insufficient. The aim of this study was to investigate population dynamics of native *S. horneri* on the southern coast of Korea to predict the extent and formation of golden tides. We examined morphology, density, recruitment, mortality, growth rate and biomass at Jindo and Munseom on the southern coast of Korea monthly from November 2017 to November 2018. The recruitments of *S. horneri* occurred during October-November and maximum density was 116 and 75 individuals m-2 at Munseom and Jindo, respectively. The density gradually declined and completely disappeared at two study sites in July. The thallus height of Jindo population gradually increased during November-May, while that of Munseom population sharply increased during January-April. Specific growth rate of Munseom population was significantly higher than that of Jindo population. Munseom population grew 12 cm per day during February. Mortality density of Munseom population was highest in

December-January, 2-3 month following the recruitment, while most plants in Jindo population die off in July when water temperature increases. During this period, maximum biomass of *S. horneri* detached from substrates was 1.5 kg fresh weight $m^{-2}$. This indicated that massive mat would be formed by free floating *S. horneri* detached from substrates and observed in the East China Sea and Yellow Sea from December-January.

## OR 03-5

### Fast and accurate quantification of *Alexandrium catenella* in very small abundance using ddPCR

**Hyemi Kim**[*1], Hyun-Gwan Lee[1], Kwang Young Kim[1]

[1] *Oceanography, Chonnam National University, Republic of Korea*

The species of genus *Alexandrium* are morphologically similar, making it difficult to identify its species and measure its abundance under microscopy. Moreover, the use of real-time PCR and species-specific primers for the quantification is affected by the inhibition of the PCR reaction due to the presence of PCR-inhibiting substances in natural seawater. Then the application using quantitative PCR remains rather unclear. To quantify the abundance of *A. catenella* which causes paralytic shellfish poisoning (PSP) and enormous damage to restaurant businesses, droplet digital PCR (ddPCR) protocol was developed by applying the methods with reliable and reproducible DNA extraction and using species-specific primers targeting the internal transcribed spacer (ITS) region. The abundance of *A. catenella* was determined through the copy number of target DNA per cell. The average copies per cell as determined via the ddPCR with known cell abundance was 1079 +/- 198. There was no difference in copies per cell from cell abundances, and also from various localities which have different plankton communities. The abundance of *A. catenella* in seawater collected from different locations, calculated via ddPCR, was in agreement with direct cell counts using a microscope. Even with a very small abundance of *A. catenella*, the method above is the most time and cost-efficient way to identify and quantify a species.

## OR 03-6

### Enrichment processes for the production of high-protein feed from the green seaweed *Ulva ohnoi*

**Marie Magnusson**[*1], Christopher Glasson[1], Matthew Vucko[2], Alex Angell[2], Loon Tze Neoh[2], Rocky De Nys[2]

[1] *School of Science, University of Waikato, New Zealand*
[2] *College of Marine and Environmental Sciences, James Cook University, Australia*

New sources of protein are required to supplement current animal- and plant-protein. Here, we quantify the quality and yield of four protein-enriched biomass products (PEB-I to PEB-IV) and a protein isolate (PI) from the commercially produced seaweed *Ulva ohnoi*. To decrease the content of components of the biomass that may be undesirable in feed, we have developed a multi-step biorefinery process to produce salt, sulfated polysaccharides (ulvan), and protein products. The content of protein increased from 22.2 ± 0.5 % dry weight (dw) in unprocessed biomass to between 39.5 ± 2.6 % in the PEB-IV and 45.5 ± 1.1 % in the PI. The quality (mol % of essential amino acids [EAA]) of the protein products was similar to soybean meal, with 41.6 ± 0.2 and 43.4 ± 0.1 mol % EAA in PEB-I and the PI, respectively. The yield of PEB products varied from 16.3 ± 1.1 to 41.0 ± 1.2 % of the unprocessed biomass, with PEB-I > PEB-II = PEB-III > PEB-IV. The yield of PEB products was four- to nine-fold greater than the PI (4.4 %). Conservatively, the biomass productivity of *U. ohnoi* is 70 t dw ha-1 year-1 resulting in a projected annual production (t dw ha-1 year-1) of 24 t of salt, 4.3 t of ulvan, 29 t of PEB-I, or 3.2 t of PI using this biorefinery process. With nine-fold higher yield, and a protein product of similar quality to the PI, we recommend producing PEB-I by concentrating the protein through the extraction of salt and ulvan over the extraction of a PI for the development of food and feed products.

## OR 04-1

### Reinstatement of *Calliblepharis jolyi* (Cystocloniaceae, Rhodophyta) based on topotype specimens and a new record of *C. saidana* in the Atlantic Ocean

**Mutue Fujii**[*1], Luanda Soares[1]

[1] *Núcleo de Pesquisa em Ficologia, Instituto de Botânica, Brazil*

The taxonomic status in flattened representatives of Cystocloniaceae (*e.g., Calliblepharis, Craspedocarpus, Hypnea and Rhodophyllis*) using traditional approaches often leads to taxonomic confusion due to their morphological similarities. Recent studies linking morphological and molecular evidence have been demonstrated hidden diversity in the red algal genus *Calliblepharis*, which presents ten species currently accepted. Some species of the genus are economically important as source of carrageenan. Because some species superficially resemble *Hypnea*, our knowledge about the diversity and distribution of *Calliblepharis* can be underestimated. *Calliblepharis jolyi* was described in 1969 from collections made in the southeastern Brazil, but later transferred to the genus *Craspedocarpus* on the basis of morphological features. In the expeditions to the southeast coast of Brazil, between 2016 and 2018, several specimens resembling *Calliblepharis* were find among drifted specimens or growing on intertidal reefs. Additionally, specimens deposited at SP and SPF herbaria (including type material) were also studied. Molecular analysis based on rbcL sequences placed samples previously identified as *Craspedocarpus jolyi* (n=12) from the type locality (Itaoca, Espírito Santo) in *Calliblepharis* sensu lato, supporting the reinstatement of *Calliblepharis jolyi*. The species formed a monophyletic clade with *C. fimbriata, C. occidentalis* and *C. rammediorum*, with intraspecific divergence values ranged between 5.4 to 6.7%. Furthermore, samples collected (n=2) in Ubatuba (São Paulo) represent a new record of *C. saidana* from Atlantic Ocean, a species so far known only from the Indo-Pacific region. Our specimens grouped in a well-supported clade with *C. saidana* from Japan (type locality), with intraspecific divergence of 0.8% for *rbcL* sequences. The results obtained here call attention to the importance of analyzing molecularly the samples of the types localities, rescuing information of the original descriptions to define their taxonomic status. Financial support: FAPESP Proc. 2016/50370-7, CNPq Proc. 440523/2015-0; CNPq Proc. 304899/2017-8.

## OR 04-2

### Revisiting some records of marine red algae belonging to the Delesseriaceae (Rhodophyta) within the South China Sea basin

**Lawrence M. Liao**[*1], Dam Duc Thien[2], Luisito T. Evangelista[3], Xuan Hoa Nguyen[4], Paul John L. Geraldino[5]

[1] *Graduate School of Biosphere Science, Hiroshima University, Japan*
[2] *Institute of Marine Environment and Resources, Vietnam Academy of Science and Technology, Vietnam*
[3] *Botany Division, Philippine National Museum of Natural History, The Philippines*
[4] *Department of Marine Botany, Institute of Oceanography, Vietnam*
[5] *Phycological Herbarium, Department of Biology, University of San Carlos, The Philippines*

The Delesseriaceae are among the most strikingly beautiful elements of the tropical and temperate marine flora. Within the South China Sea basin, at least twelve genera have been reported. Among these are two superficially similar genera characterized by flabellate blades subtended by a prominent rachis, namely *Claudea* Lamouroux and *Zellera* Martens. Three species within the two genera represent identification challenges: *Claudea* batanensis Tanaka (type: Batan Is., Philippines), *C. multifida* Harvey (type: Sri Lanka) and *Zellera tawallina* Martens (type: eastern Indonesia). One of the distinguishing morphological features between them is the placement of the tertiary branchlets which are issued adaxially in *Claudea*, while in *Zellera*, they are positioned abaxially. Current literature showed numerous errors which have been perpetuated to this day. Verification of materials in some herbaria and critical examination of literature revealed that there is only one species to be recognized under each genera and that *C. multifida* should be excluded from the marine flora of this region.

## OR 04-3

### Status and diversity of Eucheumoid in Western Indian Ocean (WIO) region: towards sustainable seaweed farming in Tanzania

**Gloria Kavia Yona**[*1], Janina Brakel[2], Flower Ezekiel Msuya[1], Amelia S. Buriyo[1], Claire Gachon[2]

[1] *Botany Department, University of Dar es Salaam, United Republic of Tanzania*
[2] *Marine Science, Scottish Association for Marine Science, United Kingdom*

The presence of native Eucheumoid seaweed along the Western Indian Ocean (WIO) region is well reported. The native Eucheumoid were harvested in WIO region and exported to Europe, due to the uncontrolled and unregulated collection of native seaweed, the population decreased and export declined. Because of the high demand for carrageenan products, the intensive commercial cultivation of *Eucheuma* and *Kappaphycus* was started. Commercial cultivation of the native Eucheumoid species in Tanzania was not successful due to the poor growth rate of those cultivars. Therefore, varieties of Eucheumoids seeds were imported from the Philippines to Tanzania and cultured by clonal propagation. Currently, the seaweed industry in WIO region is facing several production challenges, which include diseases like ice-ice and epiphytes infestations which decrease the seaweed production. The prolonged vegetative (clonal) propagation of the same plant material leads to genetic impoverishment and makes them vulnerable to diseases and pests. This is further exacerbated by climate change. In this project, we are assessing the status and diversity of wild and farmed Eucheumoid seaweed in Tanzania. This is achieved through a year-round seaweed collection and identifying them with molecular tools. The size and health status of the seaweed are recorded; the pests, epiphytes and ice-ice infected seaweed are taken for investigation in the laboratory. Also, we are collecting and developing seed-banks aimed at providing healthy, high performing indigenous seeds. This project will provide a better understanding of the status of Eucheumoid species found in Tanzania and establishment of a potential and reliable biobank.

## OR 04-4

### Phylogenomics of the Ceramiales: how many families should we recognize?

**Pilar Díaz-Tapia**[*1], Marisa M. Pasella[2], Heroen Verbruggen[2], Christine A. Maggs[3]

[1] *BioCost Research Group, Universidade da Coruña, Spain*
[2] *School of BioSciences, University of Melbourne, Australia*
[3] *Portaferry Marine Laboratory, Queen's University Belfast, United Kingdom*

The order Ceramiales includes about one third of red algal diversity (about 2,700 species). Five families (Ceramiaceae, Dasyaceae, Delesseriaceae, Rhodomelaceae and Sarcomeniaceae) were recognized based on their morphological characters. Early molecular phylogenies based on one or a few genes failed to resolve most of these families as monophyletic and phylogenetic relationships among lineages were unclear. These poorly resolved phylogenies led to a reclassification of the order and the Ceramiaceae was split into five families, while three subfamilies were recognized in the Delesseriaceae and two in the Dasyaceae. The objective of our work is to resolve phylogenetic relationships among the major lineages in the Ceramiales and reassess family level classification. We sequenced and annotated 25 new plastid genomes that were combined with 53 previously published genomes, yielding a dataset with representative species of all major lineages of the Ceramiales. Alignments were made of 205 protein-coding genes and used to construct a maximum likelihood tree, resolving most nodes with full bootstrap support. The families Rhodomelaceae, Ceramiaceae and Wrangeliaceae were resolved as monophyletic and we propose to maintain their current circumscription. By contrast, the families Callithamniaceae, Dasyaceae, Delesseriaceae, Sarcomeniaceae, Spyridiaceae and Inkyuleeaceae require revision. Our results add to the growing body of evidence that plastid phylogenomics can resolve challenging phylogenies in the red algae, providing a useful tool for advancing their natural classification.

## OR 04-5

### *Corallina berteroi* (Corallinales, Rhodophyta) an earlier name for the cosmopolitan *Corallina caespitosa*

**Paul Gabrielson**[*1], Patrick Martone[2], Katharine Hind[3], Wilson Freshwater[4]

[1] *Biology, University of North Carolina, Chapel Hill, United States of America*
[2] *Botany, University of British Columbia, Canada*
[3] *Biology, University of Victoria, Canada*
[4] *Center for Marine Science, University of North Carolina, Wilmington, United States of America*

DNA sequencing has revolutionized our understanding of coralline algal systematics. While there have been changes at higher taxonomic ranks, the most important finding is that species diversity worldwide has been greatly underestimated. Because of the high level of species diversity, along with morphological plasticity and few diagnostic characters, it is nearly impossible to correctly apply historical names to coralline species based on morpho-anatomy. This problem has mostly been solved by DNA sequencing of type specimens. *Corallina caespitosa* (type locality: Devon, England) was named in 2009 for a molecularly distinct species that had been passing under either *Corallina elongata* (now *Ellisolandia elongata*, type locality: Cornwall, England) or *Corallina officinalis* (type locality: European Seas). A partial *rbcL* sequence of 136 base pairs (bp) of type material of *Corallina berteroi* (type locality: Chile) was identical with the same sequence length from the holotype of *C. caespitosa*, and differed by 3 bp from type material of both *C. officinalis*, and *C. pinnatifolia* (type locality:

Orange County, California, USA) and by 7 bp from *E. elongata*. However, over the nearly entire length of rbcL, C. berteroi diverged from *C. pinnatifolia* by only 5 bp (0.36%) whereas it diverged from *C. officinalis* by 2.1% and from *E. elongata* by 7.1%. *Corallina berteroi* Montagne ex Kützing 1849 thus has priority over both *Joculator pinnatifolius* Manza 1937 (basionym of *Corallina pinnatifolia* (Manza) E.Y.Dawson and *C. caespitosa* R.H.Walker, J.Brodie & L.M.Irvine 2009. Thus far, *C. berteroi* is the only cosmopolitan coralline, reported from every continent except Antarctica, with new records from Chile, Hong Kong and South Africa. In North Carolina, USA (Western Atlantic Ocean), it has been found intertidally on rock jetties and subtidally on hard bottom at 14 m depth, indicating its habitat diversity.

## OR 05-1

### Reduced biomass of the kelp, *Saccharina japonica,* affects gonad production of sea urchins for following years off northeastern Japan

**Kousuke Yatsuya**[*1], Yukio Matsumoto[1], Kei Sasaki[1], Norio Shirafuji[1], Daisuke Muraoka[1]

[1] *Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, Japan*

The annual kelp, *Saccharina japonica*, grows along the northeastern coast of Japan, making the coast highly productive for herbivores i.e. sea urchins and abalones. It is well known that gonad production of sea urchins depends on the kelp biomass. The biomass of the kelp along this coast drastically varies each year due to variable environmental factors, i.e. seawater temperature and nutrient concentration, during the period of kelp germination. We carried out a field investigation to elucidate how the gonad yield fluctuates in an environment where the kelp production varies each year. Seaweed biomass and gonad weight of the sea urchin, *Mesocentrotus nudus*, were examined monthly from March 2015 through December 2018. The kelp was abundant and the gonad index (= gonad/ body weight x 100) of the sea urchins increased to more than 20 in 2015. However, in following three years (2016, 2017 and 2018), the kelp was nearly absent from the site and the maximum gonad index was far less than that in the kelp-abundant year (2015). During the kelp-scarce three years, the gonad index decreased year by year, indicating that the effect of a poor algal production on the output of sea urchins' gonad production was accumulative for following years.

## OR 05-2

### Photosynthetic characteristics and chloroplast position of *Ulva conglobata* (Ulvophyceae) under continuous light and dark conditions

**Jayvee Saco**[*1], Akio Murakami[2], Satoko Sekida[3], Ichiro Mine[3]

[1] *Verde Island Passage Center for Oceanographic Research and Aquatic Life Sciences, Batangas State University, The Philippines*
[2] *Research Center for Inland Seas, Kobe University, Japan*
[3] *Laboratory of Cell Structure and Function, Kochi University, Japan*

Chloroplast movement is a physiological strategy among higher plants and algae that provide efficiency for photosynthesis and protection against excessive light. In green benthic algae *Ulva* spp., chloroplast movement has been observed according to the photoperiod. During day time period, the chloroplast was on the surface with correspondingly higher light absorption and photosynthetic rate, while during night time, chloroplast was on the side walls with lower light absorption and photosynthetic rate. Preliminary observation of chloroplast position in *U. conglobata* under continuous light and dark conditions seem to be different from that under the light and dark conditions that alternate periodically. Thus, the study further observed possibly different chloroplast positions under continuous light and dark conditions (20 and 0 µmol photons m-2 s-1, respectively) at 20±2°C for about 4 days. The observation was done using the unialgal culture of *U. conglobata* collected from an intertidal area in Kochi City, Japan. Chloroplast position was observed under epifluorescence microscope and light absorption spectra while the photosynthetic characteristics were determined from photosynthesis-irradiance curve and PAM fluorometry. Under the continuous light condition, chloroplast inclines along the side walls of the cells with lower absorption spectra and thallus absorbance. While under the continuous dark condition, chloroplast inclines along the surface with higher absorption spectra and thallus absorbance. Photosynthetic characteristic under both conditions showed a decreasing maximum quantum yield and increasing respiration and light compensation point. The chloroplast position and photosynthetic responses under continuous dark and light conditions in *U. conglobata* might indicate a sort of light-induced movement under stressful conditions. This observation implies that the chloroplast strategically positioned along the surface of the cells for efficiently absorbing any available light under continuous dark and strategically positioned along the side walls of the cells to avoid damage caused by absorption of excess light under continuous light.

## OR 05-3

### Arctic kelp ecophysiology in a warming winter scenario

**Kai Bischof**[*1], Lydia Scheschonk[1,2], Stefan Becker[3], Jan-Hendrik Hehemann[3], Nora Diehl[1,2], Ulf Karsten[4]

[1] *Marine Botany, University of Bremen, Germany*
[2] *Functional Ecology, Alfred Wegener Institute, Germany*
[3] *Marum, Glycochemistry, University of Bremen, Germany*
[4] *Applied Ecology, University of Rostock, Germany*

Kelps, large brown seaweeds of the order Laminariales, are important ecosystem engineers in Arctic coastal ecosystems. However, knowledge of seaweed ecosystem functioning under Arctic winter conditions is scarce, but essential to understand life strategies and adaptability in an era of climate change. In high latitude coastal systems, kelps, as perennial and primarily photoautotrophic marine plants, have to face several months of darkness, precluding photosynthetic activity. Still, winterly growth of kelp tissue has been observed, fuelled by the consumption of stored carbohydrates. In the Arctic Kongsfjord (Svalbard), a pronounced increase in seawater temperature has been detected since 2006, and is expected to continue. Thus, it is essential to understand temperature related modulation of winterly ecophysiology in Arctic seaweeds. Two species of Arctic kelps (the boreal *Saccharina latissima* and the endemic *Laminaria solidungula*) collected from Kongsfjorden have been studied for the regulation of house-keeping ecophysiological processes (photosynthesis, respiration, carbohydrate turnover) in autumn and just at the end of the polar night. Furthermore, a laboratory experiment mimicking Arctic warming at temperatures of 0°, 4° and 8° C was conducted. In both species more than 80% of the storage carbohydrate laminarin is consumed during winter under current *in situ* fjord temperature, while overall photosynthetic competence is being maintained at high level, i.e. no significant changes, neither in photosynthetic rates after re-illumination nor in pigment concentration, have been detected before and after the polar night. Under

experimental warming, carbohydrate turnover significantly increases with temperature in the endemic kelp *L. solidungula* but not in *S. latissima*. Increased turnover of reserve carbohydrates may imply shortage in energy provision towards the end of the polar night. This points to a competitive disadvantage of the Arctic endemic versus the boreal kelp species in a scenario of warming winter conditions in the Arctic.

## OR 05-4

### Habitat mapping to inform customary protection of key fisheries habitats

**Matthew Desmond**[*1], Chris Hepburn[1], Daniel Pritchard[1,2], Emily Tidey[1], Nigel Scott[2]

[1] *Marine Science, University of Otago, New Zealand*
[2] *Te Ao Turoa, Te Rūnanga o Ngāi Tahu, New Zealand*

Customary Protection Areas (CPAs) in New Zealand are an effective legislative framework that enables the management of coastal fisheries at ecologically and culturally relevant scales i.e. small scale, local management to achieve local objectives. One aspect that currently compromises the effectiveness of CPAs is a lack of understanding of what habitat types are protected, and the relationship those habitats have with the fisheries they support. Kelp-forests and macroalgal habitats underpin the productivity of nearshore fisheries in coastal New Zealand and are therefore of utmost importance to understand. This study couples cutting-edge acoustic mapping approaches (multibeam echosounder) with ecological ground-truthing surveys (SCUBA and drop-camera) to quantify the distribution and community structure of kelp-forest and macroalgal habitats across a diverse geomorphological range within customary protection area boundaries.

## OR 05-5

### Thallus architecture and phenology as tools for understanding ecological impacts of harvesting the economically important seaweed *Ascophyllum nodosum* (Phaeophyceae)

**David Garbary**[*1], Alicia Kennedy[1], Robert Garbary[2]

[1] *Biology, St. Francis Xavier University, Canada*
[2] *Centre for Education in Mathematics and Computing, University of Waterloo, Canada*

Thallus architecture and reproductive phenology were used to evaluate ecological impacts of harvesting *Ascophyllum nodosum* in Nova Scotia by quantifying the distribution of vegetative and reproductive biomass along fronds. We simulated three cutting heights: 12.7 cm (standard used eastern Canada), 25.4 cm (a hypothetical cutting height), and 50% of average frond length. Populations were studied in summer when receptacle biomass was <10% of total frond biomass, and in winter when receptacle biomass was 25-50% of frond biomass. We measured biomass distribution, number of receptacles, and mass of the obligate epiphyte *Vertebrata lanosa* at 10-cm intervals along frond axes. By scaling all fronds to 100%, we assigned the metrics for mass and number in 5% increments to show cumulative distributions from base to apex. Overall, only ca. 30% of frond mass was in the lower 50% of fronds. Similarly, receptacles were primarily in the upper portion of frond canopies. Thus, regardless of cutting height, about 70% of both frond biomass and receptacles were in the upper portion of the frond, and will be removed by harvesting. Harvesting also removes >95% of *V. lanosa*. Since standing crop of beds is determined in summer, the closer to receptacle maturity that harvesting occurs, the greater the proportion of harvest biomass will comprise receptacle mass, with a decreasing impact on receptacle number from the entire population. Harvest of 20% of the standing crop in *Ascophyllum* beds in summer removes ca. 20% of the total reproductive capacity in beds and ca. 20% of the overall population of *V. lanosa*. Increasing the cutting height from 12.7 cm to 25.4 cm would have minimal impact on both retention of receptacles or populations of *V. lanosa*. Impacts of harvesting on reproductive potential of *A. nodosum* help explain changes in algal community structure in harvest beds.

## OR 05-6

### The feasibility and first steps of restoring Australia's disappearing giant kelp *(Macrocystis pyrifera)* forests

**Cayne Layton**[*1], Ceridwen Fraser[2,3], Catriona Hurd[1], Brian Von Herzen[4], Jeffrey Wright[1], Craig Johnson[1]

[1] *Institute for Marine and Antarctic Studies, University of Tasmania, Australia*
[2] *Fenner School of Environment and Society, Australian National University, Australia*
[3] *Department of Marine Science, University of Otago, New Zealand*
[4] *Executive Director, The Climate Foundation, United States of America*

Kelp forests are the foundation of the Great Southern Reef, Australia's continent-wide temperate reef system that supports high levels of biodiversity, endemism and economic value. Unfortunately, in Australia and elsewhere, kelp forests are experiencing habitat loss due to climate change, overgrazing from herbivores, and coastal development. Globally, some of the most dramatic declines have occurred in south-eastern Australia, where up to 95% of giant kelp (*Macrocystis pyrifera*) forests have disappeared in recent decades. The feasibility of ecological restoration of these underwater giants – which can reach heights above 35 m and grow 50 cm per day – is being assessed as a potential element of kelp forest conservation. We outline the key drivers of loss of Australia's giant kelp forests – increasing water temperatures and associated reductions in coastal water nutrients – and discuss the approach to assess restoration efforts. We present novel methods to overcome and alleviate the drivers of giant kelp forest loss, including identification and selection of the most thermally tolerant genotypes/populations, acclimation to current/future conditions and intervention to minimise effects of grazers and competitors after outplanting. We also examine the genetic population structure of the remnant giant kelp patches to examine whether there is any genotypic foundation to thermal performance. Additionally, we illustrate how Integrated Multi-Trophic Aquaculture (IMTA) and permaculture may facilitate kelp growth via utilisation of nitrogenous waste from finfish aquaculture. Finally, we discuss the broader management implications of our findings, and the potential to restore resilience to the sparse remaining giant kelp forests in Australia. The project outlined here is a necessary 'Phase I' of a potential larger project. It aims to assess the feasibility for future up-scaling of restoration and permaculture efforts and fill critical knowledge-gaps to provide scientific rigour and risk-management in these efforts.

## OR 06-1

### Development of scalable coastal and offshore macroalgal farming in New England and Alaska

**Michael Stekoll**[*1], Scott Lindell[2], Charles Yarish[3], Hauke Kite-Powell[4], David Fredriksson[5], Julie Decker[6], Simona Augyte[3], Beau Perry[7], Michael Marty-Rivera[3], Schery Umanzör[3], David Bailey[2], Alf Pryor[8], Trevor Sande[9], Loretta Roberson[10], Clifford Goudey[11], Andrew Drach[12]

[1] *Natural Sciences, University of Alaska SE, United States of America*
[2] *Applied Ocean Physics & Engineering, Woods Hole Oceanographic Institution, United States of America*
[3] *Department of Ecology & Evolutionary Biology, University of Connecticut, United States of America*
[4] *Marine Policy Center, Woods Hole Oceanographic Institution, United States of America*
[5] *Naval Architecture and & Ocean Engineering, United States Naval Academy, United States of America*
[6] *Alaska Fisheries Development Foundation, United States of America*
[7] *Blue Evolution, United States of America*
[8] *Dead Humpy Creations, United States of America*
[9] *Hump Island Oyster Company, United States of America*
[10] *Bell Center, Marine Biological Laboratory, United States of America*
[11] *C.A. Goudey &; Associates, United States of America*
[12] *Institute for Computational Engineering and Sciences, University of Texas at Austin, United States of America*

The United States Department of Energy has a program designated MARINER (Macroalgae Research Inspiring Novel Energy Resources) under their ARPA-E (Advanced Research Projects Agency-Energy) Division. The MARINER program has funded several projects to reach the goal of determining the feasibility of large-scale offshore seaweed farms for eventual biofuel production with the aim of keeping the cost to below 80 USD per dry metric tonne of kelp. Our project's goal was to look at how sugar kelp (*Saccharina latissima*) could be grown on both the east coast of the US and in the Gulf of Alaska. There are three major aspects of the research: determining how to seed longlines with *S. latissima*, designing an economical outplanting method and structure and developing methods to efficiently harvest the product. We assembled a team of experts in seaweed aquaculture, ocean engineers, economic modelers, and representatives from commercial seaweed farms. Aside from the standard method of releasing spores from fertile fronds on cremona-like string, we have attempted to accomplish "direct seeding" on string and on longlines. With direct seeding we initially mass culture male and female gametophytes in the lab. At specific points in the life cycle, we spray or glue the gametophyte or baby sporophytes directly on the longline using various binders to help the plants adhere. This method is especially useful for growing selected kelp strains. Farm system structures have been designed for both Alaska and New England oceanic conditions based around catenary arrays of longlines. The project team has also developed methods for harvest and transport.

## OR 06-2

### Different cultivation practices, to increase the yield of sugar kelp *(Saccharina latissima)*, in an estuarine environment

**Teis Boderskov**[*1], Adrian Macleod[2], Benny Pycke[3], Mette Møller Nielsen[4], Michael Bo Rasmussen[1], Annette Bruhn[1]

[1] *Bioscience, Aarhus University, Denmark*
[2] *Scottish Association of Marine Science, Scottish Marine Institute, United Kingdom*
[3] *Research and Development, SIOEN Industries, Belgium*
[4] *DTU Aqua, Technical University of Denmark, Denmark*

The Scandinavian and European food market is continuously evolving towards more sustainability in the food production. Therefore, the interest for locally produced seaweed is increasing. Inner Danish waters, suitable for the seaweed production, is a large estuary with saline to brackish waters and a strong seasonality in temperature, nutrient and light conditions, affecting the production strategy for *S. latissima*. The study aims to 1) compare yield and growth of *S. latissima* seeded with two different seeding strategies and 2) evaluate the effect of deployment time/site on the growth and yield of *S. latissima* in inner Danish waters. Nursed spore seeded kuralone twine and special textiles (Ribbons, ropes, nets) seeded, 1 day before deployment, using a new sporophyte seeding method, was deployed in September, October and November 2017 on 6 cultivation sites in inner Danish waters, with different exposure, turbidity, nutrient and salinity levels. The length growth and final yield were monitored and compared within and between sites. The yield after one season varied between 0.2-1.6 kg FW m-1 using the spore seeding method and between 0-1 kg FW m-1 using the sporophyte seeding method. The yield on sporophyte seeded nets were up to 2.1 kg FW m-2. Site, deployment month and seeding strategy had a significant effect on the yield of *S. latissima.* The spore seeding method generally resulted in the highest yields, except on the most exposed off-shore location where the yield were equal between methods. The study underlines the importance of a nursery step for the production of *S. latissima* in inner Danish waters, but indicates the possibility of using the new sporophyte seeding technique to seed larger nets, especially for exposed locations.

## OR 06-3

### Biosecurity policy and practice in the global seaweed industry - improving existing frameworks to limit the spread of pests and disease

**Iona Campbell**[*1], Cicilia Kambey[2], Jonalyn Matao[3], Sadock Rusekwa[4], Anicia Hurtado[3], Maria Rovilla J. Luhan[3], Flower Msuya[4], Elizabeth Cottier-Cook[1]

[1] *Blue Economy, Scottish Association for Marine Science, United Kingdom*
[2] *Global Seaweed STAR, Sam Ratulangi University, Indonesia*
[3] *Aquaculture, Southeast Asian Fisheries Development Centre, The Philippines*
[4] *Botany, University of Dar es Salaam, United Republic of Tanzania*

Each year a significant proportion of global food production is lost to pests and diseases. To limit the losses, concerted industry efforts have been made to develop effective biosecurity frameworks through both policy and practices. In aquaculture, the volume of seaweeds produced is second only to farmed fish, and red algal carrageenophytes represent approximately 42%. In recent years, top producing countries of this crop have observed a decline in production despite the growing demand, and one of the major contributing factors to this decline is the observed increases in diseases, such as 'ice-ice' and pest outbreaks of epiphytic algae. As demonstrated in other industries with similar pest and disease challenges, developing biosecurity policies and best farming practices for managing biosecurity risks can help limit the impacts. By conducting both a comparative analysis of biosecurity policies and 'Knowledge, Attitude and Practice' (KAP) surveys with farmers across the top producing countries (Indonesia, Philippines, and the United Republic of Tanzania), this work provides early indications of how biosecurity can be improved to support the productivity of carrageenophyte cultivation. After identifying the biosecurity components and core values in current policies relevant to the seaweed industry, this analysis has identified five main challenges to current frameworks: limited number of regulatory frameworks, limited guidance for implementation of biosecurity measures, insufficient information for decision making, inconsistent terminology, and a lack of explicit inclusion of seaweed cultivation. In addition to policies, farm level biosecurity will be identified through survey work conducted across top producing regions in the Philippines and the United Republic of Tanzania. These results provide an assessment of current biosecurity in the global seaweed industry and, offer early indications of where biosecurity can be strengthened to limit the impact of pests and diseases.

## OR 06-4

### Ecosystem impact of large-scale macroalgae cultivation

**Annette Bruhn**[*1], Teis Boderskov[1], Morten Foldager Pedersen[2], Silje Forbord[3], Bert Groenendaal[4], Dorte Krause-Jensen[1], Sanna Matsson[5], Adrian McLeod[6], Morten Holtegaard Nielsen[7], Mette Møller Nielsen8, Benny Pycke[4], Michael Bo Rasmussen[1], Peter Søndergaard Schmedes[8], Peter Anton Stæhr[1], Sanjina Upadhyay[1], Stiig Markager[1]

[1] *Bioscience, Aarhus University, Denmark*
[2] *Department of Natural Sciences and Environment,, Roskilde University, Denmark*
[3] *Department of Environment and New Resources, SINTEF, Norway*
[4] *SIOEN Industries, AT Sea Technology, Belgium*
[5] *Akvaplan, NIVA, Norway*
[6] *Science, Enterprise and Innovation, Scottish Association for Marine Sciences, United Kingdom*
[7] *Marine Science and Consulting, Marine Science and Consulting, Denmark*
[8] *Danish Shellfish Centre, DTU Aqua, National Institute of Aquatic Resources, Denmark*

Globally, the interest for macroalgae production for food, feed and biomolecules is increasing. Macroalgae production is also increasingly viewed as an instrument for accelerating ecosystem recovery from coastal eutrophication, as well as for climate mitigation. However, since the impact on the marine environment of large-scale macroalgal cultivation is relatively undocumented, the national authorities are reluctant in giving cultivation licences for production in larger scale and for periods longer than 5 years. The EcoMacro study aims to document the impact of large-scale macroalgae (*Saccharina latissima*) cultivation on physical, chemical and biological aspects of the marine environment. During a one-week intensive scientific cruise on-board the research vessel AURORA in early summer 2018, a thorough investigation of the marine environment surrounding two Danish macroalgae cultivation sites of 4 and 100 hectares, respectively, was carried out. In-situ parameters investigated were: Physical (hydrodynamics, light, temperature), chemical (salinity, nutrient concentrations, pH, alkalinity, cDOM, TOC, POM) and biological (pelagic chlorophyll a concentrations, macroalgae standing stock, biofouling, eDNA, benthic fauna) parameters. On-board the research vessel, also 24-hour mesocosm studies were performed, investigating in closed systems the dynamics of photosynthesis, respiration, nutrient exchange, and emission of climate gasses of young (one-year) and older (four-year) individuals of the cultivated *S. latissima*. The cruise was successful in collecting data as planned during the pre-harvest period with maximal biomass standing stock. The results of the cruise are being processed and analysed, and will be presented and discussed in the context of macroalgae production strategies and marine ecosystem management. Conclusions and recommendations for future research and management strategies will be presented.

## OR 06-5

### Intelligent management system for integrated multi-trophic aquaculture (IMPAQT)

**Kati Michalek**[*1], Adrian Macleod[1], Arlene Ditchfield[1], Michele Stanley[1]

[1] *Blue Economy, Scottish Association for Marine Science, United Kingdom*

Aquaculture is growing rapidly in response to increasing protein demands and limited resources from wild fisheries. At the same time, the sector continues to intensify and diversify by modifying systems and practices in place as well as introducing new cultivated species. Here, integrated multi-trophic aquaculture (IMTA; i.e. co-cultivation of fed species (finfish) and extractive species such as seaweeds and/or shellfish), offers a promising approach to improving the sustainable development of the sector by providing environmental benefits, spatial optimization and increased productivity for cultivation sites. The efficient development of the sector will thereby largely depend on improved monitoring and management practices offered to the producers while paving the way to both a more environmentally friendly and higher yielding industry. The project IMPAQT (Intelligent Management Systems for Integrated Multi-Trophic Aquaculture) received funding from the EU H2020 call for 'Sustainable Food Security' to specifically addresses these needs, bringing together 21 partners from academia, technology, and industry; all experts in their respective fields and businesses. The overall objective of the project is to develop and validate in-situ a *multi-purpose* (inland, coastal, offshore production), *multi-sensing* (heterogeneous sensors and new technologies) and *multi-functional* (advanced monitoring, modelling, analytics and decision making) management platform for sustainable aquaculture/IMTA production. Using six pilot sites within and outside of Europe which differ in farm scale, design and species produced (from seaweed only to IMTA farms), the project adopts a holistic approach combining i) autonomous real-time data acquisition and communication, ii) an advanced IMTA model and iii) an integrated management system. IMPAQT outputs will provide monitoring and management guidance to producers specifically, and inform and promote the eco-intensification of EU aquaculture in general.

## OR 06-6

### The gastropod mollusc *Lacuna vincta* as threat to macroalgal aquaculture in NW Europe

**Philip Kerrison**[*1], Lars Brunner[1], Adrian Macleod[1], Adam Hughes[1]

[1] *Science, Scottish Association for Marine Science, United Kingdom*

Colonisation of epibiota organisms on cultivated seaweed can cause biofouling and the degradation of crop quality. This proceeds in two ways. Firstly, the settlement of planktonic phases such as, macroalgal propagules, or juvenile animals e.g. hydroids, bryozoans, gastropods. Secondly, the migration of adult animals into the thallus. We followed summer changes in the epibiota (June-September) on two cultivated kelps, *Saccharina latissima* and *Alaria esculenta*. We report, for the first time, that the veligers of the gastropod mollusc *Lacuna vincta* settled at high density on both species. The median shell length of the snail population rose by 1 mm per month, as they progressively grazed the fronds. Egg masses were evident from July onward. By August (*A. esculenta*), or September (*S. latissima*), complete frond loss occurred. Frond damage caused by herbivorous grazing, will reduce its value as a fresh human food. From July (*A. esculenta*) or August (*S. latissima*), grazing loss overtook frond growth leading to biomass reduction in the crop; this will restrict the harvesting of bulk biomass for bioextractive industries. The stipe of both macroalgae, continued to increase in length and diameter from June to September. Adults of the amphipod *Jassa falcata* colonised both kelps through migration. They curled the frond to form burrows to brood their young. The thinner fronds of *A. esculenta*, appeared particularly susceptible, especially where colonial hydroids were present. In *A. esculenta*, the amphipod density reached 450±100 per frond in July. We discuss how the epibiota colonisation of cultivated seaweed will be influenced by local hydrodynamics, the location of epibiota seedbanks and their natural abundance cycles, and seasonal changes in planktonic abundance. Epibiota composition will also vary with geographical region. These factors should be investigated further in relation to the development of European seaweed aquaculture.

## OR 06-7

### Aquaculture act and cultivation of seaweed and harvesting of kelp in Norway

**Frode Hovland**[*1]

[1] *Aquaculture management, Sogn og Fjordane county counsil, Norway*

Cultivation of seaweed in Norway. I will speak of how we do this from the governments point of view. Key words; The Norwegian Aquaculture Act and the application process. We got the first license in 2014. The status of seaweed farms in Norway and spices that are cultivated, I will show statistics and result so far. Farmed seaweed; sugar kelp, *Saccharina latissima*, wing kelp, *Alaria esculenta*, Dusle, *Palmaria palmate* and sea lettuce, *Ulva lactuca* (onshore). Norway, February 2019, have 370 licenses, 70 of them are sugar kelp. Most of the production is sugar kelp, the other spices are more difficult. Challenges in the cultivation, short grow season and fouling organisms. Other challanges; how to build a marked for the products, processing etc. Ongoing projects; IMTA (integrated multi-tropic aquaculture) "tarelaks" is integrated aquaculture with sugar kelp and salmon, 3 fish farmers are cultivating sugar kelp together with salmon. Møreforskning is running this project. I have result and thoughts from this research. Harvesting of seaweed Norway has a big amount of kelp, that is used to produce the valuable, alginate. I will tell about the management of this marine resource. Keywords here are; The Norwegian Marine Resources Act, we got a new regulation in October 2018, this is a local made regulation and its special for Norway, more information in link under;https://kart.fiskeridir.no/tare. Institute of marine research do assessment of fields for kelp harvesting. They look at coverage of *Laminaria hyperborea* and the amount of sea urchins. This research makes the directory of fishery and the county council to predict sustainable harvesting of kelp. How the harvesting take place. A project (Optimakelp) will register the kelp resources and other species for harvesting.

## OR 06-8

### Wrinkled blades are putatively dominant to smooth ones as revealed by reciprocal crossing and selfing experiments in *Undaria pinnatifida* (Phaeophyceae)

**Tifeng Shan**[*1], Shaojun Pang[1]

[1] *Key Laboratory of Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China*

*Undaria pinnatifida* is a commercially important brown alga. As a sea vegetable of high value consumed in East Asia, the blade surface feature (smooth or wrinkled) determines its commercial value on the market. Smooth blade is more favored. However, how the blade surface feature of *U. pinnatifida* is inherited has been unknown. Two typical mature sporophytes with opposite blade surface feature, each from the wrinkled Russian wild (WRW) and the smooth variety 10#, were employed as the parental individuals for crossing experiments. Six male and six female gametophyte clones were established from each sporophyte, respectively, and reciprocal crossing were conducted. Selfing of the WRW and the variety 10# were also performed. Sporophytes resulting from reciprocal crossing and selfing were cultivated on long-lines at the same area on a seaweed farm in Lüshun, Dalian city, China. All the sporophytes resulting from reciprocal crossing and selfing of WRW were found to possess wrinkled blades, while those resulting from selfing of the variety 10# were found to have smooth blades. It is thus speculated that wrinkled blades are dominant to smooth ones under the cultivation environment in the present study. Further study will be focused on the segregation pattern of blade surface feature in offspring of the crossed sporophyte between the WRW and the variety 10#.

## OR 07-1

### Microencapsulation of chlorophyll from *Caulerpa racemosa* (sea grape) using fish gelatine and arabic gum as coating materials

**Eko Nurcahya Dewi**[*1], Nikolaus Eric Perdana[1], Lukita Purnamayati[1], Maria Dyah Nur Meinita[2]

[1] *Fish Product Technology, Diponegoro University, Indonesia*
[2] *Faculty of Fisheries and Marine Science, Jenderal Soedirman University, Indonesia*

*Caulerpa racemosa* (sea grape) is an edible green macroalga with a high chlorophyll pigment which can be utilized as a natural colorant. However, chlorophyll is susceptible to high temperature, low pH and light. Microencapsulation is a technology that might protect chlorophyll degradation and enhance chlorophyll stability. The aim of present work was to investigate the effect of fish gelatine and arabic gum composition as coating materials on chlorophyll microencapsulation from *Caulerpa racemosa*. Five different formulations of coating materials composed by fish gelatine and arabic gum at ratio 0%:10% (A), 0.5%:9.5% (B), 1%:9% (C), 1.5%:8.5% (D), 2%:8% (E) were applied to chlorophyll microencapsulation process. Yield, solubility, dissolved solids, bulk density, moisture content, chlorophyll levels, a degree of lightness test (L*, a*, b*) and the particle size of microcapsules were observed. The functional group of chlorophylls was analyzed by FTIR and the image on micrographs was visualized by Scanning Electron Microscopy (SEM). The mixture of fish gelatine and arabic gum at ratio 1%:9% was the best formula to encapsulate chlorophyll as a natural colorant. Encapsulation efficiency, surface morphology and particle size showed that powders prepared from fish gelatine and arabic gum might have potential applications in chlorophyll as natural color and its possibility to the development of herbal medicine.

## OR 07-2

### Green extraction of sulphated polysaccharides and alginate from the South African kelp *Ecklonia maxima*, by subcritical water hydrolysis

**Neill Goosen**[*1], Achinta Bordoloi[1]

[1] *Process Engineering, Stellenbosch University, South Africa*

South Africa has large natural resources of the brown seaweed *Ecklonia maxima*, which is a potential raw material for the extraction of value-added compounds. Sulphated polysaccharides have become important in food, nutraceutical and pharmaceutical industries and when purified fetch high market prices. Alginates are valued for gelation properties and biocompatibility in medical applications. *Ecklonia maxima* contains considerable amounts of both of these compounds. Subcritical water hydrolysis (SWH) is a potentially green extraction technique which does not require use of solvents and/or acid, and can recover both the compounds of interest. The work therefore aimed to optimise extraction of sulphated polysaccharides and alginate through solvent- and acid free SWH. *Ecklonia maxima* samples were hydrolysed at 40 bar to ensure subcritical conditions,

according to a central composite experimental design. Experimental factors varied were temperature (100 - 180°C), extraction time (5 – 30 minutes) and water:raw material ratio (10 – 50 mL water/gram), and the response variables measured were overall yield (total dry matter solubilised during hydrolysis), and alginate and total sulphate content in the hydrolysate. SWH resulted in high overall yields (56 - 77 %), and all three response variables showed a high dependence on the hydrolysis temperature. Yield increased as temperature increased and the highest yield (77%) was found at 180 °C, while both sulphate and alginate content were maximised at the lowest extraction temperature of 100 °C. SWH is a promising green extraction technology which delivers high yields of seaweed hydrolysates. However, overall hydrolysis yields are maximised at higher temperatures up to 180°C, while yields of sulphated polysaccharides and alginates are maximised at the lowest hydrolysis temperatures of 100°C, clearly indicating the trade-off between increased overall yield and those of sulphated polysaccharides and alginate.

## OR 07-3

### Nutrient composition, antioxidant activity and blood pressure lowering effect of brown seaweed, *Sargassum polycystum* enriched bread in prehypertensive subjects

**Patricia Matanjun**[*1], Noraidah Haini[1], Yasmin Beng Houi Ooi[1], Tek Song Tan[2]

[1] *Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, Malaysia*
[2] *Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Malaysia*

Hypertension is a strongly prevalent disease globally and is a major risk factor for cardiovascular disease. This study was designed to investigate the blood pressure lowering effect of the brown seaweed, *Sargassum polycystum* enriched bread in prehypertensive subjects. In this open label crossover trial, 12 subjects (young adults) were randomly divided into two groups, who received seaweed bread and control bread (without seaweed) for 8 weeks with two months washout period. *S. polycystum* powder (5 – 25%) was incorporated with wheat flour in producing yeast breads. These formulated breads were examined for their nutrient composition, antioxidant activities and sensory acceptance. The seaweed enriched breads contained moisture (34.65 – 37.57%), ash (1.16 – 4.74%), crude fat (6.27 – 6.43%), crude protein (8.74 – 8.92%), dietary fibre (2.26 – 9.71%) on dry weight basis, besides having high macro-minerals (K, Ca, Mg and Na) content. Seaweed enriched breads possessed higher ($P<0.05$) total phenolic content (5.34 – 13.85 mg PGE/g dry extract), FRAP (ferric reducing antioxidant power) activity (122.89 – 162.06 µM FE/g dry extract) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity (2.09 – 9.07 mg/mL) in comparison to control bread. The sensory tests scores revealed that 10% seaweed bread was highly acceptable among all panelists. In vitro anti-hypertensive assay showed *S. polycystum* powder (0.41 mg/mL) and 10% seaweed bread (3.13 mg/mL) possessed higher ($P<0.05$) ACE-inhibitor capacities than the control bread (25.01 mg/mL). Diet intervention trial showed that subjects consuming seaweed bread resulted in lower ($P<0.05$) systolic blood pressure, diastolic blood pressure, pulse and total cholesterol. On contrary, subjects consuming control bread showed no change ($P>0.05$) in diastolic blood pressure but their systolic blood pressure and pulse were higher ($P<0.05$) than the baseline. In conclusion, this seaweed enriched bread was shown to lower blood pressure and has promising value in preventing hypertension and cardiovascular disease.

## OR 07-4

### By-products from seaweed industry as source of anti-obesity bio-actives: a preliminary *in vitro* study to compare extracts from three seaweed species

**Benoit Queguineur**[*1], Teodora Stoyanova[2], Franck Hennequart[1], Jeremy Brebion[1], Marine Dehail[1], Cherry L Wainwright[2], Giovanna Bermano[2]

[1] *ALGAIA R&D Center, Algaia Ltd, France*
[2] *Centre for Natural Product in Health, Robert Gordon University, Aberdeen, United KingdomSabah, Malaysia*

Seaweed industry concentrates on extracting high yield products, such as pharmaceuticals, food ingredients (such as alginate), animal feed or biofuels, from seaweed biomass. However, following high yield extraction, a significant amount (~75%) of biomass remains un-used despite being rich in valuable chemicals: exploitation of such biomass has, therefore, great potential for increased valorisation of industry by-products. Obesity is a global epidemic and treatment of obesity and associated co-morbidities has a huge strain on health care systems around the world. Further investigation into extracts obtained from industry processing of different seaweed species may result in the identification of bio-actives with the potential to be used for obesity management. The aim of this study is to compare the effect that extracts obtained from red, green and brown algae have on lipid accumulation in an in-vitro model of adipose tissue cells differentiation. 3T3-L1 cells were used to evaluate effects of seaweed extracts on cell viability (MTT assay) and lipid accumulation. Pre-adipocytes were differentiated into mature adipocytes over 10 days, and a range of extracts' concentrations tested. Lipids within cells were stained using Oil Red O and values read at 520nm, using a microplate reader. Over the concentrations' range tested (0.001-10mg/ml), extracts exhibited some degree of cell toxicity at concentration above 1mg/ml, as determined by MTT assay. The use of N-acetyl cysteine (10mM), as positive control, inhibited lipid uptake by approximately 25% whereas seaweed extracts modulated lipid uptake differently. The *in-vitro* adipocytes cell system proved to be suitable for assessing modulation of lipid accumulation by seaweed extracts. Although the full range of biological activities of these extracts has not been fully explored, the obtained results support the need for further studies to elucidate the mechanisms by which seaweed extracts may be useful in the management of obesity.

## OR 07-5

### R-phycoerythrin of selected red algal species from the Baltic Sea

**Mihkel Saluri**[*1], Rando Tuvikene[1]

[1] *School of Natural Sciences and Health, Tallinn University, Estonia*

Phycobiliproteins (red phycoerythrins or blue allophycocyanins and phycocyanins) are hydrophilic, brightly coloured and fluorescent accessory photosynthetic pigment proteins, that capture light energy in cyanobacteria, cryptomonads, glaucophytes and red algae. The proteins, alongside with linker-polypeptides, make up the phycobilisome, which increases the photosynthetic efficiency in the aforementioned organisms. Phycobiliproteins are commonly used biochemistry, food and cosmetic industry, but are commercially only extracted from a few of red algal species. Thus, it is important to see whether additional organisms can be used as a potential source. HPLC coupled to fluorescence and photo-

diode array detectors was used to detect R-phycoerythrin from *Ceramium tenuicorne, Coccotylus truncatus, Furcellaria lumbricalis, Polysiphonia fucoides* and *Rhodomela confervoides*. Analytical standard was used as a reference to quantify the yield of the pigment protein from the red algal species. Also, preparative SEC was used to separate the algal protein mix and for a small-scale R-phycoerythrin production. The isolated proteins were further analysed with a spectrophotometer and fluorimeter. From *C. tenuicorne*, the R-phycoerythrin yield was ~1%, followed by *C. truncatus, R. confervoides, F. lumbricalis.* The lowest yield was obtained from *P. fucoides* – < 0.06% of R-phycoerythrin. The absorbance and fluorescence of the phycobiliprotein varied among the tested seaweeds. Also, low-molecular weight (~35 kDa) red fractions, with similar absorption characteristics to R-phycoerythrin, were isolated from the species. *Ceramium tenuicorne* and *C. truncatus* produced very bright R-phycoerythrin, whereas the pigment protein from *F. lumbricalis* was slightly dimmer. Of the tested species, R-phycoerythrin yield from only *P. fucoides* was too low for commercial production, compared to other seaweeds.

## OR 07-6

### Preparation, characterization and anti-*Helicobacter pylori* activity of algin-based bismuth polyuronate

**Xiancui Li**[*1], Yi Yuan[1], Pengcheng Li[1,2], Xiaolin Chen[1,2], Ronge Xing[1,2]

[1] *Experimental Marine Biological Laboratory, Institute of Oceanology, Chinese Academy of Sciences, China*
[2] *Laboratory for Marine Drugs and Bioproducts of Qingdao, National Laboratory for Marine Science and Technology, China*

*Helicobacter pylori* (Hp) is related to the development of the majority of peptic ulcers and gastric cancers, and its antibiotic resistance is currently found worldwide. The project is aimed to develop a seaweed polysaccharide bismuth-containing drug to prevent infections from drug-resistant Hp. A novel bismuth complex based on marine polysaccharide was designed and successfully prepared. The physicochemical characteristics and rheological properties of bismuth complex were investigated by FT-IR, circular dichroism, and powder X-ray diffraction. The antimicrobial activity of the complex against Hp was investigated by determining the minimum inhibitory concentration (MIC) by using the standard broth microdilution method. The MIC of the complex was 0.5mg/ml and the content of bismuth was 0.075mg/ml. These results suggest that macromolecule bismuth complex has antibacterial activity against Hp. The bismuth complex may be further exploited as a potential anti-Hp drug. The advantage of the novel designed drug is synergistic effect of bismuth and marine macromoleucles on anti-gastric ulcer and anti-Hp activity.

## OR 07-7

### Red seaweed derived natural products for crop protection

**Girish TR**[*1], Sumit Bhose[1], Pooja Malhotra[1], Sri Sailaja Nori[1], Shrikumar Suryanarayan[1]

[1] *R&D, Sea6Energy Private Limited, India*

The rapidly growing world population demands novel ways for doubling the world's food production. However, various constraints such as depletion of cultivable land area and water resources and challenging climatic conditions pose a serious threat to enhancing agricultural productivity. Moreover, direct yield losses of about 20 to 40 % of global agricultural productivity were estimated to be caused by various biotic stresses. Although, the use of synthetic pesticides/fungicides has revolutionized the agricultural productivity, the increasing amounts that need to be used to counter resistance are resulting in high residual levels of chemicals in the final food. This situation has generated an opportunity for developing novel natural solutions for crop plant protection. At Sea6 Energy, we develop seaweed derived molecular solutions that are natural and ecofriendly. Our idea is based on the hypothesis that plants possess several layers of innate immunity that can be activated by certain seaweed derived active ingredients. Based on fractional analysis of the *Kappaphycus* species of cultivated red seaplant biomass, we have identified unique active ingredients that can elicit plant defense pathways. Prophylactic, foliar application of these formulations on various crops including rice, vegetable and horticulture crops revealed about 20-40% reduction in viral and fungal incidences and an associated overall yield improvement of upto 40%. The transcriptome analysis of foliar samples (rice and tomato crops) treated with these formulations revealed several fold up-regulation of genes related to defense response pathways. Overall, our studies suggest red seaweed-based formulations can be effectively exploited to manage plant diseases with an associated overall yield improvement.

## OR 07-8

### Red seaweed oligosaccharides increase productivity, stress and disease tolerance in shrimp (*P. monodon* and *L. vannamei*) and fish (*Tilapia*)

**Hemanth Giri Rao Vantharam Venkata**[*1], Sri Sailaja Nori[1], Shrikumar Suryanarayan[1]

[1] *Research & Development, Sea6 Energy Pvt Ltd, India*

Intensive cultivation of animals reared for human consumption such as shrimp, fish, and poultry makes them susceptible to stresses arising from overcrowding, heat, ammonia accumulation and diseases. Nutritional supplements and biological actives have gained prominence in improving stress and disease tolerance to ensure high productivity. Seaweeds are a rich source of natural biological actives that can be collectively extracted using scalable technologies. We have extracted a unique combination of oligosaccharides from red seaweeds and administered it to commercially cultivated species of shrimp and fish to understand its effect on increasing survival, tolerance to temperature and salinity stresses, as well as resistance to bacterial diseases in lab and field experiments. We find that the oligosaccharides improve survival of *P. monodon* larvae by upto 20%, increase resistance of *P. monodon* larvae to *Vibrio harveyi* infection by at least 50%, and enhance the survival of *P. monodon* post-larvae by upto 35% (relative to control). The same extract also increases both survival and tolerance to salinity stress of *L. vannamei* post-larvae upto 13% and 19% respectively. Interestingly, *Tilapia* fry also showed increased weight gain of upto 58% by including red seaweed oligosaccharides in their diet. *Tilapia* fry also showed lower mortality of upto 37% at double the stocking density (relative to control). Our results indicate that red seaweed oligosaccharides stimulate the immune systems of these animals to sustain the stresses of intensive cultivation. In addition, we have optimized the dosage of these oligosaccharides to achieve a balanced immune stimulation while ensuring that nutritional resources are sufficiently available for growth. We present a natural, renewable, scalable and economically feasible solution that responsibly utilizes marine resources to improve animal health and productivity to meet increasing protein demand without the use of pharmaceutical drugs and antibiotics.

## OR 08-1

### 1-Octen-3-ol, a self-stimulating oxylipin messenger, can prime and induce defense of marine algae

**Haimin Chen**[*1], Rui Yang[1], Juanjuan Chen[1], Qijun Luo[1]

[1] *College of Marine Science, Ningbo University, China*

Short chain oxylipins derived from fatty acids in plants as the main volatile organic carbon have been identified and speculated to playing an important role for plant innate immunity in decades, however, not yet intensively studied and far away established as the fully recognized algae defense signals. Herein, we have provided the first proof of concept study to demonstrate that 1-octen-3-ol, the short chain oxylipin from the red seaweed *Pyropia haitanensis*, can act as a self-stimulating community messenger. The production of 1-octen-3-ol is self-induced via the fatty acid-oxylipin metabolic cycle through a positive feedback upon 1-octen-3-ol treatment. Meanwhile, 1-octen-3-ol might act as a messenger that induces *P. haitanensis* to be in a "primed" state and ready for defense by upregulating the synthesis of methyl jasmonic acid, indole-3-acetic acid, and gibberellin A3. It also adjusts the redox state in cells and promotes primary metabolism and cell division, resulting in host defense activation. These multiple effects of 1-octen-3-ol may explain why *P. haitanensis*, a very ancient lineage within plant kingdom, thrives in the niche of intertidal zones. Acting as a self-amplifying community messenger, 1-octen-3-ol demonstrates for the first time that plant can exert collective actions for its own benefit.

## OR 08-2

### Prophylactic activation of self-defence: a suitable crop protection concept for kelp aquaculture?

**Florian Weinberger**[*1], Gaoge Wang[2], Lirong Chang[3], Rui Zhang[2], Shasha Wang[1], Xiaojiao Wei[2], Esther Rickert1, Peter Krost[4], Luyang Xiao[3]

[1] *Marine Ecology, GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Germany*
[2] *College of Marine Life Sciences, Ocean University of China, China*
[3] *Weihai Changqing Ocean Science & Technology Co., Ltd, Weihai Changqing Ocean Science & Technology Co., Ltd, China*
[4] *Coastal Research and Management (CRM), Coastal Research and Management (CRM), Germany*

Diseases increasingly threaten aquaculture of kelps and other seaweeds. At the same time, protection concepts that are based upon application of biocides are usually not applicable, as such compounds would be rapidly diluted in the sea, causing ecological damage. An alternative concept could be the application of immune stimulants to prevent and control diseases in farmed seaweeds. We here present a pilot study that investigated the effects of oligo-alginate elicitation on juvenile and adult sporophytes of *Saccharina japonica* cultivated in China and on adult sporophytes of *Saccharina latissima* cultivated in Germany. In two consecutive years, treatment with oligo-alginate clearly reduced the detachment of S. *japonica* juveniles from their substrate curtains during the nursery stage in greenhouse ponds. Oligo-alginate elicitation also decreased the density of endobionts and the number of bacterial cells on sporophytes of *S. latissima* that were cultivated on sea-based rafts. However, the treatment increased the susceptibility of kelp adults to settlement of epibionts (barnacles in Germany and filamentous algal epiphytes in China), possibly because protective microorganisms were also eliminated. In addition, oligoalginate elicitation accelerated the aging of *S. japonica* adults. Based upon these findings, oligoalginate elicitation can be a feasible way to provide "environmentally friendly" protection of kelp juveniles in nurseries. However, the same treatment causes not only beneficial, but also unwanted effects in adult kelp sporophytes. Therefore, it is not recommended as a treatment after the juvenile stage is completed. Future tests with other elicitors and other cultivated seaweed species may allow for the development of more feasible applications of targeted defense elicitation in seaweed aquaculture.

## OR 08-3

### Exploring the molecular bases of biotic interactions between *Saccharina latis sima* and an algal endophyte

**Catherine Leblanc**[*1], Qikun Xing[1], Sylvie Rousvoal[1], Erwan Corre[2], Tristan Le Goff[3], Bertrand Jacquemin[3], Philippe Potin[1], Akira Peters[4], Miriam Bernard[1]

[1] *Integrative Biology of Marine Models Laboratory, Sorbonne Université, CNRS, Station Biologique de Roscoff, France*
[2] *FR2424, Analysis and Bioinformatics for Marine Science, Sorbonne Université, CNRS, Station Biologique de Roscoff, France*
[3] *CEVA, Pleubian, Centre d'Etude et de Valorisation des Algues, France*
[4] *Santec, Bezhin Rosko, France*

The kelp *Saccharina latissima* is cultivated in Europe in the open sea, and thereby exposed to potentially harmful organisms, such as *Laminarionema elsbetiae*, a filamentous brown algal endophyte with a high prevalence in European wild kelp populations. Infections by algal endophytes coincide with morphological changes in the hosts, such as dark spots, galls, twisted stipes and blade deformations. However, little is known about the molecular bases of this interaction and its physiological impacts on the hosts. A qPCR-assay was developed for monitoring *L. elsbetiae* infection in kelp tissues. To get further insight into host-endophyte specific interactions, we measured the impact of the endophytes on the hosts' growth. An RNAseq approach was conducted to study the transcriptomic responses of laboratory-grown sporophytes of *S. latissima* and of the occasional host *Laminaria digitata* during the first contact with the endophyte. We showed that *S. latissima* sporophytes get infected by *L. elsbetiae* very early in their life in natural populations of Northern Brittany. In cultivated *S. latissima*, on the other hand, our results suggested that the deployment time in late autumn could be an important factor for avoiding early endophytic infections in kelp farms. In laboratory, co-cultivation of *L. elsbetiae* did not affect the growth of the main host *S. latissima*, but significantly decreased that of *L. digitata* within less than a week. Moreover, differences between both species in the transcriptomic regulation were observed. The molecular detection of endophytes after two weeks of co-cultivation showed a lower prevalence in *L. digitata*, suggesting that defence reactions against *L. elsbetiae* were more efficient in this species under controlled laboratory conditions. Altogether, these differences in physiological responses and molecular cross-talk of the two kelp species with the endophyte could explain specific patterns of host-endophyte interactions observed in natural kelps populations.

## OR 08-4

### Designing a study to investigate observed hnomalies on cultivated seaweed (*Eucheuma*)

**Ivy Matoju**[*1], Georgia Ward[2], Stuart Ross[3], Flower Msuya[1], Amelia Buriyo[1], David Bass[3], Grant Stentiford[3], Juliet Brodie[2]

[1] *Botany, University of Dar Es Salaam, United Republic of Tanzania*
[2] *GlobalSeaweedStar Project, Natural History Museum, United Kingdom*
[3] *GlobalSeaweedStar Project, Centre for Environment, Fisheries and Aquaculture Science, United Kingdom*

Seaweed pests and diseases are economically detrimental to the industry as they reduce the quality of seaweed which reduces the income generated especially for the farmers. Therefore, there is an urgent need to understand them so as to reduce their occurrence. Changes in the environment, temperature in particular, has been noted to be one of the leading causes for disease outbreaks, however, physiological changes of seaweed play a role. Visible anomalies on the seaweed have been observed, and are attributed to causes such as grazing or colonization by other organisms. These anomalies must be studied to identify their role as potential contributors/precursors to the factors that cause seaweed diseases. For example, the causes of the outbreak of "Ice-ice" disease, range from environmental changes to an interacting complex of microbes, perhaps these anomalies create the ideal environment for the microbes to thrive. The objectives include the development of a study that will allow for the understanding of the observed anomalies on seaweeds when growing and whether they contribute to the weakening quality of the seaweeds by enhancing occurrence of pests and diseases. Molecular techniques such as DNA sequencing and histological techniques, currently being tried within the GSS program, will be adapted with slight modifications and field observations on the subsequent effect, disease occurrence, on the select samples will be collected. This study will generate results in histological descriptions and sequencing that allows for identification and characterization especially for microbes (seaweed holobiome). It will also shed light on whether a correlation exists between the presence of anomalies and increase in pests and diseases or lack of. By understanding these anomalies, it becomes easier to design and establish early detection tools to prevent costly outbreaks.

## OR 08-5

### Disease and pest assessment on farmed carrageenophytes in central and southern Philippines

**Joseph P. Faisan, Jr.**[*1], Ma. Rovilla J. Luhan[1], Rema C. Sibonga[1], Anicia Q. Hurtado[1], Janina Brakel[2], Stuart Ross[3], Grant Stentiford[3], David Bass[3,4], Georgia Ward[4], Juliet Brodie[4]

[1] *Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC/AQD), Tigbauan, Iloilo, The Philippines*
[2] *Scottish Association for Marine Science, Oban, United Kingdom*
[3] *Aquatic Animal Health Theme, Centre for Environment, Fisheries and Aquaculture Science, Weymouth, United Kingdom*
[4] *Deparment of Life Sciences, Natural History Museum, London, United Kingdom*

Disease and epiphytic pest outbreaks have been reported to be one of the main causes of seaweed production decline in the Philippines. Up-to-date information on the scope of these problems is crucial to mitigate if not entirely prevent further losses of this major economic industry. However, data on the occurrence of these problems at the farm level is still sparse. This study aims to update the presence of disease and pest infestations on two major seaweed producing regions in the country: Bohol (n=4) in the central Philippines, and Davao del Norte (n=1) and Tawi-Tawi (n=1) in the southern Philippines. The assessment was conducted from October to November 2018. Five percent of the total farmed seaweeds per site were individually checked for the presence of disease and pests. In addition, 24-40 samples were randomly collected from each farm. For each sample, the apical, middle and basal regions of the seaweed were checked and the percentage incidence was recorded. At the same time, environmental parameters including pH, temperature, salinity, light intensity, dissolved oxygen, phosphate, nitrite, nitrate, and ammonia levels were monitored. Results showed that ice-ice and epiphytic pests are the two most common problems observed on the farms. Environmental parameters showed that the results differed from one farm to another. This study revealed that ice-ice and epiphytic pests are now present in most farms where the bulk of seaweeds are being produced in the country. Mitigating strategies should be given priority such as regular monitoring and the use of disease-free planting materials to prevent outbreaks and to minimize further losses.

## OR 08-6

### Transcriptomic analysis of innate immunity-related genes in response to necrotrophic pathogen *Pythium porphyrae* in the red alga *Pyropia yezoensis*

**Lei Tang**[*1], Yunxiang Mao[1]

[1] *College of Marine Life Sciences, Ocean Univesity of China, China*

*Pyropia yezoensis*, one of most economical red algae in East Asia, suffered from biotic stress of oomycete necrotrophic pathogen *Pythium porphyrae* causing red rod disease. However, little is known about immune response in *Pyr. yezoensis*. The present study aimed to provide an overall view of innate immune system in this species. According to the state of cells in *Pyr. yezoensis*, the whole infection process was divided into three stages: no infection, slight infection and severe infection. The transcriptome of different infection stages was analyzed to obtain the molecular defensive mechanism of *Pyr. yezoensis* against *Pyt. porphyrae*. Totally, 2334 up-regulated and 1979 down-regulated genes were identified in all comparison of three infection stages. *In Pyr. yezoensis*, a gene encoding transmembrane C-lectin receptor was characterized as pattern recognition receptors (PRRs) which could activate downstream PAMP-triggered immunity (PTI). Expression of several defensive enzymes (respiratory burst oxidase, chitinase, polyphenol oxidase) and protective enzyme (catalase, peroxidase and superoxide dismutase) were both up-regulated during infection to inhibit *Pyt. porphyrae* hyphae and protect *Pyr. yezoensis* cells. It was validated at level of transcription and physiological that secondary metabolism in *Pyr. yezoensis* was induced by infection. Three up-regulated protease inhibitors were predicted in *Pyr. yezoensis*, which could inactivate protease secreted by pathogen. ETI, as the second line of immunity defense, was triggered after successful effectors-R protein recognition. 29 putative R proteins were predicted in *Pyr. yezoensis*. Comprising with high plant, R proteins in *Pyr. yezoensis* kept ancient protein structure with single typical domain (LRR, NBS or TIR). Plant innate immunity-related genes were first identified in *Pyr. yezoensis*, which played important roles in response to *Pyt. porphyrae* infection. The results indicated that *Pyr. yezoensis*, as an ancient photosynthetic organism, own innate immunity system of PTI and ETI homologous to high plants probably.

## OR 08-7

### Pathogens of New Zealand Bangiales

**Joe Zuccarello**[*1], Nora Diehl[2], Gwang-Hoon Kim[3]

[1] *School of Biological Sciences, Victoria University of Wellington, New Zealand*
[2] *Institute of Biological Sciences, University of Rostock, Germany*
[3] *Department of Biology, Kongju National University, Republic of Korea*

Members of the Bangiales include the economically important crop genus *Pyropia* (Japanese name -Nori). *Pyropia* species, mostly the species *P. yezoensis* and *P. tenera*, are one of the main aquacultural crops in Asia. Like many crops this agriculture is susceptible to pathogen attack that can

seriously reduce crop yield and crop quality. The pathogens that infect *Pyropia* aquaculture have been extensively studied, and among others consist of two main oomycete genera, *Pythium* and *Olpidiopsis*. In Japan the main *Pythium* pathogen is *Pythium porphyrae* (doubtfully distinguishable from *P. chondricola*), which causes red rot disease; and *Olpidiopsis porphyrae* or *O. pyropiae*, once called 'chytrid-disease'. New Zealand is known to be a centre of Bangiales diversity with several genera of leafy Bangiales, once all known as *Porphyra*, and several lineages of filamentous "*Bangia*". We investigated the diversity of Bangiales pathogens around Wellington in New Zealand, using molecular markers and culture studies, and also their host specificity on various Bangiales. On the common *Pyropia plicata* we found a *Pythium* infecting plants in winter that is identical to *Pythium chondricola* from Korea and other parts of the world. This *Pythium* was also able to infect, in culture, many different species and genera of Bangiales but is not able to infect the sporophytic stages ('conchocelis-phase'). Genetic species delimitation methods indicate that one species of *Pythium* is found around the world, without any obvious genetic differences, infecting red algae and should go under the name *P. porphyrae*. This species seems to have a wide host range of Bangiales, and could even be a pathogen of terrestrial plants. We also found *Olpidiopsis* on several Bangiales, which also is similar to the species found in algae in Korea and Japan. These results will be discussed further.

## OR 08-8

### Defense responses triggered by the 22 amino acid peptide (flg22V63) deduced from the n-terminus domain of pathogenic bacterium flagellin in *Saccharina japonica*

**Gaoge Wang**[*1], Lu Zeng[1,2], Xiaoyang Zhang[1,2], Dandan Li[1,2], Lirong Chang[3], Luyang Xiao[3]

[1] *Marine Ecology,, Ocean University of China, China*
[2] *Institute of Evolution & Marine Biodiversity, Ocean University of China, China*
[3] *General Affairs, Weihai Changqing Ocean Science &; Technology Co., Ltd, China*

Flg22, which is a 22 amino acid peptide spanning the most conserved domain derived from the N terminus of flagellin, has been identified as an active elicitor of immune defense responses in both higher plants and in algae. However, N terminal sequences of algal pathogenic bacteria and their elicitor activities in algae are still poorly understood. Therefore, the flagellin genes of both pathogenic- and non-pathogenic bacteria of *Saccharina japonica* were cloned and sequenced. By using luminol-dependent fluorescence detection, the release of $H_2O_2$ was triggered in both gametophytes and young sporophtytes by flg22V63, which was deduced from the N-terminus domain of flagellin of pathogenic bacterium--*Vibrio* sp. 63. Cytological observations of reactive oxygen species (ROS) were consistent with quantitative measurements of H2O2 via a 2', 7'-dichlorofluorescein diacetate (DCFH-DA) fluorescent probe. Meanwhile, 1 μM of both flg22 V63 and flg15 V63 inhibited the growth of the sporelings. Furthermore, the aspartic acid (D) at position 43 of flg22V63 was the active site for its elicitor activity and flg15V63 was the smallest peptide for elicitor. Our results not only help to establish a new experimental model of interactions between pathogenic bacterial flagellin/flg22 – *S. japonica*, which makes up the lack of stable experimental model in this field currently, but also could lay an important foundation for further research in signaling pathways of immune defense responses in *S. japonica*.

## OR 09-1

### Preliminary assessment of the diversity of farmed Eucheumatoids in central and southern Philippines

**Rema C. Sibonga**[*1], Janina Brakel[2], Joseph P. Faisan Jr.[1], Maria Rovilla J. Luhan[1], Claire MM Gachon[2], Anicia Q. Hurtado[1]

[1] *Aquaculture Department, Southeast Asian Fisheries Development Center, The Philippines*
[2] *Blue Economy, Scottish Association for Marine Science, United Kingdom*

Commercial seaweed farming in the Philippines started in the early 1970s. Eucheumatoids, namely *Kappaphycus* spp. and *Eucheuma* spp., are the most cultured species which are the major sources of carrageenan making the Philippines one of the top seaweed carrageenan producing countries and regarded as the major global exporter of semi-refined and refined carrageenan. At present, seaweed farming is being practiced almost all over the country. Different species and varieties of Eucheumatoids are farmed using different farming techniques depending on the site. This study aimed to assess the diversity of Eucheumatoids farmed in some of the major seaweed-producing regions in the Philippines. Different farms in central and southern Philippines were visited and assessed. Samples were collected and their external morphological characteristics were recorded for initial species identification. Results showed that *K. alvarezii, K. striatus* and *E. denticulatum* are the commonly farmed species. Each species has several varieties and colour morphotypes while local names differ from one farm to the other. For *K. alvarezii*, tambalang and cottonii are the common varieties while varieties for *K. striatus* are sacol, bisaya, subol-subol, gadong-gadong and duyan-duyan; and *E. denticulatum* are known as espi or spinosum. Green, brown and red are among the colour morphotypes of the farmed seaweeds. Initial external morphological identification of the collected samples showed high diversity of farmed Eucheumatoids in the Philippines. However, these need molecular analyses to confirm the differences among the varieties and colour morphotypes, which are in progress.

## OR 09-2

### Organellar genome variation architecture and population genetic analysis of chinese *Pyropia yezoensis* assessed by whole-genome resequencing

**Kuipeng Xu**[*1], Yunxiang Mao[1]

[1] *College of Marine Life Sciences, Ocean university of china, China*

*Pyropia yezoensis* is an economically important marine crops and distributed in wide regions of the world. The huge economic value of this algae has generated considerable interest in breeding programs to enhance production of dates. Whole mitochondrial and plastid genomes of *P. yezoensis* strain RZ-58 was sequenced using the PacBio RS II platform. 54 wild *P. yezoensis* collected from Qingdao, Yantai and Weihai of China were resequenced on Illumina Genome Analyzer. SNP genotyping was perfromed on a population scale using a Bayesian approach based SAMtools program. Nucleotide diversity, Tajima's D, and population divergence were calculated using VCFtools. Population structure analysis was conducted by Structure 2.3.4. The updated mitochondrial genome of *P. yezoensis* is 41,692 bp in size with the overall GC content of 32.72%. The plastid genome is 191,977 bp with the GC content of 33.09%. By comparison, the plastid genomes processed conserved genome structure, but mitochondrial genomes were quite different, mainly due to the different patterns of intron distribution in intraspecific level. Futhermore, 463 and 366 high quality SNPs were detected in mtDNA and ptDNA, respectively. The Qingdao wild group has the highest diversity with the mean pi of 0.00348 of mtDNA and 0.000388 of ptDNA.

Structure analysis clustered the whole collections into three subpopulations and results revealed wild *P. yezoensis* grouped as admixed. Accessions from each geographical population were present in at least two clusters. The results indicated that organellar genome SNP marker stands out as a high throughput, high accuracy and low cost method for population genetic analysis. Knowledge of these genetic information is important factors for adequate and efficient conservation of core germplasm and could provide the theoretical basis for breeding strategies.

## OR 09-3

### Molecular investigations of the globally distributed agar-producing genus *Pterocladiella* (Gelidiales, Rhodophyta): how much species diversity? where did it originate? how did it disperse?

**Ga Hun Boo**[*1,2,3], Line Le Gall[1], Kathy Ann Miller[3]

[1] *Institut Systématique Evolution Biodiversité, Muséum national d'Histoire naturelle, France*
[2] *Department of Biology, Chungnam National University, Korea*
[3] *University Herbarium, University of California, USA*

The red algal genus *Pterocladiella* is widely distributed from tropical to temperate seas and currently comprises 24 species. Many species are economically important sources of food, agar and agarose. To understand its contemporary global distribution, we examined the historical biogeography and species diversity of the genus using five organellar gene sequences (mitochondrial *cox1*, *cob* and plastid *psa*A, *psb*A, *rbc*L) from ca. 250 samples, including type specimens. Species delimitation analyses with coalescent-based methods revealed that *Pterocladiella* comprised at least 43 molecular OTUs, nearly doubling the previously recognized number of species. We used a time-calibrated phylogeny based on our concatenated dataset to infer ancestral geographical ranges with biogeographic models. The origin of *Pterocladiella* was estimated to be located in the Western Indo-Pacific (Madagascar and South Africa region), probably in the Tethys Sea, during the upper Cretaceous, followed by subsequent diversification and dispersal to the Atlantic and Pacific oceans. Our analyses showed that the main diversification events, resulting in 20 species, occurred in the Central Indo-Pacific. The South China Sea/Sunda Shelf and Western Coral Triangle regions served as important centers of interspecific and intraspecific diversification for *Pterocladiella*. Today, most species have limited ranges and are restricted to a single marine province.

## OR 09-4

### Gracilariaceae phylogenomics: congruence of organellar and nuclear trees

Goia M. Lyra[2,3], Christopher J. Grassa[2], Cintia Iha[1], José Marcos Castro Nunes[3], Charles C. Davies[2], **Mariana C. Oliveira**[*1]

[1] *Botany, USP, Brazil*
[2] *Department of Organismic and Evolutionary Biology, Harvard University Herbaria, United States of America*
[3] *Laboratório de Algas Marinhas, Instituto de Biologia, Universidade Federal da Bahia, Brazil*

Chloroplast, mitochondrial and nuclear genomes were assembled and annotated for 32, 37 and 33 species of Gracilariaceae (Rhodophyta), respectively, using Illumina Whole Genome Shotgun Sequencing, and were combined with published genomes to infer phylogenies from orthologous gene clusters. Congruent and highly supported topologies were obtained for both organelles and nuclear genomes phylogenies. Mitochondrial and chloroplast genomes were highly conserved in gene synteny and variation mainly occurred in regions where insertions of plasmid-derived sequences (PDS) were found. Our taxonomical sampling supports the presence of three main lineages: *Melanthalia, Gracilariopsis* and *Gracilaria sensu lato. Melanthalia intermedia* was sister to a clade including *Gracilaria* and *Gracilariopsis*, which were resolved as monophyletic clades. Organellar genome architecture shows the loss of the plastid gene *pet*P in *Gracilaria* and the rearrangement position of the gene trnH in the mitochondrial genome of *Gracilariopsis* and *Gracilaria sensu lato*. The recently split of *Gracilaria sensu lato* into four genera, *Gracilaria sensu stricto, Hydropuntia*, and the new genera *Agarophyton* and *Crassiphycus* will be discussed in the light of this large molecular data set and the highly supported phylogenomic trees to date.

## OR 09-5

### Exploring the genetic resources of a marine crop – *Eucheuma* and *Kappaphycus* in the spotlight

**Janina Brakel**[*1], Rema C. Sibonga[2], Gloria K. Yona[3], Joseph Faisan[2], Ivy A. Matoju[3], Georgia Ward[4], Pui Ling Tan[5], Sze Wan Poong[5], David Bass[4,6], Flower E. Msuya[3], Maria R. J. Luhan[2], Anicia Q. Hurtado[2], Phaik Eem Lim[5], Juliet Brodie[4], Claire M.M. Gachon[1]

[1] *Microbiology, Scottish Association for Marine Science, United Kingdom*
[2] *Aquaculture Department, Southeast Asian Fisheries Development Center, The Philippines*
[3] *Botany Department, University of Dar es Salaam, United Republic of Tanzania*
[4] *Department of Life Sciences, Natural History Museum, United Kingdom*
[5] *Institute of Ocean and Earth Sciences, University Malaya, Malaysia*
[6] *Pathology and Molecular Systematics Team, Centre for Environment, Fisheries and Aquaculture Science, United Kingdom*

Seaweed aquaculture is a fast growing industry worldwide. For most terrestrial crops, efforts to control, manage and improve seed stocks, including their resistance against pathogens, has been an ongoing process for millennia. In comparison, seaweed domestication for most seaweed species is much more recent. Consequently, knowledge about the genetic variability of seed or germplasm stocks, how to manage them and their connectivity to wild populations is much less developed. Cultivation of red algae belonging to the genera *Kappaphycus* and *Eucheuma* has become an important source of income for coastal communities especially in many areas in South East Asia and the Western Indian Ocean. Despite this economic importance, knowledge about the genetic variability of the currently used germplasm stocks is sparse. Pioneering work shows that e.g., cultivars of *Kappaphycus alvarezii* cultivated globally belong to a relative small number of haplotypes, indicating a narrow genetic base. Similarly, the understanding of genetic variability in wild populations and their potential as new cultivars is limited. This includes the taxonomy of eucheumoids, population structure of individual species, as well as the connectivity between natural populations and the gene pool of domesticated individuals. In this talk, we present the approaches developed by the international GlobalSeaweedSTAR consortium to address the issues raised above. We are collecting cultivated and non-cultivated eucheumoids from seaweed farms and natural habitats on a global scale, with emphasis on the Philippines, Malaysia and Tanzania, three centres of eucheumoid production. We will line out the following steps in order to assess intra- and inter-specific diversity. Our aim is that novel knowledge on seed stocks will be applicable to an improved management of genetic resources.

## OR 09-6

### Reinstatement of the family Grateloupiaceae (Halymeniales, Rhodophyta) based on the reproductive structures

**Hyung Woo Lee**[*1], Su Yeon Kim[2], Myung Sook Kim[1,2]

[1] *Biology, Jeju National University, Republic of Korea*
[2] *Research Institute of Basic Sciences, Jeju National University, Republic of Korea*

The taxonomic revisions of the red algal family Halymeniaceae based on molecular analyses have been delimitated *Grateloupia* strictly in spite of synapomorphic characteristics on vegetative and reproductive structures among *Grateloupia* and the related taxa. To resolve the taxonomic status of *Grateloupia* and sister taxa from Korea and Japan, we conducted morphological and molecular analyses of total 14 species; a species of *Grateloupia*, eight of *Pachymeniopsis* and five of *Prionitis* from Korea and Japan. These 14 species of three genera are monophyletic with *Dermocorynus*, *Mariaramirezia*, *Neorubra, Phyllymenia* and *Yonagunia* supported strongly in the maximum likelihood and Bayesian analyses. In conclusion, we propose the reinstatement of the family Grateloupiaceae F.Schmitz including our 14 species with *Grateloupia* and the related genera based on synapomorphies of reproductive characteristics definitely distinguished from the real Halymeniaceae clade including *Halymenia* and *Cryptonemia*. The members of Grateloupiaceae shared the reproductive characteristics as follows: tetrasporangia laterally branched from outer cortical cells; simple carpogonial branch, 2-celled, and auxiliary cell ampullae, two or three ordered; specific nutritive filaments originated from gonimoblast initial; pericarp composed of lateral ampullar filaments and secondary medullary filaments.

## OR 09-7

### Taxonomic investigation of *Ralfsia*-like (Ralfsiales, phaeophyceae) taxa in the north Atlantic Ocean based on molecular and morphological data, with descriptions of one novel family and two novel genera and species

**Manuela I. Parente**[*1], Robert L. Fletcher[2], Filipe O. Costa[3] and Gary W. Saunders[4]

[1] *Research Centre in Biodiversity and Genetic Resources, University of the Azores, Portugal*
[2] *Institute of Marine Sciences, University of Portsmouth, UK*
[3] *Centre of Molecular and Environmental Biology, University of Minho, Portugal*
[4] *Centre for Environmental & Molecular Algal Research, University of New Brunswick, Canada.*

In this study we investigated *Ralfsia*-like crusts (i.e. excluding Ralfsia sensu stricto, *Stragularia* spp. and/or Scytosiphonaceae crustose phases) with an emphasis on the North Atlantic Ocean using multi-locus molecular data (COI-5P, ITS and rbcL-3P) combined with morpho-anatomical comparisons of type material and contemporary specimens. Of the four species of *Ralfsia* sensu lato reported in Europe, only *R. fungiformis* is presently recognized as belonging to *Ralfsia* sensu stricto, Ralfsiaceae, with the remaining species, viz. *R. lucida, R. ovata* and *R. verrucosa*, of uncertain taxonomic status. The present study revealed 11 independent genetic lineages of *Ralfsia*-like taxa, which were not assignable to any of the recognized families of the Ralfsiales. To accommodate this undescribed diversity, we propose a new family, including two new genera. One of the genera includes *Ralfsia verrucosa* (Areschoug) as the generitype, a new species and seven undescribed genetic groups requiring additional material. The other genus includes a new species, and also an undescribed genetic group represented by a single sterile specimen from Swanage, UK. Three characteristics differentiate the genera from one another – the abundance of vesicles, non-synchronous development of the plurangia and hair pits arising from both middle and lowers cells of the erect filaments. Species of the new family can be distinguished from *Ralfsia* sensu stricto (Ralfsiaceae) mainly by DNA sequences and by consistently having frequent hair pits, and typically unsymmetrical thalli.

## OR 10-1

### Effects of light quality and temperature on the photosynthesis and pigment content of an edible red alga *Meristotheca papulosa* (Solieriaceae, Gigartinales) from Japan

**Iris Ann Borlongan**[*1], Sayuri Suzuki[2], Gregory Nishihara[3], Ryuta Terada[1]

[1] *United Graduate School of Agricultural Sciences, Kagoshima University, Japan*
[2] *Faculty of Fisheries, Kagoshima University, Japan*
[3] *Institute for East China Sea Research, Organization for Marine Science and Technology, Nagasaki University, Japan*

*Meristotheca papulosa* is one of the popular edible seaweeds that has been commercially used as ingredient for salads in Japan. Since laboratory cultivation is an important means of sustaining such production, this study aimed to assess the effects of different light spectral qualities and temperature on the photosynthesis and pigment content of this alga. Photosynthesis–irradiance (*P–E*) experiments were carried out under red, blue, green, and white light, and at 12, 20, and 28°C, respectively. Maximum net photosynthetic rates (*NPmax*) were highest under green light. Other *P–E* parameter estimates were similar among algae under red, blue and green light, including their lower α (quantum yield of oxygen evolution) and higher saturation irradiances *(Ek*) as compared to those under white light. Such distinct light responses suggest the acclimation potential of the alga to spectral irradiance. Additionally, *NPmax* and *Ek* under white light were highest at 28°C, and lowest at 12°C with characteristic photoinhibition at PAR greater than 150 µmol photons $m^{-2}$ $s^{-1}$. Gross photosynthesis and dark respiration experiments determined over a range of temperatures (8–40°C) revealed that the maximum gross photosynthetic rate (*GPmax*) occurred at 22.1°C, which was within the optimal temperature range of *Fv/Fm* (21.5–23.6°C). Thallus segments were likewise exposed to the different light qualities at 100 µmol photons $m^{-2}$ $s^{-1}$ for 7 days; their chlorophyll a and phycobiliprotein contents were analyzed after this period. Phycoerythrin concentration increased when algae were subjected to blue and green light, while chlorophyll a and phycocyanin showed little variation in all light qualities. Therefore, considering future management prospects for *M. papulosa* mariculture, we suggest that green light could be utilized to enhance photosynthesis. Furthermore, if the aim is to achieve high phycoerythrin content, exposure to blue or green light could be a good alternative.

## OR 10-2

### *Sargassum plagiophyllum* population structure in Southern Thailand

**Anchana Prathep**[*1], Supattra Pongparadon[2], Janmanee Panyawai[1],

Watcharapong Tongwong[1]

[1] Seaweed and Seagrass Research Unit, Department of Biology, Prince of Songkla University, Thailand
[2] Excellence Centre for Biodiversity of Peninsular Thailand, Prince of Songkla University, Thailand

*Sargassum* is the largest brown alga commonly found in the tropics and subtropics, there are 14 *Sargassum* species reported in Thai waters. Here, we investigated development, coverage, reproduction and population structure of *Sargassum plagiophyllum* C.Agardh at Koh Lanta Krabi province, Southern Thailand. The study was carried out monthly during February 2017- April 2018 at 2 sites: Klong Hin and Ba Kan Tiang. Some physical (wave exposure, sediment movement, light intensity and temperature) and chemical parameters (Nitrate and Phosphate) were investigated. We examined *S. plagiophyllum* development; and how environmental parameters could influence *S. plagiophyllum* population, coverage and fertility. *S. plagiophyllum* were categorized into 7 life stages: 1) Pre-juvenile, 2) Juvenile, 3) non-fertile Adult Plant, 4) Fertile Adult Plant, 5) Fertile Plant-Senescent, 6) Senescent and 7) Holdfast-Senescent. The population differed among months; pre-juvenile and juvenile stages were dominant and occurred throughout the year, while non-fertile adult plant was dominant during the rain season; and later stages were dominant during summer months. Interestingly, pre-juvenile stage was dominant twice, during April, just after the sexual reproduction season and again in November during the transitional monsoon season. The population are rather dynamics as they are greatly influenced by the environments. The highest coverage, over 70%, occurred during summer months, then declined afterward, which might be a result from combinations of after plant reproduction and harsh environments during the rainy season. This information is important for further implications of *Sargassum* as a potential bio-resource.

## OR 10-3

### The importance of habitats dominated by macroalgae in the shallow tropical seascape of East Africa

**Christina Halling**[*1], Maria Eggertsen[1], Stina A Tano[1], Dinorah Chacin[2], Charlotte Berkström[1,3]

[1] Department of Ecology, Environment and Plant Sciences, Stockholm University, Sweden
[2] College of Marine Sciences, University of South Florida, United States of America
[3] Department of Aquatic Resources, Swedish University of Agricultural Sciences, Sweden

Compared to other tropical macrophytic habitats, such as mangroves and seagrass meadows, being highlighted as important nurseries and feeding grounds for a diversity of species, tropical macroalgal beds have so far, received significantly less attention. This despite the fact that knowledge about the ecological role of macroalgae and macroalgae dominated habitats is essential for a fully understanding of the structures and functions in the tropical seascape as a whole. However, this ignorance is about to change.Our research indicates, that macroalgae dominated habitats are of significant importance as bioengineers, creating complex habitats structuring the community composition of other organisms including invertebrates and fish. By studying environmental variables and habitat features, species compositions and assemblages, and specific species interactions (i.e. herbivory) in multiple shallow habitats (macroalgal beds, seagrass meadows and coral reefs), explicit habitat patterns have been mapped revealing a complex and often species specific multi-habitat utilize. One example is that the abundance of juvenile fishes in macroalgal beds was twice as high as that of seagrass meadows, while there was no difference in total, subadult or adult fish abundance. Additionally, in macroalgal beds the abundance of commercially and coral reef associated juveniles was higher as was the fish species richness. Such specific habitat use patterns have implications also of the ecological functions and for instance fish production on the larger seascape scale as it highlights the connectivity between various habitats including macroalgal beds and coral reefs through ontogenetic shifts. Our research emphasises the importance of a wide view within coastal management and the need of incorporating, along with the whole seascape and its range of habitats, also the macroalgae beds in management actions.

## OR 10-4

### Traveling in ice cold water: floating algae in Antarctic Peninsula

**Erasmo Macaya**[*1]

[1] Departamento de Oceanografía, Universidad de Concepción, Chile

Several studies have confirmed that dispersal via floating macroalgae contribute to population connectivity, not only for the algae themselves but also for the associated organisms. Floating macroalgae have been found through all major oceans, however information from Antarctica is scarce. The aim of this study was to investigate the presence of floating algae near Doumer Island (DI) (64°52′S; 63°35′W) and Fildes Bay (FB) (62°12'1.09"S; 58°57'3.15"O) in Antarctic Peninsula. Surveys and collections were carried out during February 2017 and January 2018 aboard of a zodiac rigid boat, during daytime navigation under calm weather conditions. Number of floating items (pieces or whole individuals), wet weight (ww) and morphological-reproductive analysis were carried out. Number of floating items and species was higher in FB with more than 5000 items found from 19 species, whereas in DI only 235 items from 13 species were collected. The brown alga *Cystosphaera jacquinotti* was the most abundant in biomass for both sites whereas *Adenocystis utricularis* was the most abundant in number of floating items. The red alga *Palmaria decipiens*, the green algae *Monostroma hariotii* and *Ulva intestinalis* were also abundant in both sites. Most of the species were found reproductive (88%). Among all species *C. jacquinotti* was the only with buoyant structures (pneumatocysts) and others had part or whole inflated thalli (*U. intestinalis* and *Adenocystis utricularis*). The results also indicate that large individuals were able to stay at the surface (e.g. up to 4.6 m long in *C. jacquinotti* and 1.45 m in *P. decipiens*). Some of the floating species have been reported as recent introductions (e.g. *U. intestinalis*), thus dispersal through floating thalli might be an alternative mechanism to spread in Antarctica, especially in a global change scenario where water temperatures and wind speeds will be affected. Funding: FONDAP-IDEAL 15150003

## OR 10-5

### Nitrogen and phosphorus ecophysiology of coralline algae

**Hang Nguyen**[*1], Daniel Pritchard[1,2], Christopher Hepburn[1]

[1] Marine Science, Otago University, New Zealand
[2] Te Ao Tūroa, Te Rūnanga o Ngāi Tahu, New Zealand

The characteristics of nutrient uptake in macroalgae are generally well known but surprisingly little is known about nutrient uptake in coralline algae despite their ecological importance and extensive depth distribution.

This study provides the first information on nitrate, ammonium and phosphate storage and uptake by articulated (geniculate) and crustose (non-geniculate) coralline algae that are dominant features of temperate subtidal rocky reefs. Seawater nutrient concentration and nutrient storage by coralline algae were monitored approximately every two months between June 2016 and November 2017 in a kelp forest in Southern New Zealand. Time-course nutrient depletion experiments were conducted to evaluate the changes in uptake of nitrate, ammonium, and phosphate of two coralline algae species over time in winter and summer and to determine appropriate incubation times for multiple-flask experiments. Kinetic parameters (Vmax and Ks) for ammonium, nitrate, and phosphate uptake were determined for articulated and crustose coralline algae. The uptake of ammonium exhibited a saturable kinetics in both species with Vmax of articulated coralline algae (2.07± 0.32 µmol. gDW-1. h-1) significantly higher than that of crustose coralline algae (0.58 ± 0.17 µmol. gDW-1. h-1). There was no significant difference in ammonium Ks between articulated and crustose coralline algae species (3.43 and 4.60 µM, respectively). A linear relationship with concentration was observed in nitrate and phosphate uptake by both coralline alga groups. Ammonium was considered a preferred nitrogen source for these coralline algae compared to nitrate in both summer and winter. The difference in morphology of coralline algae was considered to be a main factor resulting in the difference in nitrogen and phosphorus uptake rates and kinetic parameters between groups.

## OR 10-6

### Reduction and core bed protection of macroalgae on the coasts of Ojika Island, off Western Kyushu, Japan

**Daisuke Fujita**[*1], Masanori Tagawa[2], Hiroaki Maeda[2], Toshihiro Yamada[2], Syou Sakai[2], Hidemasa Kurosaki[2], Katsunori Nagai[2], Toshiaki Kato[3]

[1] *Marine Biosciences, Tokyo University of Marine Science and Technology, Japan*
[2] *Industry Promotion, Ojika Town Office, Japan*
[3] *Technical Research and Development Laboratory, Nippon Steel & Sumitomo Metal Corporation, Japan*

Ojika Island is the second island from north in the Goto Islands off Western Kyushu (200 km east of Jeju). The shallow waters were dominated by perennial ecklonian and sargassacean forests, which supported high production of abalones for more than 600 years. On the island, town office has monitored the distribution of canopy forming species by line transect method since 1987. In the recent two decades, the above foundation species, particularly ecklonian kelp were almost lost; *Ecklonia bicyclis* and *Sargassum macrocarpum* disappeared in 2002 and 2009, respectively. In place of these perennial canopy-formers, annual canopy-forming *Sargassum* spp. became dominant. The decrease of these algal diet led the drastic reduction of abalone: recent catch is < 1 % of previous stable level before 1980s with the peak of 92 metric ton in 1987. Seawater temperature raised by 2.6 °C in winter but the summer temperature was at most around 28 °C. Monthly monitoring of nutrients revealed short of nitrite (< 2 µmol/l) from February to August. On the rocky shore, *Diadema* was removed to improve feeding grounds of abalone and edible sea urchins, but only small algal tufts were restored. Since 2004, core bed protection was conducted using mounted cages on sandy bottoms at a depth of 7 m. This project revealed that *Ecklonia kurome* could survive and reproduce when they were protected from herbivorous fish (*Kyphosus*). Blades of the kelp were browsed when protruded from the mesh of the cage or when the fish invaded from the space of broken nets. The offspring derived from the protected kelp grew on the hard substrata around the cages, but failed to come of age due to browsing. Therefore, continuous catch of herbivorous fishes and enlargement of protected areas are needed for the restoration of macroalgal beds.

## OR 10-7

### Effects on cover, abundance and development of early stages of brown seaweed *Lessonia spicata* exposed to contaminated coastal waters of central Chile

**Carolina Oyarzo**[*1,2,4], Nicolas Latorre[1,2,3], Cristian Bulboa[1], Loretto Contreras-Porcia[1,2,4]

[1] *Ecologia y Biodiversidad, Universidad Andres Bello, Chile*
[2] *Centro de investigación Marina (CIMARQ), Universidad Andres Bello, Chile*
[3] *Programa de Doctorado Medicina de la Conservación, Universidad Andres Bello, Chile*
[4] *Center of Applied Ecology and Sustainability (CAPES), Pontificia Universidad Católica de Chile, Chile*

The brown seaweed *Lessonia spicata* is an important ecosystem engineer in the lower intertidal levels in the coasts of the center-south of Chile. This species is sensitive to high concentrations of copper, presenting cell damage, growth and spores release reduction. Due to its life cycle and ecological importance this seaweed was selected to evaluate the effect of pollution in three sites near to the industrial park of Quintero (Ventanas, Horcón and Cachagua), located in Valparaíso Region. Quintero Bay corresponds to one of the five sacrifice zones of the country, which in recent years has been the focus of controversy due to industrial pollution. The objective of this research was to evaluate the population structure by morphological characters and the early stage development of *L.spicata*. The population descriptors were cover and morphometric characteristics, in the case of the development, it was recorded from sporulation to the formation of sporophytes. The results indicate that all the sites presented high concentrations of copper and arsenic in water and sediments, suggesting that the pollution have expanded in the bays of the V Region. Significant differences were observed at morphological level and in the in vitro experiments. Among the populations: Ventanas, the site closer to the industrial park, showed the smallest plants with an average of 77 $cm^2$ of holdfast area and 56 cm of longest frond. In addition, Ventanas was the treatment which evidenced a delay in the development and showed the lowest percentage of sporophytes. These results help to clarify the negative effects on the natural populations of *Lessonia spicata* exposed to contaminated waters, additionally this research allows to project the environmental commitment for the continuous industrial activity and the impacts in the biodiversity of those localities. Funded by: FONDECYT 1170881 and APP 2018-1

## OR 10-8

### Photosynthetic responses in two population of the red seaweed, *Gracilaria salicornia*, from Japan and Thailand

**Jantana Praiboon**[*1], Iris Ann Borlongan[2], Yuki Watanabe[2], Narongrit Muangmai[1], Chatcharee Kaewsuralikhit[1], Anong Chirapart[1], Ryuta Terada[2]

[1] *Fishery Biology, Kasetsart University, Thailand*
[2] *United Graduate School of Agricultural Science, Kagoshima University, Japan*

*Gracilaria salicornia* is widely distributed throughout warm temperate seas around the Indian Ocean, and in the Western Pacific. In this study

a comparison of photosynthetic responses of *G. salicornia* from two different biogeographical regions (Japan and Thailand) was determined to better understand its physiology. The effect of photosynthetically active radiation (PAR) and temperature on the photosynthesis of *G. salicornia* was determined by laboratory measurements. Dissolved oxygen sensors and pulse amplitude modulated (PAM) fluorometry were used for the measurements of photosynthetic efficiency. Net photosynthesis-Irradiance (P-E) curves at 24 ℃ revealed that the values of Pmax for Thai and Japanese species were 7.24 and 7.83 μg $O_2$ $mgww^{-1}$ $min^{-1}$(6.38-8.13 and 7.28-8.02 $O_2$ $mgww^{-1}$ $min^{-1}$, 95% Bayesian prediction interval (BPI)), respectively. Photoinhibition was not observed even at 1,000 μmol photon $m^{-1}s^{-1}$. Gross photosynthesis and dark respiration characteristics over a range of temperature (8-36 ℃) revealed optimum temperature for photosynthesis is to be 33.83 ℃ for Japanese species and 36.76 ℃ for Thai species. Dark respiration also increased linearly when temperature increased from 8 ℃ to 36 ℃, indicating that the increase in dark respiration at highest temperature most likely caused decreased in net photosynthesis. The maximum quantum yield (Fv/Fm) was determined using Imaging-PAM were estimated to be 0.55 and 0.53 (0.54-0.56 and 0.51-0.54, 95% BPI) for Thai and Japanese species, respectively. These characteristics of photosynthesis indicated well adaptation result in wildly geographical distribution of this *Gracilaria* species.

## OR 11-1

### Brown algal extracts (AMPEP, Kelpak®) influence growth and thermal resistance in *Saccharina* spp.

**Schery Umanzor**[*1], Sookkyung Shin[2], Michael Marty-Rivera[1], Simona Augyte[1], Charles Yarish[1], Jang K. Kim[2]

[1] *Ecology and Evolutionary Biology, University of Connecticut, United States of America*
[2] *Department of Marine science, Incheon National University, Republic of Korea*

AMPEP and Kelpak® are commercial extracts derived from brown seaweeds. These extracts are commonly applied to increase the performance of land crops and have also been reported to enhance growth and potentially temperature tolerance of seaweed crops. To assess the effects of AMPEP and Kelpak® on the growth and thermal tolerance of *Saccharina latissima* and *S. angustissima* cultivars, we performed two separate manipulative experiments. At the beginning of the experiments, juvenile sporophytes were dipped (i.e. 30 and 60 min) in either AMPEP or Kelpak® solutions of different concentrations (0.001, 0.005, 0.05, 1 and 5 mg·L-1). Sporophytes were then cultivated in half-strength Provasoli´s Enriched Seawater (PES) and allowed to grow at different temperatures (12, 16, 19, 23 and 25°C ±1) for 15 days using a temperature gradient table. Photoperiod was maintained at 12:12 L:D with a photosynthetically active radiation (PAR) of 90±10 μmol m-2 s-1. Following the 15-day period, the surviving sporophytes were transferred to an incubator set at 18°C (i.e. LD50 temperature) to assess for any delayed effect of both AMPEP and Kelpak®. All sporophytes cultured at 23 and 25°C perished during the first 7 days post-dipping. Results also showed a differential response between species and the extract products in sporophytes exposed to 18°C and lower. Sporophytes exposed to AMPEP showed a delayed enhancement in thermal tolerance regardless of the species and thus, had a greater growth than control sporophytes growing at 18°C. On the other hand, sporophytes exposed to Kelpak® showed an immediate response on growth, particularly when exposed to 16°C or lower and in thermal tolerance by showing more than 70% survival at 19°C. These results indicate that the commercial extracts from the brown seaweeds may enhance the growth capacity of Saccharina even when exposed to suboptimal temperatures (e.g. 18-19°C). Further assessments will be presented.

## OR 11-2

### Growth and epiphytic responses of *Gracilaria fisheri* to the seaweed extract ampep under controlled-culture conditions

**Anong Chirapart**[*1], Sunisa Khreauthong[1], Jantana Praiboon[1], Surichay Rattanasaensri[1]

[1] *Fishery Biology, Kasetsart University, Thailand*

*Gracilaria fisheri* is an important red seaweed on the sea coast of Thailand. Cultivation of this seaweed has brought economic benefit to the farmer in the country. However, its low growth and quality is a problematic due to high contamination and epiphyte outbreak. This study was done to examine growth and epiphytic responses of the *G. fisheri* to the seaweed extract (SE) (Acadian marine plant extract powder, AMPEP). Samples were treated with Provasoli Enriched Seawater (PES) and SE at different concentrations (0, 0.1, 0.5, and 1 g $L^{-1}$ SE). The alga growth was determined under controlled-culture conditions at salinity of 30‰, temperature of 25–26°C, and light intensity of 200 μmol photons $m^{-2}$ $s^{-1}$; supplement with and without 5% $CO_2$ treatments. Results showed significant reduction of epiphytes (>90%) in the sample after one week of treatment with 1 g $L^{-1}$ of the SE. Use of the SE significantly stimulated growth of the *G. fisheri* ($p<0.05$). In comparison to the control plant (PES), growth rate of the treated samples with PES+0.1 g $L^{-1}$ SE was 3.40±0.56% $day^{-1}$ obtained in the first week of culture, but increased to 3.84±0.69% $day^{-1}$ when treated with PES+1 g $L^{-1}$ SE. The growth rate was significantly increased to 5.46±1.16% day-1 when supplement treatment of PES+1 g $L^{-1}$ SE with 5% $CO_2$. The algal growth and production responses to the SE were also observed in an indoor controlled-culture tank, which similar results were obtained. This study suggested that use of the seaweed extract AMPEP could enhance growth and inhibit epiphytic attachment in the *G. fisheri* culture.

## OR 11-3

### Micro-propagation of selected, commercial *Kappaphycus* cultivars, and out-planting (nursery studies)

**Majid Khan Majahar Ali** [*1,2]

[1] *School of Mathematical Sciences, Universiti Sains Malaysia, Malaysia*
[2] *Seaweed Research Unit (UPRL), Universiti Malaysia Sabah, Malaysia*

The increasing demand for seaweeds has promoted the designation of the seaweed industry as the third Entry Point Project (EPP), under the National Key Economic Area (NKEA) initiative of the Malaysian government's Economic Transformation Programme (ETP). The farming of carrageenophytes has emerged as a successful enterprise and provides a promising, alternative livelihood option for low-income, coastal communities in several countries. However, over time, the productivity of the crop (carrageenophytes) has declined in some regions due to sourcing of seedlings from single, selected genetic stocks considered to have higher yield potential which resulted in strain fatigue, or loss of vigour. To circumvent the crop productivity issues arising from clonal propagation, the raising of planting materials from the development and success achieved in micro-propagation of *Kappaphycus*, has been initiated

to support the sustainability of selected, farmed carrageenophytes. Four strains of *Kappaphycus* spp. (viz. *K. alvarezii* (tambalang brown and green,) *K. malesianus* (aring-aring) and *K. striatus* (sacol green)) were used in the present study to optimize the use of *Ascophyllum* Marine Plant Extract Powder (AMPEP) as a culture medium ingredient acting as a biostimulant, applied with the addition of terrestrial plant growth regulators (PGRs). Data will be reported on the relative performances of the treated cultivars grown under the same conditions. The use of the brown seaweed-derived extract acting as a biostimulant and as the main ingredient of the culture medium for the micro-propagation of four strains of *Kappaphycus* was highly encouraging and one which may be promoted as a protocol for the economic and commercial mass production of new plantlets (asexual seedlings) which are an urgent requirement for Malaysian seaweed farming to meet its full potential.

## OR 11-4

### Red seaweed derived bioformulation, AgroGain, improves crop yields by enhancing photosynthesis, metabolism and nutrient uptake

**Sri Sailaja Nori**[*1], Sawan Kumar[1], Sam Kuruvilla[1], Shrikumar Suryanarayan[1]

[1] *Research & Development, Sea6 Energy, India*

Increasing demand for food production, worldwide, requires technologies that can enhance agricultural productivity and its quality. Cultivated red seaweeds have conventionally been used till date only to produce the gelling agent, carrageenan. However, we have identified unique bio-active ingredients from red seaweeds which can be explored for improving plant growth and development. Freshly harvested red seaweeds are fractionated into distinct chemical components using proprietary processes and optimally blended to form the bioformulation, AgroGain. The active ingredients of the bioformulation are well characterized, and this enables manufacturing a consistent product. Several field trials were conducted in various agroclimatic zones across multiple geographies and seasons to evaluate the efficacy of the bioformulation. These trials were undertaken at the research facilities of Indian Council for Agriculture Research (ICAR) and by several agri-experts in other countries. In addition, to elucidate the mode of action of AgroGain, tomato (*Solanum lycopersicum*) and rice (*Oryza sativa*) plants were foliar-treated with the bioformulation and leaf transcriptomes were analysed at 24 and 48 hours post treatment by the RNA Seq method. Application of AgroGain at a dose of 500ml/hectare in vegetative and early reproductive phases resulted in yield increases of 10-30%. AgroGain also improved phenotypic characteristics such as root length and volume, plant height, leaf area and improved flowering. Transcriptome studies on tomato and rice plants indicate upregulation of several genes involved in photosynthesis, cell division, metabolism and nutrient uptake. We present a sustainable, scalable and consistent product formulation from cultivated red seaweeds for use in agriculture to improve crop yields

## OR 11-5

### Seaweed extracts for plant growth & nutrition

**Cécile Le Guillard**[*1], Florence Cruz[1], Jean-Claude Yvin[1]

[1] *Laboratory of Plant Nutrition, CMI Roullier, France*

For centuries seaweeds have been used for promoting plant growth and increasing crop yields. In the current context of world population increase, climate change and reduction of chemical inputs, agriculture can benefit from molecules developed by seaweeds to tackle agricultural challenges. CMI Roullier works on the development of innovative seaweeds extracts to offer tailored solutions to solve numerous agronomic issues. Our experimental approach can be summarized as follow: selection of seaweeds based on literature, production of crude extracts (CEs) under various conditions, CEs screening via agronomic trials, selection and characterization of the most promising CEs, extraction optimizations to selectively isolate the desired categories of molecules using appropriate conditions (duration, pH, temperature). Secondary trials on the fields are carried out for efficacy validation. The success of this methodology can be illustrated by extracts from *Ascophyllum nodosum* (AZAL5) and *Fucus serratus* (Phéoflore), designed respectively for foliar and soil application, where aqueous extracts were produced from dried seaweeds in optimized conditions. AZAL5 contains minerals, polyphenols and phytohormones with high amounts of indoleacetic acid and abscisic acid. Even under water-stressed conditions, trials on wheat demonstrated that AZAL5 significantly increases the grain K uptake and leads to a +25 % yield with N supplementation. An enhancement of N, C and S assimilation has also been demonstrated on rapeseed. Another strategy is to stimulate plant growth by acting on the soil microbiome, for instance the addition of Phéoflore to mineral amendment increases the microbial population and promotes favorable microbes, leading to an improved soil fertility thanks to a better degradation of organic matter. On the basis of these conclusive results, we are continuing our screening of algae with agronomic potential and are also aiming at developing sustainable extraction processes to take full advantage of algae potential.

## OR 11-6

### Tropical seaweed extract based agro bio-stimulant 'SAGARIKA' for better crop health and higher crop production

**Shanmugam Munisamy**[*1], Abhiram Seth[1], Tanmaye Seth[1], Tarunendu Singh[2], Arup Ghosh[3]

[1] *Research & Development, AquAgri Processing (P) Ltd., India*
[2] *Research & Development, Indian Farmers Fertilizers Cooperative Limited, IFFCO, India*
[3] *Agronomy and Biofertilizer Group, CSIR-Central Salt and Marine Chemicals Research Institute, India*

Seaweed extract based agricultural bio stimulant that are currently available in the market, are manufactured mainly from brown seaweeds of cold water origin. 'SAGARIKA' a seaweed extract based product of 'AquAgri – IFFCO Bazar' is a tropical seaweed based agricultural bio-stimulant manufactured from *Kappaphycus alvarezii* and *Sargassum* species. CSIR-CSMCRI, Bhavnagar, Gujarat has been the technology provider of this product and has also conducted seaweed sap efficacy trials in collaboration with 43 universities on different crops and agro-climatic conditions of India recording 11% -36 % higher crop yields. SAGARIKA is a repository of micro and macro-nutrients, plant growth regulators (PGR) such as Auxins, Cytokinins and Gibberellins. In addition, it is also a source of thermo-stable glycine, betaine and choline which help boost crop yields, through activation of its internal metabolic processes. Basal application of SAGARIKA granule (@25 Kg/ha) and foliar application of SAGARIKA liquid ( @ 0.25 %) at critical crop growth stages has become an integral part of balanced soil- crop nutrition programme. It has resulted into yield enhancement to the tune of 9.5 to 36.0% in different crops. SAGARIKA has also led to

improvement in crop immunity and its tolerance to various biotic - abiotic stresses. Present investigation on SAGARIKA summarizes its production, nutrient profiling and constituent details as well as its efficacy trial results in different crop geographies. Authors have also attempted to focus on its stress relieving properties and mechanism of action in plants. Key Words: Tropical Seaweeds; SAGARIKA; IFFCO; Agro bio stimulants; Crop production; Crop health

## OR 12-1

### Global climate change and *Macrocystis pyrifera* (Ochrophyta): does environmental history affect the ability to acclimate to future oceanic conditions?

**Pamela Fernandez**[*1], Alejandro Buschmann[1], Jorge Navarro[2]

[1] *Centro i-mar & CeBiB, Universidad de Los Lagos, Chile*
[2] *Instituto de ciencias marinas y limnologicas & centro Fondap (IDEAL), Universidad Austral de Chile, Chile*

Global environmental changes such as warming and acidification of the oceans, OW and OA, respectively, are predicted to have wide-ranging effects on marine organisms. However, coastal marine ecosystems are highly variable. For example, along the Chilean coast, large fluctuations in pH/$CO_2$, temperature and nutrient regime have been well documented as a consequence of e.g., upwelling events. This has led to suggestions that organisms living in highly variable environments (upwelling zones) will be more tolerant to future global (i.e. OW and OA) and local changes (i.e. eutrophication) to those living in more stable environments. Therefore, the aim of this study was to determine the interactive effects of OA and OW on the physiological performance of juvenile sporophytes of *Macrocystis* from populations that are naturally exposed to high environmental variability due to upwelling events (Las Docas: 32°08´S, 71°42´W) v/s coastal areas with more stable conditions (El Tabo: 33°27´S, 71°66´W). To test this, juveniles from both populations, which were previously grown for 3 months in a common garden experiment, were incubated for 3 weeks under three temperatures (12, 16, 20°C) and two $CO_2$ treatments (ambient: 400uatm/pH 7.9, OA: 1200uatm/pH 7.5) with ambient nutrient concentrations. We found that growth rates of both populations were negatively affected by high temperature (20°C), regarding of the $CO_2$ treatment, but significant differences were found among populations (Las Docas > El Tabo). However, photosynthetic rates of both populations were neither affected by temperature nor $CO_2$. Nitrate reductase (NR) varied among populations (Las Docas > El Tabo) but was unaffected by the experimental treatments while carbonic anhydrase (CA) varied among populations (Las Docas < El Tabo) but was also affected by temperature. Our results showed that the environmental conditions to which organisms are naturally exposed will affect their physiological responses to future oceanic conditions, making some ecotypes more resilient than others.

## OR 12-2

### *Diploneis serrate* (Bacillariophyceae), a new diatom species from Kenting, Taiwan, and the structural mechanistic analysis of the striae pattern of Its frustrule under shear, normal and uniform loading

**John Perez**[*1], Yutang Chang[2], Ming Ying Wang[2], Po-Chein Hsiao[3]

[1] *International College / Sustainability Science and Engineering, Tunghai University, Taiwan*
[2] *Institute of Biotechnology, National Chung Hsing University, Taiwan*
[3] *Department of Civil Engineering, National Chung Hsing University, Taiwan*

An understanding of the forces involved in silica cell wall deformation that may be encountered during stress from nutrient depletion and ocean acidification can also help explain the different modes of diatom existence, planktonic or benthic, the molecular and physical forces that have made the diatoms one of the most abundant phytoplanktonic organisms in all the earth's aquatic habitats, and the potential effects of a changing ocean habitat by contemporary global warming patterns. Phytoplanktonic microalgae-diatoms belonging to the genus *Diploneis* collected from a microcosm made of intertidal submerged benthic shore rocks from Kenting National Park, Taiwan were observed at the ultrastructural microscopic scale and classified both morphologically and resolved molecularly using 18s ribosomal DNA as a marker for cladistics. Furthermore, the naked diatom cells void of organic material (frustules of silica) were subjected *in vivo* to shear forces in order to study the proportion of stiffness and strength resistance to cell deformation and ultimate structural failure by fracture. It was observed that stiffness and strength were greatly magnified and improved by ultracellular silicone structures conforming to a triangular beam-like support shape towards the middle of the frustule as opposed to more rectangular beam-like support structures also found in the cell wall, but more towards the poles. When a uniform loading direction was applied, the ratio of stress and strain between the triangular vs. the rectangular shape showed very little improvements in test for maximum stress and maximum deflection suggesting that gains in stiffness and strength do not seem to benefit the strength of the frustule when a uniform loading stress is applied, for example during gliding or sliding on mucilaginous mats that are part of a benthic existence.

## OR 12-3

### Historical climate-driven range shifts shape latitudinal diversity gradients of the marine brown alga *Sargassum thunbergii* in the Northwest Pacific

**Zi-Min Hu**[*1], Jorge Assis[2], Han-Gil Choi[3], Ester Serrão[2], De-Lin Duan[1]

[1] *Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China*
[2] *CCMAR, CIMAR-Laboratório Associado, University of Algarve, Portugal*
[3] *Faculty of Biological Science and Research Institute for Basic Science, Wonkwang University, Republic of Korea*

The centre-periphery hypothesis (CPH) is a 'classic' biogeographical paradigm used to explain genetic diversity patterns across a species' distributional range. However, this hypothesis has seldom been tested in the Northwestern Pacific, where coastal shorelines and hence spatial gradients in marine biodiversity have been sharply influenced by range shifts during the Last Glacial Maximum (LGM) due to thermal and sea level changes. Herein, we chose the brown alga *Sargassum thunbergii* (Mertens ex Roth) Kuntze as a model to explore whether historical factors contributed to latitudinal diversity patterns by linking present population genetic variation to geographical range shifts from the LGM to the present, predicted with species distribution modelling (SDM). We used 11 polymorphic microsatellites to estimate heterozygosity, allelic richness, private diversity, and population differentiation. We found strikingly rich diversity and diverged genetic lineages in the centre-north periphery, contradicting predictions based on the CPH. SDM showed the predominant roles of sea ice thickness, ocean and air temperatures in determining the distributions of *S. thunbergii*, and hindcasted regions of persistence and

extinction during the LGM as well as post-LGM range shifts of 10 degrees of latitude northward. The present centre-north periphery of the species' range consists of populations that survived *in situ* during the LGM or expanded post-LGM, leading to a unique diversity pattern in the Northwest Pacific compared to other marine regions. The congruence between current genetic diversity richness in *S. thunbergii* and persistence during the LGM highlights the importance of niche conservation and unique gene pools at the centre-north periphery to mitigate biodiversity loss under projected climate warming.

## OR 12-4

### Physiological and transcriptomic responses of *Saccharina latissima* from the arctic to dark exposure simulating a warming winter

**Huiru Li**[*1], Lydia Scheschonk[2], Sandra Heinrich[3], Inka Bartsch[4], Klaus Valentin[5], Lars Harms[6], Gernot Glöckner[7], Erwan Corre[8], Kai Bischof[2]

[1] *Department of Aquaculture, Fisheries College, Ocean University of China, China*
[2] *Marine Botany, Faculty Biology/Chemistry, University of Bremen, Germany*
[3] *Molecular Plant Genetics, Institute for Plant Science and Microbiology, University of Hamburg, Germany*
[4] *Functional Ecology, Alfred-Wegener-Institute Helmholtz-Centre for Polar and Marine Research, Germany*
[5] *Polar Biological Oceanography, Alfred-Wegener-Institute Helmholtz-Centre for Polar and Marine Research, Germany*
[6] *Scientific Computing, Alfred-Wegener-Institute Helmholtz-Centre for Polar and Marine Research, Bremerhaven, Germany*
[7] *Institute of Biochemistry I, Medical Faculty, University of Cologne, Germany*
[8] *Station Biologique de Roscoff, plateforme ABiMS, CNRS: FR2424, Sorbonne Université (UPMC), France*

Kelps in the Arctic region are facing challenging natural conditions. They experience over 120-day darkness during the polar night, thus surviving by the consumption of storage compounds without conducting photosynthesis. To the date, studies on algae exposed to prolonged darkness are mainly focused on the physiological states and biochemical mechanisms. The transcriptomics of kelps coping with darkness are poorly understood. Furthermore, the Arctic is experiencing continuous warming because of climate change. The increased temperature enhances the metabolic activity of kelps, which might pose a problem to carbohydrate provision by the end of the winter period. To investigate the life strategy of kelps during darkness in the warming Arctic, we studied the physiological and transcriptomic responses of *Saccharina latissima*, one of the most common kelps in the Arctic, after a two-week dark exposure at two temperatures (0°C and 4°C) versus the same temperatures in the light. Our results showed that darkness had a greater impact on the performances of S. latissima than increased temperature, as indicated by low relative growth rates (%/day) in dark treatments and high numbers of differentially expressed genes (DEGs) between the dark and light treatments. DEGs showed that the transcriptomic regulations of *S. latissima* in darkness involved most of the major metabolic activities, e.g. carbohydrate metabolism, as well as the components of photosynthesis and transporters. Meanwhile, the number of down-regulated DEGs encoding metabolic activities was higher than up-regulated DEGs in the dark treatments. At higher temperature the down-regulation of DEGs was enhanced. In contrast, several DEGs encoding WSC domain-containing protein, responsible for cell wall integrity and stress response, were 3- to 5- log2 fold induced in dark treatments. Our results enlighten the main metabolic pathways of *S. latissima* in the transcriptomic level managing with the prolonged darkness within increased temperature.

## OR 12-5

### Seaweed solution and Carbon Zero Seaweed Town (CØST) with Asian Network of Algae as Mitigation and Adaptation Measures (ANAMAM)

**Ik Kyo Chung**[*1], Jin Ae Lee[2]

[1] *Oceanography, Pusan National University, Republic of Korea*
[2] *Environmental Science & Engineering, Inje University, Republic of Korea*

It is the time to go beyond sustainable development to achieve low carbon green growth. We proposed to build a net zero carbon emission community with seaweed-based mitigation and adaptation measures. During the 2nd Wando Seaweed Expo 2017, we declared the initiation of the Carbon Zero Seaweed Town (hereafter CØST). As the Paris Agreement adopted the Nationally Determined Contributions (NDC), seaweed solutions have been introduced as a new additional paradigm of climate change. Under the CØST we could manage a carbon neutral community by maximizing the ecosystem services provided by the Blue Carbon and Seaweed Aquaculture Beds (SABs), and with other renewable ocean energy options as solutions of the NDC option for all seaweed growing countries. Seaweed Solution and CØST provide sustainable mitigation and adaptation measures in the context of climate change and create the new green jobs and revenues. The Asian Network of Algae as Mitigation and Adaptation Measure (ANAMAM) promotes the international coalition.

## OR 13-1

### Effect of inorganic micronutrients on growth of *Arthrospira (Spirulina) maxima*

**Won-Kyu Lee**[*1,2], Yong-Kyun Ryu[1,2], Taeho Kim[1], Chulhong Oh[1,2], Soo-Jin Heo[1,2], Do-Hyung Kang[1,2]

[1] *Jeju Marine Research Section, Korea Institute of Ocean Science & Technology, Republic of Korea*
[2] *Marine Biology, University of Science and Technology, Republic of Korea*

Underground seawater sampled from Jeju, Korea (so called Jeju magma seawater, JMS) has high amount of inorganic micronutrients as much as 10 times comparison to its amount of natural seawater. Especially, JMS contains high amount of zinc (Z, 0.019 mg/L), iron (F, 0.015 mg/L), manganese (M, 0.008 mg/L), vanadium (V, 0.015 mg/L), selenium (S, 0.013 mg/L) and germanium (G, 0.002 mg/L). Inorganic micronutrients are the essential elements for the photosynthetic metabolism and growth of marine algae. However, there is no information about relation between the micronutrients of JMS and marine algae, just fewer studies of plant cultivations using JMS have been conducted. The purpose of this study was to investigate the effect of the micronutrients on growth of blue-green alga, *Spirulina maxima* in the modified medium using different ratio of inorganic components in JMS. Screening experiment for the growth rate of *S. maxima* was accomplished using spectrophotometric measurement (λ=664 nm) with 64 modified SOT media of each micronutrient combinations. The 6 micronutrient components ratio of the culture media was made each concentration same as JMS under scale-up conditions. Eight modified media were then selected for comparison of biochemical differences and scale-up growth performance under 20 L culture condition for one month. In 10 mL scale culture at 14 days, growth rate of *S. maxima* in the medium containing mixed component of M and V (M+V) showed highest absorbance, mixed M+Z+V and M+Z+F combinations, while the medium component of mixed M+Z+S+G recorded the lowest absorbance, following

Z+V+S+G, and Z+F+V, respectively. In 20 L scale culture, specific growth rate and final biomass production of *S. maxima* in the media of single Z and mixed M+Z showed significantly higher than other media. These results indicated that M and Z have significant effects on photosynthesis and growth rate of *S. maxima*.

## OR 13-2

### Light and balanced growth in *Ulva pertusa*

**Rigoberto Sanchez-Medina**[*1], Alwyn Rees[1], Richard Taylor[1]

[1] *Marine Science, University of Auckland, New Zealand*

Light is an essential resource for photosynthetic organisms including seaweeds. During periods of low photon flux density they can acclimate to achieve a new steady-state, but during the transition their growth is likely to be unbalanced, with some constituents (e.g. chlorophyll) increasing and others decreasing. Expressing growth on a number of different measures of biomass and constituents provides information on these changes and allows direct comparisons to be made because all the values have the same units (d-1). To determine these changes *Ulva pertusa* was cultivated for 30 days in chambers with constant water flow and submitted to 10, 15, 30, 50 and 100% of ambient light using shade cloth. Twice per week they were weighed, trimmed and samples for chlorophyll (Chl) content, fresh (FW), dry weight (DW), ash-free dry weight (AFDW) and total surface area were taken. Mean maximum growth rate was 0.20 d-1 and growth was zero below 6.1% ambient light. Total chlorophyll at 100% ambient light remained steady throughout the experiment with mean values of 3.9 mg g-1 DW. For the 10% treatment there was a marked increase over the first 7 days (to 11.6 mg g-1 DW). There were two distinctive phases regarding total chlorophyll: increase (3-7 days) and steady-state (21-31 days). In the control, all growth rates were similar throughout the experiment, indicating balanced growth. During the 3 to 7 day period the chlorophyll increase was 0.32 d-1. During steady-state the chlorophyll and AFDW growth rates were 30% higher than that for fresh weight, but that for area was 48%. These data suggest that chlorophyll and organic matter were increasing at a faster rate than the standard measure of growth (fresh weight) and area was increasing at a slower rate, because the tissue was becoming thicker (possibly due to the increase in organic matter).

## OR 13-3

### Scaling-up bio-fuel production in the H2020 project MacroFuels

**Jaap Van Hal**[*1], Karla Dussan[1], Ana Lopez Contreras[2]

[1] *Biomass and Energy Efficiency, ECN part of TNO, Netherlands*
[2] *Food and Biobased Research, Wageningen Research, Netherlands*

The MacroFuels project (www.macrofuels.eu) aims to develop seaweed to biofuels processes targeting butanol, ethanol and furfural. The project aims to produce sufficient bio-fuels to perform an engine test. This paper describes the technical feasibility of the scale-up of furanics based biofuels. *Palmaria palmata* (Dulse) was chosen for this fuel due to its high levels of easily convertible and fermentable sugars. *Palmaria* was treated with HCl to release the sugars. To remove the salts from the syrup for fermentation to ABE, membrane purification was used to desalt and concentrate the liquid fraction. The syrup was subsequently fermented to ABE. For the production of furfural from the xylose in *Palmaria*, the same raw liquid was used. This liquor was concentrated *in vacuo*. Furfural was then produced from the liquor in a bi-phasic reactor using toluene as the second solvent. Subsequent reaction with butanol yielded the furanics based fuel mixture. 80% of the sugars could be released into monomers from *Palmaria palmata*. The reactions were performed at the 100 l. scale. The sugars were concentrated to about 50 g./l while reducing the salt concentration in the process. A total of 120 L of syrups were produced and subsequently converted to ABE. In the bi-phasic reactor, furfural was obtained in > 95% yield from the xylose present in the liquor produced at the same scale as above. The reaction of furfural with butanol in the presence of hydrogen yielded a complex mixture of furanic based fuel molecules which can then be tested in a car engine. It is technically possible to produce sufficient amounts of biofuels from seaweed using different fermentation strategies and seaweeds. Sufficient amounts of seaweed based biofuels were obtained to enable engine test under realistic conditions.

## OR 13-4

### Seaweed biorefinery: co-extraction of hydrocolloids, plant bioactive compounds and bioplastics

**Jeremy Brébion**[*1], Franck Hennequart[1], Marine Dehail[1], Fabien Canivet[1], Benoit Queguineur[1]

[1] *Research and Development, ALGAIA, France*

ALGAIA is the main processor of brown seaweeds in France, producing and commercializing alginates and other bioactive ingredients for the global market. ALGAIA is also providing R&D services on macro- and micro-algae to many companies worldwide in order to sustain novel extract development for further valorization of algal wild stocks or cultivated resources (as in the GENIALG project).The present study has been designed to develop the ALGAIA strategy to maximize the use of each ton of seaweed processed in the factory. ALGAIA is producing more than seventy types of alginates, generating many sources of by-products. Several modifications of the production line have been carried out recently in order to make better use of those valuable sources of active compounds. The main approach has been to identify the different sources of by-products generated along the extraction and production of the alginate products. On those different sources, a systematic analytical research of valuable bioactive has been setup. The objective to identify in particular plant biostimulant bioactives in those alginate by-products. Indeed, compounds such as laminarans and fucoidans have been described as active compounds in plant physiology. In addition, the end raw material in this process has been studied for its potential as natural plasticising agent, due to its polysaccharide remaining composition, including cellulose and mineral content. Proper characterization, extraction yields and bioactivities on plants of those extracts will be presented and discussed. Volumes, technical feasibility and limits of such development will also be disclosed and discussed especially within the frame of local circular economy. This overall biorefinery approach and related results will be presented and discussed along with GENIALG results in order to suggest hypotheses of actions for sustainable development of active and natural seaweed extracts targeting several markets.

## OR 13-5

## *Agrobacterium*-mediated genetic transformation of seaweed *Kappaphycus alvarezii* using Gα gene and callus cultures

**Erina Sulistiani**[*1], - Suharsono[2], Ence Darmo Jaya Supena[2], - Miftahudin[2]

[1] *Product Development and Services, SEAMEO BIOTROP, Indonesia*
[2] *Biology, Bogor Agricultural University, Indonesia*

Cottonii seaweed (*Kappaphycus alvarezii* Doty) is one of the most important commercial sources of carrageenan which are widely used in the pharmaceuticals and the food industry. A problem in the cultivation of this seaweed is the ice-ice disease, which is caused by extreme changes in environmental conditions such as temperature and seawater salinity. Gene transformation to produce a transgenic of Cottonii seaweed that are tolerant to environmental stress is potential solution to this problem. Gα gene encodes for the heterotrimeric G protein α subunit is a gene that plays a role in tolerance to biotic and abiotic environmental stresses. This study aimed to: (a) introduce the Gα gene into callus of *K. alvarezii* and regenerate transformed callus to transgenic plantlets; (b) determine the appropriate concentration of acetosyringone and *Agrobacterium tumefaciens* strain for gene transfer into the callus of *K. alvarezii*. The calli were co-cultivated with *A. tumefaciens* LBA4404 or EHA105 that carried pGWB502-Gα expression vector with 35S CaMV promoter and hygromicin resistance gene. The co-cultivations were carried out by treatments of acetosyringone concentrations (0, 20, 40, 60 mg/L). The regeneration of higromycin resistant calli into transgenic plantlets had been successfully performed using somatic embryogenesis techniques. Polymerase chain reaction (PCR) analysis on twenty transgenic plantlets indicated that the Gα gene was successfully introduced into the genomic DNA of all of them. The highest transformation efficiency was in the co-cultivation treatment of 20-40 mg/L acetosyringone (22-28%). The transformation efficiency produced by *A. tumefaciens* EHA105 (23%) was not significantly different from the transformation efficiency produced by the LBA4404 (15%).

## OR 13-6

## Effects of light quantity, quality and duration on the growth rate, pigment composition and photosynthesis of *Spirulina maxima* Geitler

**Jihae Park**[*1], Soyeon Choi[2], Hojun Lee[2], Geonhee Kim[2], Taejun Han[2,3]

[1] *Department of Environmental Technology, Food Technology and Molecular Biotechnology, Ghent University Korea, Republic of Korea*
[2] *Department of Marine Science, Incheon National University, Republic of Korea*
[3] *Ghent University Korea, Republic of Korea*

The ubiquitous existence of cyanobacteria implies that they must have effective adaptation systems closely linked to the production of certain metabolites under stress conditions. The production of metabolites during microalgae growth is affected by light among many other environmental factors. This study presents the effects of light quantity, quality and duration on the growth rate, pigment composition and photosynthesis of *Spirulina maxima* Geitler. Maximum growth rates of *S. maxima* were recorded at 120 µmol photons $m^{-2}s^{-1}$ of all the light colors, while those at the same irradiance were highest in red and lowest in blue. *S. maxima* showed an increasing order of growth rates in 6L:18D>12L:12D>18L:6D> 24L:0D. The lowest amount of Chl-a was observed in blue light, while the contents of Chl a were similar in the other colored lights. After exposure to different photoperiods, the highest Chl a content was collected under 12L:12D. Both APC, PC and PE were found to be maximal in blue light (0.19 mg g-1 for APC and 0.97 mg $g^{-1}$ for PE). Higher contents of phycobiliproteins were found in shorter light periods (6 and 12 h light per day). Fv/Fm values did not show statistically significant difference between the samples grown under different light conditions. There was a similar change trend in NPQ and qP values regardless different prior light treatments showing that the NPQ values increased while qP decreased as actinic photon irradiances increased. The ΦPSII, values in the blue light-grown samples maintained high levels of 0.30-0.33 and were significantly higher than those in red and white light. Maximal ETRmax were recorded at 120 µmol photons $m^{-2}s^{-1}$ in blue whereas they were at 5 µmol photons $m^{-2}s^{-1}$ in red and white light. Maximal Fv/Fm values were recorded under 12L:12D while minimal values were found under 6L:18D and continuous light. The ΦPSII, values were highest under 12L:12D and lowest in continuous photoperiod. Samples exposed to 12L:12D for 7 days revealed the highest ETRmax (124.2). The significance of the results is discussed.

## OR 14-1

## Development of a Swedish kelp industry - the seafarm project

**Fredrik Gröndahl**[*1]

[1] *Sustainable development environmental science and engineering (SEED), KTH, Royale Institute of Technology, Sweden*

Kelp farming circumvents several disadvantages related to land-based biomass production, e.g. the need for fertilizers and irrigation, and does not compete for valuable arable land. In addition, seaweeds grow fast and their farming counteracts coastal eutrophication and may stimulate biodiversity. The overreaching goal of the SEAFARM project is to develop a sustainable system for the use of seaweeds/kelp as a renewable resource in a future bio-based industry for the Swedish society. The trans disciplinary research approach includes techniques for cultivating seaweeds to be used as raw material in a bio refinery for the production of food, feed, bio-based materials and bioenergy. A holistic approach is used where utilization of the resource is maximized in each step of the process cycle. Seaweeds are cultivated at the Swedish west coast and methods suitable for preservation and storage are evaluated. The obtained biomass will subsequently be fractionated in an integrated bio-refinery. The different fractions are thoroughly characterized and recovered for production of biochemical, polymers, and food/feed additives. The residues from the bio refinery are utilized for production of biogas and biofertilizers. In parallel, a general multi-process sustainable assessment method was developed to analyse the overall sustainability of the system. The multi-disciplinary research team collaborates closely with a set of state agencies, commercial enterprises and other stakeholders in the different tasks of the project. The study presented here will summarise the results from the successful five-year project and how the SEAFARM project have boosted the development of a growing new bio based kelp industry in Sweden.

## OR 14-2

## Who gets what from whom? support mechanisms in the Philippine seaweed industry

**Jee Grace B. Suyo**[*1], Josephine Tsui[2], Louise Shaxson[2], Maria Rovilla Luhan[1], Anicia Hurtado[1]

[1] *GlobalSeaweedSTAR, Southeast Asian Fisheries Development Center/Aquaculture*

*Department, The Philippines*
[2] *GlobalSeaweedSTAR, Overseas Development Institute, United Kingdom*

Seaweed farming is not simply a livelihood of last resort but a major economic endeavour of households in the seaweed-producing areas in the Philippines. The potential for high profitability relative to farming effort has made seaweed farming attractive to both women and men. Over the last decade, however, the industry has been struggling from the impacts of fluctuations in production volume and prices with varying repercussions on the key players across the seaweed value chain. Support mechanism, an aspect of social capital, is one of the themes to examine in order to understand the economic situation of the stakeholders. This study analysed the socioeconomic condition and the nature of support mechanism at the production and marketing segments of the seaweed value chain. The data were obtained from interviews with 115 seaweed farmers in Zamboanga City (30), Bohol (38), and Tawi-Tawi (47). The degree of reliance of the seaweed farmers to sources of assistance was determined using a 5-point Likert Scale, wherein scores indicated high or low reliance to either internal or external sources of assistance across the four selected parameters, namely, farm set-up, marketing, financing, and governance. The scores were then used as basis for mapping the interrelationships among the actors in the seaweed production and marketing segments using Social Network Analysis (SNA). Results show a high reliance of the seaweed farmers on internal sources of assistance, e.g. family, all across the selected parameters. Comparison of scores of women and men showed a statistical difference in the sources of assistance for farm start-up with men having more access to external sources ($p<0.01$). The results of this study highlighted the issues concerning access to resources and power relations in the seaweed industry and are integral in the formulation of strategies towards fostering capacities and resilience of the seaweed farmers.

## OR 14-3

### East African seaweed farming; huge potential but vast challenges

**Christina Halling**[*1], Maria Eggertsen[1], Stina A Tano[1], Flower Msuya[2], Amelia Buriyo[3]

[1] *Department of Ecology, Environment and Plant Sciences, Stockholm University, Sweden*
[2] *Institute of Marine Sciences, University of Dar es Salaam, United Republic of Tanzania*
[3] *Department of Botany, University of Dar es Salaam, United Republic of Tanzania*

The seaweed farming in East Africa is at a crossroads. Due to its high productivity and straightforward procedures seaweed farming has been considered as an important measure to reduce poverty in rural coastal communities since it was first introduced to the region from the Philippines in 1989. Soon seaweed farming became the largest contributor to aquaculture production in the region and yet today, in the absence of other large scale aquaculture activities there is a great expansion potential in East Africa, especially when considering the continuous increase in global demand for seaweed products. However, present decline in farming viability, caused inter alia by reduced seaweed productivity and ongoing environmental conditions changes underlines the need for management reconstruction including vitalization of stock. The fact that years of ecological research shows that introduced South East Asian seaweed haplotypes have spread from the seaweed farms and are now established and abundant in the wild outside farms, with uncertain ecological consequences, disputes further introduction of foreign stock. Future seaweed farming will therefore be highly dependent on the identification and commercialisation of indigenous East African seaweed resources. Further recognizes our research on macroalgae dominated habitats the seaweeds' considerable importance for sustaining tropical coastal ecosystems functions and services. Together this point, significantly, at the urgent need for increased knowledge on tropical seaweeds in general, but in East African seaweeds, specifically; both on their farming potential and their ecological importance. Such knowledge is essential for securing future coastal ecosystem services and for facilitating the evolution towards ecologically sustainable and profitable seaweed farming benefitting the local coastal communities in a changing world.

## OR 14-4

### Establishing an aquaculture-based large-scale seaweed industry in Norway: strategic, environmental and economic considerations

Jan Emblemsvåg[1], Nina Pereira Kvadsheim[1], Jon Halfdanarson[1,2], Matthias Koesling[3], Bjørn Tore Nystrand[4], Jan Sunde[4], **Celine Rebours**[*3,4]

[1] *Molde, Møreforsking AS, Norway*
[2] *Department of Industrial Economics and Technology Management, NTNU, Norway*
[3] *Division of Food Production and Society, NIBIO, Norway*
[4] *Ålesund, Møreforsking AS, Norway*

Norway is the leading European producer of seaweed-based products such as alginates and seaweed meal. The industry has a long history, starting with the first alginate research facility established in 1897, but it relies upon wild resources whose potential is limited unless harvested areas are expanded. Research on seaweed has therefore been focusing over the last 10 years into developing cultivation and conservation processes required to convert seaweed biomass into value-added products. So far, the results are products for high-end markets, such as restaurants, but in very modest volumes. The authors therefore conducted a strategic analysis to 1) identify the strategic-, environmental- and economic challenges to overcome when developing such industrial sector, and 2) define the steps required to create a large-scale seaweed aquaculture. Data were collected through stakeholder interviews and by means of relevant literature and databases. After identification of the potential market in Norway, an investigation was conducted in order to understand how Seaweed Protein Concentrate (SWPC) could replace Soya Protein Concentrate (SPC) used today in the Norwegian salmon aquaculture. Activities and drivers of these activities were first identified to design each value chain, and then, analyses were performed to compare cost, economic performance and environmental footprint of both production systems. With today's conditions, and in the foreseeable future, these results confirm that substituting SPC with SWPC in aquafeed leads to an environmental improvement in the case of phosphorus whereas the competitive situation for SWPC over SPC is less clear albeit positive under certain circumstances. Finally, the results are discussed to identify the research efforts needed to establish a successful aquaculture-based seaweed industry in Norway.

## OR 14-5

### Flow cytometer cell sorting as an alternative method for kelp meiospore isolation

**Michael Marty-Rivera**[*1], Simona Augyte[1], Schery Umanzor[1], Charles Yarish[1], Steven Pitchford[2], Gary Wikfors[2], David Bailey[3], Scott Lindell[3]

[1] *Department of Ecology & Evolutionary Biology, University of Connecticut, United States of America*

[2] Northeast Fisheries Science Center, National Oceanic and Atmospheric Administration, United States of America
[3] Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution, United States of America

Currently, isolation of kelp gametophytes relies on manual meiospore isolation techniques, which can be time consuming. We propose an alternative approach using a cell sorting flow cytometer method (FCM). This technique can sort up to 1152 individual meiospores per hour. In comparison, using the manual pipette isolation, 24 gametophytes can be isolated per hour. To evaluate the efficiency and effectiveness of using a flow cytometer (JSAN cell sorter) to isolate viable gametophytes, we collected fertile sorus tissue of *Saccharina latissima*, and induced spore releases of 90 individual parent sporophytes from 13 different sites in the Northeastern coast of North America. Successful releases were then processed for the manual and FCM isolation techniques. Meiospores were identified by the FCM using front scatter, side scatter, and chlorophyll a parameters and sorted based on internal complexity, meiospore size and auto fluorescence. We compared the success rate of isolations, and viability of isolated spores obtained with both techniques. Using the FCM, we isolated 192 (two 96 well plates) meiospores from each of the individual parent sporophytes. For the traditional – manual method, we pipetted spores from a freshly released spore solution onto coverslips and once these germinated, we isolated an average of 24 gametophytes from the same parental sporophytes. Our results show an average yield of 23 viable gametophytes (11.9%, SD= 5.7) via FCM isolation, while the traditional method had a yield rate of 6 gametophytes (25.6%, SD = 11.1). FCM has the potential to be an efficient isolation method for starting clonal cultures of spore producing macroalgae. This approach makes it possible to obtain large number of cultures at a faster rate and lower cost which is ideal for a breeding program.

## OR 14-6

### Institutional dynamics of industry structuration: seaweed aquaculture's emergence in the United States

**Holly Cronin**[*1], Brian E. Robinson[1]

[1] Geography, McGill University, Canada

The burgeoning seaweed aquaculture sector in the United States (US) is seemingly sidestepping several of the environmental, social, and regulatory hurdles which have long hindered growth of finfish mariculture in the US. In less than a decade, a promising institutional foundation for domestic seaweed farming has begun to emerge. This within-case analysis investigates people, organizations, places, and moments that have played key roles in developing a viable US seaweed aquaculture industry. Here we present how the formation of novel institutions--defined as structures and rules of a social system--can be channeled to foster the emergence of a new form of industry. Investigation of the dynamics of a young sector allows for the complementary use of archival and ethnographic research methods to capture the trajectory of industry structuration. The results of this research identify processes of institutional development together with causal relationships and patterns that may be analytically generalizable as institutional drivers across emerging seaweed aquaculture and other resource-based industry contexts. These findings address an identified gap in organizational scholarship on institutional entrepreneurship by providing examples of how entrepreneurs in a new market category influence the development of institutions such as regulations, standards, certifications, and cultural perceptions. This work also provides insights into the influence of social and environmental movements on the growth of a nascent industry and identifies connections between resource characteristics and institution-building. From the findings of this investigation, recommendations are outlined to inform future development of the global seaweed sector and resource-based industries more broadly. sea surface (0.197 ± 0.052 vs. 0.045 ± 0.027, respectively). We further evaluated NIR reflectance for 18 other satellite images of floating *Sargassum* and cultivated seaweed from different parts of the world, obtaining in all cases significant and similarly high differences. Additionally, for three cultivated floating seaweed plantings on the Pacific of Costa Rica, we measured highly significant differences in fraction of photosynthetically active radiation received on the surface that penetrated to 0.5 m depth between under seaweeds (0.266 ± 0.029) and under no seaweeds (0.847 ± 0.025). These results evidence that seaweeds floating on the sea surface significantly alter solar radiation relations. To directly contribute in counteracting planetary and, particularly, ocean warming is yet another ecosystem service from floating seaweed cultivation, as well as a promising bio-geoengineering tool for solar radiation management.

## OR 15-1

### Exploring solar radiation relations of seaweeds floating at sea: a tool to counteract ocean warming?

**Ricardo Radulovich**[*1], Andrés Sánchez-Sanabria[1], Tatiana Vásquez-Alvarado[1]

[1] Department of Biosystems Engineering, University of Costa Rica, Costa Rica

The ocean has low reflectivity and is a major sink for solar radiation. Ocean warming is a particularly relevant subset of planetary warming. Floating seaweed cultivation is a growing activity that may eventually cover significant sea areas. By reflecting a higher portion of insolation than the surrounding water while inhibiting solar radiation entry into the water, seaweed cultivation may contribute to counteract ocean and planetary warming. To evaluate that we analyzed solar radiation relations of nine satellite images of *Sargassum* seaweed masses floating away from the Caribbean/Gulf of Mexico coasts, comparing signals to surrounding sea using paired t-test. In all cases both digital numbers and reflectance values for visible light (with band 8 integrating bands 3 and 4 at 503 - 676 nm) and near infrared (NIR, band 5, 851 - 879 nm) were significantly larger for floating seaweed than for the surrounding sea, evidencing a higher albedo. The differences for NIR were particularly large, with seaweed NIR reflectance values averaging 4.38 times those for bare

## OR 15-2

### A model to assess the relative impacts of multiple climate stressors on macroalgal productivity

**Janet Kübler**[*1], Steven R. Dudgeon[1]

[1] Biology, California State University at Northridge, United States of America

We developed a model of simultaneous drivers of photosynthetic rates of macroalgae with carbon concentrating mechanisms (CCM). *Ulva* spp., having a well characterized CCM, served as our model alga to explore the relative impacts of ocean acidification (OA), warming, light intensity (PFD) and boundary layer thickness on photosynthetic demand for

inorganic carbon and regulation of CCMs. Model output can be compared to empirical data from experiments manipulating these factors. OA is hypothesized to enhance productivity, but the effects are small relative to responses to temperature or light intensity. Most carbon fixed at boundary layer pH<8.7 can be supplied through conversion of $HCO_3$- to $CO_2$ by external carbonic anhydrase (CAext) under all combinations of conditions. Any energetic bonus from downregulation of active transport of Ci with OA would only be evident when photosynthetic rate is optimized by the other stressors. The proportion of carbon fixation directly from diffusive uptake of dissolved $CO_2$ as a function of boundary layer pH fits an exponential function with coefficients that varied slightly with additional stressors. Across the range of combinations of environmental conditions, every 0.1 decline in pH corresponded to a ~20% increase in the proportion of total DIC uptake directly by diffusion of dissolved $CO_2$. We estimate the increase in daily growth rate associated with a decline in pH of 0.4 units (e.g., from 8.1 to 7.7, corresponding to $pCO_2$'s of ~400 and ~950 µatm, respectively), ranged from 0.2% to ~4% per day depending on light intensity, temperature and boundary layer thickness. Estimates are consistent with reported values of growth rate in response to OA, filling gaps between and unifying empirical observations. The model predicts that discrimination against $^{13}C$ due to mode of Ci acquisition is proportional to $pCO_2$ and inversely related to temperature, diffusion pathlength and light intensity (up to saturating light intensity).

## OR 15-3

### Globally driven changes in carbon chemistry change threatens a rare seaweed community and associated industry in the Baltic Sea

**Liina Pajusalu**[*1], Gerli Albert[1], Evie Fachon[2], Christopher D. Hepburn[3], Jonne Kotta[4], Kiran Liversage[4], Tiina Paalme[1], Anneliis Peterson[4], Daniel W. Pritchard[3], Arno Põllumäe[1], Kaire Torn[1], Georg Martin[1]

[1] *Department of Marine Biology, Estonian Marine Institute, University of Tartu, Estonia*
[2] *Biology Department, Woods Hole Oceanographic Institution, United States of America*
[3] *Department of Marine Science, University of Otago, New Zealand*
[4] *Department of Marine Systems, Estonian Marine Institute, University of Tartu, Estonia*

Wild harvest of seaweeds supports small scale, high value industries in a number of regions in the world. The amount of seaweed biomass available for harvest varies in time and space and dependent on different environmental factors. The direct connection between the productivity of seaweed-based industries and environmental drivers of marine productivity, means that global changes in the marine environment such as ocean warming and ocean acidification could strongly impact on wild harvest. So far, the information is entirely lacking on how increasing $CO_2$ concentrations in seawater, could impact on wild harvest situations. The present study focuses on a mixed red algal community of loose-lying *Furcellaria lumbricalis* in close association with *Coccotylus truncatus* in the West Estonian Archipelago Sea, NE Baltic Sea. In Estonian coastal waters the wild harvest of *F. lumbricalis* started in 1960s and it has been since used as raw material for furcellaran production. The aim of this study was to determine how ocean acidification may impact the balance of these two red algal species on wild harvest situations. Mechanistic assessment of the carbon physiology of *F. lumbricalis* and *C. truncatus* are used to predict productivity and competitive interactions between these species in a high-$CO_2$ world. Carbon use strategies in macroalgae were determined by analyzing the natural abundances of carbon isotopes (δ13C), pH drift and photosynthesis vs. dissolved inorganic carbon (DIC) curves. Our results showed that *F. lumbricalis* (operating with $CO_2$ concentrating mechanisms (CCMs)) has significantly lower photosynthetic rates under different DIC concentrations compared to *C. truncatus* (non-CCM). Therefore, ocean acidification has the potential to influence the productivity of *F. lumbricalis* and thus also sustainability of the wild harvest of this community and the quality of product provided.

## OR 15-4

### Better local management of kelp forests supports ecosystem resilience in a changing ocean

**Christopher Hepburn**[*1]

[1] *Marine Science, University of Otago, New Zealand*

We have degraded the local environments we live in and these changes are now being modulated by anthropogenic forcers operating at broad regional and global scales. Advising people, responsible for a bay, an island or even a small country, why and how they can mitigate the local impacts of global environmental change is difficult. There is a reason for this, dealing with ecosystem degradation at a local-scales are rightly priorities for guardians of our coastal ecosystems when political interventions to deal the drivers of environmental change seem beyond even the largest government agencies. Kelp forests in southern New Zealand provide many values to local people. More than 10 years of research has investigated how *Macrocystis pyrifera* kelp forests and their associated values will be affected by stressors driven by local and broader processes. Kelp forests in New Zealand are being subjected to invasion by the kelp *Undaria pinnatifida*, sediment loading, ocean warming and acidification This research has been strongly supported by community managers of local fisheries and the findings have been shared extensively with the local community. The most important finding from this work is that intact and properly functioning ecosystems will bring benefits today and provide the best chance of successful outcomes for the future. Local management approaches to prevent and control invasive species and reduce sediment are our best chance to deal with broader changes due to warming and ocean acidification. Coastal seas can be resilient against global change and the more extreme climate, but degradation of habitats and over exploitation of fisheries can put these ecosystems and the values they provide at greater risk.

## OR 15-5

### Investigating the potential impact of ocean warming events on the productivity of two South African kelp species; the ecologically dominant *Ecklonia maxima* and the rare *Macrocystis pyrifera*

**Mark Rothman**[*1], Michael Fleischman[2], John Bolton[2]

[1] *Inshore Resources, Department of Agriculture Forestry and Fisheries, South Africa*
[2] *Biological Sciences Department, University of Cape Town, South Africa*

At present, anthropogenic climate change arguably poses the largest threat to the world's oceans. Rising ocean temperatures will increase climatic variability, leading to increases in the frequency, duration and intensity of extreme climatic events, such as storms and Marine Heat Waves (MHW's). We investigated the impact of Marine Heat Waves (MHW's) on both *M. pyrifera* and *E. maxima*. Both species were subjected to an experimentally simulated MHW for a three day period. Plants were subjected to four temperature treatments: 15°C, 17.5°C, 20°C and 22.5°C. The impact of the simulated MHW

on the samples was measured via photosynthetic oxygen production. The findings suggested that the thermal tolerance ranges and optimums varied among the two species, with *M. pyrifera* displaying a greater sensitivity to MHW's. Both species indicated minimal cell deterioration at the 15°C and 17.5°C treatments. However, at 20 °C, 80 % of the *M. pyrifera* samples and 40 % of the *E. maxima* samples displayed signs of cellular deterioration. This increased to 100 % of *M. pyrifera* samples and 80 % *E. maxima* samples in the 22.5 °C treatment, exhibiting signs of cellular deterioration. The findings of this study highlight the threat of MHW's to South African *M. pyrifera* and *E. maxima*. Additionally, findings allowed for a better understanding of the physiological thresholds of both species and their resultant geographical distributions in South Africa.

## OR 16-1

### Overexpression of *Gα* gene increases growth and hyposaline tolerance in *Kappaphycus alvarezii* transgenic plantlets

**Erina Sulistiani**[*1], - Suharsono[2], Ence Darno Jaya Supena[2], - Miftahudin[2]

[1] *Product Development and Services, SEAMEO BIOTROP, Indonesia*
[2] *Biology, Bogor Agricultural University, Indonesia*

G proteins are membrane proteins that play roles in signal transduction in living organisms. They consist of α, β and γ subunits, with the G protein α subunit (Gα) playing a role in plant tolerance to biotic and abiotic environmental stresses. Transgenic plantlets of *Kappaphycus alvarezii* carrying the *Ga* gene with 35S CaMV promoter have been successfully obtained through Agrobacterium tumefaciens-mediated transformation. The study aimed to (a) test the growth of non-transgenic and transgenic plantlets of *K. alvarezii in vitro* using Provasoli enriched seawater (PES) medium with normal salinity and hyposalinity and (b) analyze the expression level of the *Ga* gene in transgenic plantlets using quantitative polymerase chain reaction (qPCR). The results showed that all transgenic plantlets (six clones) had a significantly higher daily growth rate (DGR,% h-1) than that of non-transgenic under condition of normal salinity (30 ppt) and hyposalinity (15 and 20 ppt) for 5 weeks. At 15 ppt, transgenic plantlets were more tolerant than non-transgenic ones, as most thalli of transgenic plantlets remained brown in color, whereas most thalli of non-transgenic plantlets were bleached. This caused the DGRs of transgenic plantlets to be significantly higher (0.8 - 1.2% h-1) than those of non-transgenic plantlets (0% h-1) at 15 ppt. The results of qPCR analysis showed that the expression of the *Ga* gene in transgenic plantlets was increased by 6.43-8.03 times compared with that of non-transgenic plantlets. This study revealed that overexpression of the *Ga* gene in *K. alvarezii* transgenic plantlets increased their growth and tolerance to hyposalinity.

## OR 16-2

### Application of seaweed constituents in chemicals, materials and fuels

**Paulien Harmsen**[*1], Ben Van den Broek[1]

[1] *Biobased Products, Wageningen Food and Biobased Research, Netherlands*

In the Circular Economy we aim amongst others for a transition from petrochemical to renewable resources as feedstocks for our fuels and materials. This calls for efficient use of our natural resources, both terrestrial and marine, and in addition for biorefinery solutions. How can seaweed contribute to the challenges we are facing? Wageningen Food and Biobased Products is working on seaweed as resource for the production of food, feed, materials and fuels. This presentation shows results of our work on processing of seaweed for the production of biofuels and biobased plastics.For example we produced sugars for fermentation to biofuel by mild enzymatic hydrolysis of *Saccharina latissima*, isolated protein for food or feed and alginate for materials. To produce biobased materials we prepared seaweed-starch biocomposites by co-extrusion of whole seaweed and seaweed extracts and starch to prepare filaments with low melting temperature (<120 °C) to feed a 3D-printer. In addition, a desktop study was performed on the feasibility of producing the bioplastic polylactic acid (PLA) from seaweed. In the MacroFuels-project we demonstrated the isolation of sugars, suitable for further fermentation to biofuel. As coproducts an enriched fraction of protein and alginate was obtained. In the MacroCascade-project we studied the isolation methods of alginate and their impact on the final properties. Monomers of alginate are interesting chemical building blocks due to their acid functionality as shown in the Kelp2Plastics-project, and lower qualities can be processed in seaweed-based biobased materials, as shown in the AMS-project A circular supply chain for the city. We concluded that the total use of all seaweed constituents is a prerequisite for a viable seaweed business case. We have shown that seaweed constituents can be applied beyond the traditional application areas and are interesting resources for biofuels and materials like biobased plastics.

## OR 16-3

### Achieving high lipid productivity with high biomass productivity in *Ettlia* sp. under optimized nitrogen concentration and UV-A exposure

**Seong-Hyun Seo**[*1], Ankita Srivastava[1], Myung-Soo Han[2], Hee-Mock Oh[1]

[1] *Cell Factory Research Center, Korea Research Institute of Bioscience & Biotechnology, Republic of Korea*
[2] *Department of Life Science, Hanyang University, Republic of Korea*

Lipid production in microalgae can be induced by various stress factors. However, stress induced lipid accumulation requires considerable time leading to the decrease in final lipid productivity. Here, we attempted to increase the lipid productivity while maintaining the high growth of *Ettlia* sp. by optimizing nitrogen concentration and UV exposure in continuous culture mode. The biomass and lipid productivities of *Ettlia* sp. cultured with 150 mg/L N and UV-A added PAR were 1.67 ± 0.08 g/L/d and 0.55 ± 0.05 g/L/d, respectively. Lipid productivity and lipid content were around 43.7% and 33.7% higher, respectively in UV-A treatment compared to the control. Moreover, gene-expression patterns related to antioxidant defense and intracellular ROS levels indicated that UV-A treatment affected certain ROS and antioxidants pathways and successfully induced the lipid accumulation in *Ettlia* sp. The results of this study can be applied to other microalgal strains.

## OR 16-4

### Hydrothermal liquefaction technology for the conversion of red seaweeds to bio crude

Sri Sailaja Nori[1], Senthil Chinnasamy[2], **Shrikumar Suryanarayan**[*1]

[1] *Research & Development, Sea6 Energy, India*
[2] *Research & Development, Aban Infrastructure - Biotechnology Division, India*

Red seaweeds, in particular *Kappaphycus* and *Euchuema* species, have yield potential exceeding 100 dry tonnes/hectare/annum and thus represent scalable feedstock options for conversion to biofuel. Hydrothermal liquefaction (HTL) is a promising thermochemical conversion technique carried out at 250-350°C and sub-critical pressures of water (150-200 bar). HTL can handle feedstocks with 70-90% moisture and hence this is the most suited technology for processing seaweed biomass. Experiments were conducted in lab bench scale reactor to optimize the biomass concentration, catalyst loading, temperature and reaction time. *Kappaphycus alvarezii* and *Euchuema spinosum* biomass samples were used in these experiments. The biocrude obtained was further analyzed with gas chromatography-mass spectrometry (GC-MS) for its chemical composition. We have optimized experimental conditions that result in 30-35% w/w biocrude yield on ash free basis and 65 -70 % energy recovery in biocrude. Our analysis also revealed that biocrude fraction consists of hydrocarbon compounds predominantly with the nutrients retained in the aqueous fraction. Overall, HTL presents a renewable , scalable and sustainable opportunity to produce biocrude and renewable chemicals from red seaweeds.

## OR 16-5

### Impacts of *Ascophyllum* marine plant extract powder (AMPEP) on carrageenan quality: yield, viscosity and gel strength of tissue cultured outpants, of four commercial cultivars of *Kappaphycus*

**Majid Khan**[*1,2]

[1] *School of Mathematical Sciences, Universiti Sains Malaysia, Malaysia*
[2] *Seaweed Research Unit (UPRL), Universiti Malaysia Sabah, Malaysia*

Four strains of <*Kappaphycus* spp. (viz. *K. alvarezii* - tambalang brown and green, *K. malesianus*- aring-aring and *K. striatus*- sacol green) were grown in Semporna, Sabah, for three consecutive growth cycles, each for a duration of 45 days. The study was established to determine the impacts of *Ascophyllum* marine plant extract powder (AMPEP) on the daily growth rates (DGR), percentage incidence of endophytic *Neosiphonia apiculata*, and the commercial, quality characteristics of extracted carrageenan from the harvested biomass (i.e., yield, viscosity, and gel strength). Results showed that the AMPEP-treated thalli were significantly different ($P < 0.01$), in terms of the three major assessment criteria used in this study. Amongst the four cultivars and under the conditions tested, *K. striatus* was the most resistant to the incidence of *N. apiculata*, especially when treated with AMPEP. The use of AMPEP as a red seaweed biostimulant for the promotion of thallus growth rate, reduction of biotic stress caused by endophytes, and important improvements to commercially valuable traits, such as carrageenan quality, are encouraging and could be adopted in crop management protocols to assist the industry.

## OR 16-6

### Applications of bioactive seaweed substances in functional food products

**Yimin Qin**[*1]

[1] *State Key Laboratory of Bioactive Seaweed Substances, Qingdao Brightmoon Seaweed Group, China*

Seaweeds contain many types of bioactive substances with health benefits that are not easily obtained from land-based food staff. As consumers pay more and more attention to healthy natural ingredients, there is a huge scope of applications for seaweed derived bioactive substances in functional foods and nutraceuticals. With health benefits beyond basic nutrition, bioactive seaweed substances can, through their diversified range of structures and properties, help design functional food products that can correct nutritional deficiencies, promote optimal health and reduce the risk of disease. In addition, the application of modern science and technology in the research and development of bioactive seaweed substances can be used to provide many additional functional foods, and future scientific and technological advances promise an even greater range of health benefits for consumers.

## OR 17-1

### Farming of *Kappaphycus alvarezii* in Sri Lanka: current status and opportunity develop carrageenan industry

**Sivaram Kulendran**[*1], Munisamy Shanmugam[2], Abhiram Seth[1,2]

[1] *Research & Development, Aquagri Lanka (Pvt) Ltd, SriLanka*
[2] *Research & Development, AquAgri Processing Private Limited, India*

The current annual world production of *Kappaphycus alvarezii* is about 200K MT and its value added product carrageenan is approximately 60,000MT/yr *K. alvarezii* has been farmed successfully since 2012 in Sri Lanka. Over 250 fishers from 3 districts viz. Mannar, Kilinochchi & Jaffna are currently involved in farming for their livelihood and additional income options. Floating bamboo raft and mono-lines, the two popular cultivation methods were adapted and ADGR% of *K. alvarezii* in 45 d with 150 gm of seed propagule, across different locations with respect to seasons ranged between 3.50 - 4.00. The average monthly production of dry seaweed of a cultivator was 450 to 550 kg with monthly income of US$ 150 to US$ 225. The quality of dry seaweed like moisture (35%), clean anhydrous weed (CAW 38%), soluble salt (28% and impurities (<1.0%) were much comparable to the quality of commercial material. The yield of SRC ranged between 30% whereas refined carrageenan was 25%. The average potassium and water gel strength of SRC manufactured were 600 - 950 g cm-2 and 250 - 450 g cm-2 respectively and milk gel strength was 90 - 150 g cm-2. *K. alvarezii* farming has been introduced to over 25 countries over the last 35 years. However, only five to seven countries produce commercial volumes (over 1000mt/yr) for the carrageenan industry today. Sri Lanka has recently been added in the list of countries doing farming of *K. alvarezii* and it is estimated that it has a potential to produce over 25,000 mt dry-weed per year, therefore there is huge opportunity to develop carrageenan industries over there. Current status of farming of *K. alvarezii*, scope for expansion and opportunity to develop carrageenan industries in Sri Lanka are discussed in the present study.

## OR 17-2

### Indonesian seaweed hydrocolloids: challenges and perspective for future development in global value chain

**Maya Puspita**[*1], Safari Azis[1]

[1] *Indonesian Seaweed Association, Indonesia*

As tropical country located in Coral Triangle region of Southeast Asia with no typhoons, Indonesia has a favorable condition for seaweed to grow compared to the other Asian countries. Known as one of producer country of the red algal galactan seaweed from *Kappaphycus alvarezzii* (commercial name: cottonii), *Eucheuma denticulatum* (commercial name spinosum), and *Gracilaria* sp., seaweed farming activity in Indonesia has been increasing for the past few years. These three species are source of hydrocolloids known as kappa carrageenan, iota carrageenan and agar. Further, the applications of carrageenan and agar-agar are mostly meant for food processing industries because of their functions as ingredients or food additives. For the past few years, seaweed-derived hydrocolloids have become the center of attention, especially to those who concern about healthy life style. Since 2008, seaweed-derived hydrocolloids, particularly carrageenan and agar, were considered harmful for human health. Furthermore, certain parties even suggested that carrageenan and agar should be delisted from the organic list. Black campaign against carrageenan in particular has been occurring ever since, giving bad images about this product. Such issues gave tremendous effect towards the demand of seaweed-derived hydrocolloids and certain users have shifted to another alternatives. U.S Department of Agriculture's (USDA) organic regulations released Federal Register Vol. 83 No. 65 in April 2018 stating that carrageenan and agar stayed in the National List as organic food ingredients. The issuance of this document valid for 5 years, therefore, there is still some challenges to face to avoid the same problem to come. Public insight about seaweed-derived hydrocolloids is poor, thus it is crucial to socialize more about it. Multilateral cooperation of seaweed-derived hydrocolloids producer needs to be strengthened as well as inter-governmental cooperation to maintain the global value chain sustainability of the commodity.

## OR 17-3

### Age growth, pigments and carageenan content of the brown and the green varieties of marine algae *Eucheuma*

**Yenny Risjani**[*1], Yunianta Yunianta[2]

[1] *MSP, Universitas Brawijaya, Indonesia*
[2] *Agricultural Product Technology, Universitas Brawijaya, Indonesia*

Genus *Eucheuma* is typical of the brown and the green in color, naturally common in the coastal area of Indonesia. Information based on their biological characteristics such as growth, pigments, and hydrocolloid is important to facilitate algae yield production and to get benefit from biotechnology. This study aims to evaluate the relationship between age culture on growth, pigments and its carrageenan content on *Eucheuma alvarezii* of two different varieties, brown and green. The culture was done naturally in the coastal area using floating-rack methods and in the laboratory scale culture by controlled media and different light intensity. The culture was divided into three age steps, first period from 1 to 14 days, second period from 15 to 28 days, and the third period from 29 to 42 days. For the first age period, the brown variety has a higher growth rate than the green variety but it changed since the plant attained 15 days of culture. In general, *E. alvarezii* of the green and brown was significantly different in age and growth rate. For outdoor culture in the coastal area, the chlorophyll-a content was relatively the same between the brown of the green, but for indoor laboratory culture, it was higher in the green variety. Phycoerythrin and phycocyanine content were higher in the brown var. than in the green. The plant age was very significantly has a positive effect on chlorophyll-a, phycoerythrine and phycocyanine pigments. Carrageenan content was relatively the same between brown and green varieties. The light intensity of about 1500 lux gives the best result for the formation of pigments in algae.

## OR 17-4

### Differential growth performance and carrageenan quality of gametophyte and sporophyte *Kappaphycus alvarezii* grown from spores and some notes on morphology, fecundity, spore survival rates and chimera

**Maria Rovilla J Luhan**[*1], Jonalyn Mateo[1], Hananiah Sollesta[1]

[1] *GlobalSeaweedSTAR in The Philippines, Southeast Asian Fisheries Development Center (SEAFDEC), The Philippines*

One dilemma facing the farming of the carrageenophytes *Kappaphycus* is the deteriorating quality of seedlings at the nursery phase. Rejuvenating the commercial stocks using spores from reproductive wild parents that are sexually and asexually produced could perhaps restore the traits that are useful for culture. Carpospores and tetrsapores of *Kappaphycus alvarezii* were shed in vitro, vegetative thalli grown in the natural condition and carrageenan quality were determined to look at the possibility of producing seedlings for "cottonii" farming coming from spores. The growth rate of the diploid thalli was significantly higher than of haploid *Kappaphycus ex vitro* (2N, 2.6%day$^{-1}$; N, 1.8%day$^{-1}$). The gel strength (>400 g cm$^{-2}$) of carrageenan extracted from the two life cycle phases were not significantly different, while the yield and viscosity were significantly higher ($p<0.05$) in the diploid tissues. In terms of growth rate and the physical properties of extracted carrageenan, the sporophytes were observed to be superior. Sporophytic *Kappaphycus* is potentially a better source of seedlings for mass production of healthy and vigorous seedlings for enhancement cultivation of this important commercial crop. Some notes on the morphology of the mature reproductive thalli from the wild, germination rate, sporeling survival rate, and chimera were also described.

## OR 17-5

### Biomolecular composition and revenue explained by interactions between extrinsic factors and endogenous rhythms of *Saccharina latissima*

**Xueqian Zhang**[*1], Marianne Thomsen[1]

[1] *Environmental Science, Aarhus University, Denmark*

*Saccharina latissima*, a brown algae native to North Atlantic and North Pacific, has received increasing attention recently for its potential for high-yield biomass production and rich content of valuable biomolecules. Extracts of alginate, mannitol, fucoidans, laminarin, proteins, and lipids are among the top value-added algal products possessing the potential to improve the net profitability of seaweed bioeconomic businesses. This review provides a systematic overview of the spatial and temporal variations in the content of biomolecular constituents of *S. latissima* on the basis of 34 currently available scientific studies containing primary measurements. We demonstrate the potential revenue of seaweed production and biorefinery systems by compiling a product portfolio of high-value extract products and assuming that *S. latissima* biomass is processed in a phase I biorefinery (i.e., producing one type of extract product at a time). Further,

an investigation into the endogenous rhythms and extrinsic factors that impact the biomolecular composition of *S. latissima* is presented, and key performance factors for optimizing seaweed production are identified. Besides the provisioning ecosystem service, we highlight the contribution of green-engineered seaweed production systems to the mitigation of the ongoing and historical anthropogenic disturbances of the climate balance and nutrient flows. We conclude that there are risks of mismanagement, and we stress the importance and necessity of creating an adaptive ecosystem-based management framework within a triple-helix partnership for balancing the utilization of ecosystem services and long-term resilience of aquatic environment.

## OR 17-6

### Structural and functional characterisation of high-value bioactive compounds from *Alaria esculenta* cultivated on long-lines in Bantry Bay, Ireland

**Silvia Blanco Gonzalez**[*1], Fiona Wanjiku Moejes[1], Julie Maguire[1]

[1] *Bantry Marine Research Station Ltd, Ireland*

Based in the south-west of Ireland, Bantry Marine Research Station Ltd (BMRS) is one of the only institutions with a large-scale at-sea seaweed farm in Europe. Based on a 6-hectare site, BMRS currently cultivates over 10 tonnes (wet weight) of *Alaria esculenta* on long-lines in Bantry Bay annually. *A. esculenta* contains various high-value compounds, including fucoxanthin and phlorotannins, with the potential to enhance both human and animal nutrition and general well-being. However, optimal deployment and harvesting dates of the long-lines must be identified in order to optimise the cultivation of *A. esculenta* for these high-value bioactives. Long-lines were deployed in a staggered manner in the autumn/winter of 2017, and sampled at intervals during the spring of 2018. Fucoxanthin and phlorotannins (both cytoplasmic and membrane-bound) were extracted and characterised using UHPLC methods. Antioxidant activities of both compounds were also determined.Highest biomass was found in the ropes deployed last (09/12/2017) and harvested on 28/05/2018. The average weight was 12kgs per 1m of line (wet weight) when harvested. A general observation was that the weight increased over time, but the length of the blades reached their maximum at the beginning of May (2.25m), after which they became broader rather than longer.Fucoxanthin levels were highest (2 $g.kg^{-1}$ dried) in the rope deployed last (09/12/2017) and harvested on 05/05/2018, three weeks before final harvest. The results also indicated that freeze-dried samples had a more consistent moisture content and had a higher fucoxanthin content when compared to oven-dried samples. The project has only just entered its second year. However, based on the results of Year One, delayed deployment of the long-lines provided better overall yields. Furthermore, the fucoxanthin levels observed were comparably higher than those reported. Phlorotannin characterisation is being completed in January/February 2019.

## OR 17-7

### Bioactive compound production and stability in long term cultures of *Asparagopsis armata* (Bonnemaisoniales, Rhodophyta)

**Marianela Zanolla**[*1], Elliot Murphy[2], Olivier Thomas[2], Dagmar Stengel[1]

[1] *Botany and Plant Science, National University of Ireland, Ireland*
[2] *Marine Biodiscovery. School of Chemistry and Ryan Institute, National University of Ireland, Ireland*

Increased media and scientific attention has been paid lately to the red algal genus *Asparagopsis*, particularly since novel applications were described for its bioactive components, including anti-methanogenic activity of its halogenated compounds and Mycosporine-like aminoacids (MAA) as UV protectors. However, a sustainable biomass supply underpinning industrial applications of these products remains to be resolved. On-land cultures are an alternative to natural population harvesting or cultivation in the sea. As a step towards developing a protocol for the safe production of consistent high-value biomass under controlled conditions, this project investigated the effect of temperature on biomass production, as well a quantity and composition of MAAs and halogenated compounds. Specifically, the tetrasporophyte stage of *A. armata* was cultured in culture chambers using 20 L carboys at 13 and 17°C. Cultures were maintained and monitored for >12 months using supplemented seawater with Provasoli- enriched media regularly. Chosen growth irradiance was = 30 micromol photons m-2 s-1 with a photoperiod of 12:12 (L:D). Halogenated compounds were analysed monthly using Proton NMR Spectroscopy, MAAs using HPLC. High levels of halogenated compounds and MAAs were detected throughout the experiment, but were lower than in wild-collected samples. However, the amount of compounds differed to that in its wild state. MAAs concentrations varied over time possibly related to culture cycles. On-land cultures of A. armata is suggested as a productive alternative to wild harvest, there is potential for the further optimisation of culture conditions to achieve higher levels of bioactive compounds.

## OR 17-8

### *Macrocystis pyrifera* source for the production of bioactive compounds

**Allison Leyton**[*1], María-Elena Lienqueo[2], Carolina Shene[3,4]

[1] *Chemical engineering, Universidad de La Frontera, Chile*
[2] *Chemical Engineering, Biotechnology and Materials Centre For Biotechnology And Bioengineering, Universidad de Chile, Chile*
[3] *Chemical engineering, Centre For Biotechnology And Bioengineering, Universidad de La Frontera, Chile*
[4] *Chemical engineering, Center of Food Biotechnology and Bioseparations, Universidad de La Frontera, Chile*

In recent decades, the chemistry of natural products of marine origin has been the subject of intense investigation, new substances with pharmacological and nutraceutical properties have been discovered. A great source of biologically active compounds is marine organisms, especially seaweed. On the other hand, the search for processes more economical and friendly to the environment to produce biocompounds has been increasing. One alternative propose the use of biorefinery for the production of variated bioproducts, allowing increasing profitability of process and decreasing generated pollution. Our research group has evaluated the extraction of carbohydrates and phlorotannins from brown seaweed *Macrocystis pyrifera*, to be use in the production of carotenoids and antioxidant compounds, respectively. A design of experiments (Box–Behnken) was employed to test the effect of time, temperature and liquid to solid ratio on the extraction of carbohydrates and phlorotannins from *M. pyrifera*; for the extraction, an alkaline solution was used. The best condition for the extraction of both compound was 100°C, 180 min and 20 mL solvent: 1 g of dried seaweed. The extraction yields of carbohydrate and phlorotannins were 81.02 ±8.9 and 1.62 ± 0.13%, respectively. The phlorotannins extracted had an

antioxidant activity of the extract 227.2±31.4 mg TE/ g DS. The carbohydrate extract was used for the cultivation of a marine Rhodotorula mucilaginosa producer of different carotenoids. The carotenoid content of the biomass ranged between 287 and 427 mg/g of dry biomass. Main carotenoids was lycopene (38.4±9.4%), followed by β-carotene (21.8±1.5%) and astaxanthin (1.8±0.3%). This work demonstrates that *M. pyrifera* can be used as bioproducts platform. Acknowledgements: This research was supported by postdoctoral project Fondecyt N°3170610 and the Centre for Biotechnology and Bioengineering (CeBiB) FB-0001.

## OR 18-1

### Endophytic and epiphytic core microbiota associated with an invasive seaweed across the Northern Hemisphere

**Florian Weinberger**[*1], Guido Bonthond[1], Till Bayer[1], Stacy A. Krueger-Hadfield[2], Gaoge Wang[3], Masahiro Nakaoka[4], Myriam Valero[5]

[1] *Marine Ecology, GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Germany*
[2] *Department of Biology, University of Alabama at Birmingham, United States of America*
[3] *College of Marine Life Sciences, Ocean University of China, China*
[4] *Akkeshi Marine Station, Hokkaido University, Japan*
[5] *Station Biologique de Roscoff, CNRS, France*

We characterized the microbial communities associated with *Agarophyton vermiculophyllum* (synonym: *Gracilaria vermiculophylla*) throughout the Northern hemisphere of earth, including 6 populations located in the native distribution range (Japan, China) and 8 populations located in the non-native distribution range (Germany, France, Virginia and California). We sampled individual thalli from all fourteen populations during September 2017 and from a subset of four populations during September 2016, and conducted high-throughput sequencing of partial 16S and 18S rDNA to characterize prokaryotic and eukaryotic communities. Both pro- and eukaryotic communities followed a strong population-specific pattern, where communities from the same population but subsequent years remained relatively similar. We also compared microbial communities between algal surface (epiphytes) and tissue (endophytes). Epi- and endophytic communities differed from each other. Endophytic communities were characterized by lesser species richness, and at the same time they were particularly rich in Cyanobacteria classified to the genus *Pleurocapsa*. These - together with some Rhodobacteraceae - appear as an endophytic core microbiome of *A. vermiculophyllum* that is present in at least 95% of all tissue samples. Our results thus indicate that the microbial community contains a set of core taxa, which have been maintained across the native and non-native ranges. Site-specific differences across the ranges also exist and require further investigation, as they could result from adaptations during the invasion process.

## OR 18-2

### Selective utilization of fatty acids of two copepods with five algae

**Min-Chul Lee**[*1], Jun Chul Park[1], Deok-Seo Yoon[1], Yoseop Lee[1], Hyuntae Choi[2], Jeong Ha Kim[1], Kyung-Hoon Shin[2], Jae-Seong Lee[1]

[1] *Department of Biological Science, College of Science, Sungkyunkwan University, Republic of Korea*
[2] *Department of Marine and Convergence Sciences, College of Science and Technology, Hanyang University, Republic of Korea*

To investigate the relationship between algae (*Tetraselmis suecica* [*Ts*], *Chlorella* sp. [*Chl*], *Isochrysis galbana* [*Ig*], *Chaetoceros* sp. [*Cha*], and *Nannochloropsis oculata* [*No*]) and copepods (*Tigriopus japonicus* and *Paracyclopina nana*), we assessed life cycle parameters of copepods, motility of five algae species, gut imaging, stable isotope analysis, and fatty acid composition after feeding five algae. In *Ts*-fed group (control), growth and fecundity of both *T. japonicus* and *P. nana* showed the best performance. In *No*-fed group, developmental time of *T. japonicus* showed the worst, but in *P. nana*, only *Ts*- and *Ig*-fed group was well-developed and other groups were not developed. In addition, stable isotope values were significantly changed in delayed- or non-developed algae-fed copepods compared to well-developed algae-fed group. Gut imaging analysis and expression of *insulin-like peptide (ILP)* gene indicated that *P. nana* did not ingest three algae (*Chl-*, *Cha-*, and *No*-fed). The motility of *Ts* was the most active among the five algae species, *Ig* was on the second position, but others were moveless, suggesting the algae movement may be one of the crucial factors affecting feeding behavior of *P. nana*. Lastly, to examine the effect of algae species on lipid metabolism of copepods, fatty acid composition and gene expression were analyzed. From single fatty acid analysis results, the content of fatty acids was highly dependent on the content of fatty acid in each algae species in *T. japonicus*. However, *P. nana* showed less efficiency, especially in omega-3 fatty acid composition. Genome-wide identification of fads and elovl genes revealed that genes were highly diversified in *T. japonicus* rather than *P. nana*, especially in *fads5/6* genes. This study demonstrated the relationship between five algae and copepods in selective utilization of algal foods to copepods.

## OR 18-3

### Microbiota interactions with Laminariales gametophytes, impact on phytochemistry

**Erwan Le Gelebart**[*1], Erwan Jourdan[1], Maëva Menguy[1], Julien Fouilland[1], Esther Causin[1], Rémi Laville[1]

[1] *Innovation Direction, BiotechMarine-SEPPIC, France*

Macroalgae surface is a highly competitive environment as it provides a shelter rich in nutrients for a wide variety of organisms (1). Seaweed–bacterial associations have been studied from the end of the 19th century (2). Molecular investigations have shown that most of these associations are highly specific (3)(4). Bacteria isolated from their host can be related to a wide range of activity like anti settlement of invertebrate larvae, growth-enhancing, quorum sensing, morphogenesis, nitrogen fixation, settlement of zoospores, antibacterial activity (2). Host-Microbiota balance is a key factor to keep macroalgae in good conditions. Like for marine sponges it's not easy to determine who is responsible for the production of specific compounds, is it the sponge, is it bacteria sheltered by the sponge or is it the association of both? Today we started to investigate the relation between brown algae gametophytes and their microbiota and its implication on biomass phytochemistry. After achieving axenic cultures of brown algae gametophytes, axenic biomass was produced in order to compare its phytochemical content with biomass grown with its microbiota. Ethanol and water extracts of axenic and non-axenic biomasses were analysed through Thin Layer Chromatography (TLC) and High Pressure Liquid Chromatography (HPLC) coupled with Diode Array Detector (DAD) and Charged Aerosol Detector (CAD). Results obtained from ethanol and water extracts showed clear differences with apparition and disapparition of

peaks from low polarity to high polarity depending on the presence or the absence of the associated microbiota. In the light of these results, controlling and preserving the integrity and the quality of this microbiota in culture, for instance in avoiding any step of axenisation, could lead us to produce original compounds or to overexpress molecules. Microbiota appears to have a major role in the phytochemical composition of gametophytes of brown macroalga.

## OR 18-4

### Do microbes play a role in facilitating the range expansion of tropical fish into temperate systems?

**Adriana Verges**[*1], Ines Richter[1,2], Torsten Thomas[1,2], Derrick Cruz[1,2], Suhelen Egan[1,2]

[1] *School of BEES, UNSW Sydney, Australia*
[2] *SIMS, Sydney Institute of Marine Science, Australia*

The climate-mediated range expansion of tropical, herbivorous fish into temperate regions has profound impacts on temperate reefs, through overgrazing of habitat-forming seaweeds. The mechanisms that control such novel plant-herbivore interactions between tropical consumers and temperate seaweeds are largely unknown, but recent studies show that microorganisms can strongly impact plant-herbivore interactions and can enable the use of novel plant hosts. In this study, we compared the microbial communities in the gastrointestinal tract of three range-shifting and four non-range-shifting species of closely related tropical surgeonfish as well as their diet source, the epilithic algae matrix (EAM). Further, we compared EAM and fish gut microbiome samples along a latitudinal gradient for the range-expanding convictfish *Acanthurus triostegus*. High-throughput sequencing of the 16S rRNA gene showed strong differentiation among tropical fish species, but these were not grouped by range-shifting status. Although the microbiome of the gastrointestinal tract of all fish species was distinct from their diet source, half or more of the microbial taxa found within the guts of surgeonfish were also found in local EAM samples. We found high dissimilarity in the gut microbial communities of tropical and temperate populations of *A. triostegus*, suggesting range-shifting fish acquire new microbial taxa to assist in the digestion of novel food sources when they move into higher latitude reefs.

## OR 19-1

### Optimization of the production of single cell protein and hydrophobins from marine fungi fed using seaweed and seaweed waste

**Catalina landeta salgado**[*1,2], Elena Lienqueo María[1,2], Javier Gimpel[2]

[1] *Biotechnology Department, University of Chile, Chile.*
[2] *Center for Biotechnology and Bioengineering, University of Chile, Chile.*

Seaweeds have a fundamental structure of complex polysaccharides that restricts the efficient obtaining bioproducts. Marine fungi have the capacity to assimilate these carbohydrates. Since a couple of decades ago some species of fungi have been used to produce Single Cell Protein (SCP), for human food and animal feed, and others important proteins from fungi are the Hydrophobins (HFBs). Hydrophobins are amphiphilic and active proteins on the surface and has been proposed in the pharmaceutical, food and nanotechnology fields. The objective of this study was to develop and optimize a method for utilizing seaweed and seaweed waste to feed marine fungi and extract from these SCP and HFBs. A screening of 13 strains of Ascomycetes marine fungi and filamentous (NBR collection), was carried out, in order to find the fungi with the ability to assimilate alginate and cellulose from seaweed. The utilization of *Macrocystes pyrifera* and wastes from the algae industry (Waste A and B) in order to produce SCP by preselected fungi, *Dendryphiella salina* and *Asteromyces cruciatus* using submerged fermentation technique was carried out, pursuant to Box-Benhken design. Salinity, incubation temperature and pH parameters with three levels were evaluated in order to increase the SCP. In the case of HFBs, 4 marine fungi were evaluated and 4 different methods were set up to extract HFBs of class I and II, from the mycelium and the culture broth in two different minimal mediums. This HFBs were analyzed by SDS-PAGE, Far-UV circular dichroism spectra and emulsification capacity. Maximal total protein productivity of 7.9, 3.3 and 2.6 mg/g.day-1 for *M. pyrifera*, Waste A and B respectively was produced by *D. salina*. The best medium for improve the yield of putative HFBs Class I, in *D. salina* and *Penicilium pinophilum* was alginate medium in the culture broth, producing 280 and 258 µg mL-1, respectively.

## OR 19-2

### Antioxidant, anti-inflammatory and anti-proliferative effects of fucoidan extracted from the brown seaweed *Sargassum ilicifolium* (Turner) C. Agardh (*in vivo* and *in vitro*)

**Mangaiyarkarasi Ravirajan**[*1], Rakesh Sharma[1], Thamizh selvan Elumalai[1], Indrani Biswas[1], Periyasamy Cellaiya[2]

[1] *Central Inter Disciplinary Research Facility, Sri Balaji Vidyapeeth (Deemed University), India*
[2] *Department of Botany, Pasumpon Muthuramalinga Thevar College, Tirunelveli, India*

Seaweeds (Marine macro algae) are a large and diverse group of marine organisms and an excellent source of biologically active secondary metabolites. They have been shown to exhibit a wide range of therapeutic properties, including anti-cancer, anti-oxidant, anti-inflammatory and anti-diabetic activities. Hence seaweeds have been used to treat a wide variety of health conditions such as cancer, digestive problems, and renal disorders etc. Algae are a promising source of bioactive compounds including pharmaceuticals and nutraceuticals. Therefore the present study aims to evaluate the anti-inflammatory, anti-oxidant and anti-cancer potential of fucoidan extracted from *Sargassum ilicifolium* (SIF) by in vivo and in vitro model. Inflammatory diseases have become one of the leading causes of health issues throughout the world. The Crude fucoidan extracted from *Sargassum iliciolium* purified into fractions using ion-exchange chromatography, this chromatographic technique which purify molecules based on the overall charge. The anti-inflammatory activity of SIF was determined in-vivo by carrageenan-induced rat paw edema assay. Antioxidant activity was evaluated by DPPH scavenging activity using 96 well plate U-bottom microplate and microplate reader. The anti-proliferative activity was studied on cancer (MCF7 and MDA-MB-231) cell lines by the ability of the cells to metabolically reduce MTT formazan dyes, in comparison to a reference drug Cyclophosphamide. Results demonstrated that SIF exhibited significant anti-inflammatory activity in a dose dependent manner by comparison to reference drugs. It showed the maximum percentage of DPPH scavenging activity 74.58 achieved by 3.125mg/ml concentration with IC50 .6. This result is more or less equal to the positive

control. SIF has anti-proliferative activity against both cell lines MCF7 and MDA-MB-231. These pharmacological efficacies translate that SIF could have a promising role in future in the field of medicine and nutrition when used as drug or food additive.

## OR 19-3

### The potential transfer of arsenic species from a seaweed animal meal

**Michéal Mac Monagail**[*1], Enda Cummins[2], Ricardo Bermejo[1], Eve Daly[1], Declan Costello[3], Liam Morrison[1]

[1] *Earth and ocean, The national university of ireland, galway, Ireland*
[2] *School of Biosystems and Food Engineering, Agriculture, and Food Science, University College Dublin, Ireland*
[3] *Publlic Analyst's Laboratory, University Hospital Galway, Ireland*

Some species of seaweed are well-known accumulators of the metalloid arsenic (As). Arsenic toxicity to humans is well established and is considered a class 1 human carcinogen. As mankind's appetite for livestock produce continues to grow unabated, there is a concern that consumption of livestock produce reared on a diet supplemented with seaweed animal feed (SAF) may pose a threat to the human population due to potentially high levels of As present in seaweed. To address this concern and provide end users, including industry, consumers, policymakers and regulators with information on the exposure associated with As in commercial seaweed animal feed, the estimated daily intake (EDI) of As was calculated to evaluate potential human exposure levels. Using As data from a commercially available seaweed meal over a five-year period (2012–2017) a population exposure assessment was carried out. A Monte Carlo simulation model was developed to characterise the feed to food transfer of As from animal feed to animal produce such as beef, milk, chicken, and eggs. The model examined initial levels in seaweed, inclusion rate in animal feed, animal feeding rates and potential transfer to food produced from a supplemented diet of SAF. The analysis of seaweed animal feed showed that inorganic As was a small fraction of the total As found in seaweed meal (80:1). Statistical analysis found significant differences in the concentration of As in seaweed animal feed depending on the grain size ($p < 0.001$), with higher As concentrations in smaller sized grain fractions. The EDI calculated in this study for the livestock produce evaluated at the 95th confidence interval was<0.01% of suggested safe levels of inorganic As intake. The threat to the general population as a result of consumption of livestock products reared on a diet consisting of SAF is found to be negligible.

## OR 19-4

### Protein extraction by enzyme-assisted extraction(EAE) followed by alkaline extraction from red seaweed *Eucheuma denticulatum* (Spinosum) used in carrageenan production

Alireza Naseri[1], **Susan Løvstad Holdt**[*1], Charlotte Jacobsen[1]

[1] *DTU Food, Technical University of Denmark, Denmark*

In 2014, the global amount of carrageenan production was 60,000 ton with a value of US$ 626 million. From this number, it can be estimated that the total dried seaweed consumption for this production was at least 300,000 ton/year. The protein content of these types of seaweed is 5 – 25%. If just half of this total amount of protein could be extracted, 18,000 ton/year of a high-value protein product would be obtained. The overall aim of this study was to develop a technology that will ensure further utilization of the Spinosum seaweed that is currently only utilized as raw materials for carrageenan production as single extraction. More specifically, proteins should be extracted from the seaweed either before or after extraction of carrageenan with focus on maintaining the quality of carrageenan as a main product. Different mechanical, chemical and enzymatic technologies were evaluated. The optimized process was implemented in lab scale and based on its results, experiments were done to further upscale the process at pilot scale at CP Kelco company. In order to calculate the efficiency of the new upstream multi-extraction process, protein content of the seaweed was tested before and after extraction. After this step, the industrial extraction of carrageenan was mimicked and carrageenan content and yield were evaluated. The functionality and quality of carrageenan were measured based on rheological parameters. The results showed that by using the new multi-extraction process; it is possible to extract almost 50% of total protein without any negative impact on the carrageenan quality. The protein showed interesting amino acid profile and nutritional value for the growing non-meat market. Further work will be carried out in order to improve properties of the protein such as color, solubility, and taste.

## OR 20-1

### Phylogeographic diversification and postglacial range gynamics shed light on the conservation of the kelp *Saccharina japonica*

**Jie Zhang**[*1], Jianting Yao[1], Zi-Min Hu[1], Alexander Jueterbock[2], Norishige Yotsukura[3], Tatiana N Krupnova[4], Chikako Nagasato[5], Delin Duan[1]

[1] *Key Laboratory of Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China*
[2] *Faculty of Biosciences and Aquaculture, Nord University, Norway*
[3] *Field Science Centre for Northern Biosphere, Hokkaido University, Japan*
[4] *Pacific Research Fisheries Centre, (TINRO-Centre), Russian Federation*
[5] *Muroran Marine Station,Field Science Center for Northern Biosphere, Hokkaido University, Japan*

Studies of postglacial range shifts could enhance our understanding of seaweed species' responses to climate change, and hence facilitate the conservation of natural resources. However, the distribution dynamics and phylogeographic diversification of the commercially and ecologically important kelp *Saccharina japonica* in the Northwest Pacific (NWP) are still poorly surveyed. In this study, we analyzed the evolutionary history of *S. japonica* using two mitochondrial markers and 24 nuclear microsatellites. A STRUCTURE analysis revealed two partially isolated lineages: lineage H, which is scattered along the coast of Japan; and lineage P, which occurs along the west coast of the Japan Sea. Ecological niche modeling projections to the Last Glacial Maximum (LGM) revealed that the southern coasts of the Japan Sea and the Pacific side of the Oshima and Honshu Peninsulas provided the most suitable habitats for *S. japonica*, implying that these regions served as ancient refugia during the LGM. Ancient isolation in different refugia may explain the observed divergence between lineages P and H. An approximate Bayesian computation analysis indicated that the two lineages experienced post-LGM range expansion, and that postglacial secondary contact occurred in Sakhalin. Model projections into the year 2100 predicted that *S. japonica* will shift northwards and lose its genetic diversity center on the Oshima Peninsula in Hokkaido and Shimokita Peninsula in Honshu. The range shifts and evolutionary history of *S. japonica* improve our understanding of how climate change

impacted the distribution range and diversity of this species and provide useful information for the conservation of natural resources under ongoing environmental change in the NWP.

## OR 20-2

### Phylogeographic pattern of the marine red alga *Gracilaria salicornia* (Gracilariales) in Thailand: evidence for an east-west genetic break around the Thai-Malay peninsula

**Narongrit Muangmai**[*1], Sinchai Maneekat[1], Anong Chirapart[1], Giuseppe C. Zuccarello[2]

[1] *Fishery Biology, Faculty of Fisheries, Kasetsart University, Thailand*
[2] *School of Biological Sciences, Victoria University of Wellington, Wellington, New Zealand*

Understanding phylogeography and connectivity is crucial for conservation, management and sustainable use of marine species. *Gracialria salicornia* is a widely distributed marine red alga commonly found in tropical and subtropical regions. Despite its diverse ecology and board distribution, spatial genetic variation and population structure of this species remains understudied, especially around the Thai-Malay peninsula a well-known genetic barrier to marine organisms. We analyzed phylogeographic patterns of *G. salicornia* using mitochondrial DNA (COI) sequences from 164 individuals distributed on the eastern and western coasts of Thailand. Our genetic analysis indicated low genetic diversity, consisting of eight haplotypes, six of which are newly discovered, from both coast of Thailand. One haplotype was restricted to the eastern coast, the Gulf of Thailand, whereas the other seven haplotypes were commonly found in the western coast, the Andaman Sea. SAMOVA analyses indicated a weak but significant genetic break between eastern and western populations. Our analyses also suggested that the Thai-Malay peninsula populations of *G. salicornia* had historically experienced a sudden population expansion. Our study suggested an east–west phylogeographic break of *G. salicornia* populations around the peninsula, and this pattern is likely facilitated by regional and local current patterns.

## OR 20-3

### Developing novel biomarkers targeting stage-specific transcripts for monitoring harmful marine organisms

**Juhee Min**[*1], Kwang Young Kim[1], Hyun-kwan Lee[1], Gun Su Shin[1]

[1] *Oceanography, Chonnam National University, Republic of Korea*

Active monitoring harmful species is crucial in preventing damages done to the marine ecosystem and human health. The moon jellyfish, *Aurelia aurita* is a cosmopolitan species that seasonally blooms in coastal and shelf sea. The outbreak of *A. aurita* is significantly associated with asexual reproduction in its early developmental stages. One method for early detection is using environmental DNA (eDNA) that has been screened to identify a target species. However, eDNA analysis may lead to false positive due to the fact that dead cells and tissue debris can be detected as well. Thus, we clarified the developmental stage-specific molecules for designing biomarkers by analyzing transcriptome expressed in five stages: planula, polyp, strobila, ephyra, and medusa. The planula harvested from mature *A. aurita* (captured in the South Sea of Korea) were cultured at 20℃ and 32 psu. The strobila and the ephyra from the polyps were induced by shifting the temperature from 20℃ to 10℃. Transcriptome were de novo assembled and clustered with each developmental stage. Out of 187 expressed genes, with 27 ubiquitously expressed, 138 candidates specifically expressed within the target stage were used for designing PCR primers. The specificity of primers was confirmed in conventional PCRs against genomic DNA and cDNA acquired from each developmental stage. As a result, it is optimal to use novel biomarkers for specifically detecting live *A. aurita* in the different developmental stages. The proposed protocol to design transcript-specific biomarker is ideal to monitor various marine species with precision in the ocean.

## OR 20-4

### Phylogenomic analysis of brown algal organelle genome

**Ji Won Choi**[*1], J Mark Cock[2], France Denoeud[3], Patrick Winker[3], Seok Wan Choi[1], Hwan Su Yoon[1]

[1] *Department of Biological Science, Sungkyunkwan University, Republic of Korea*
[2] *Integrative Biology of Marine Models Department, Station Biologique de Roscoff, France*
[3] *Genoscope, CEA, Evry, France*

The Phaeophyceae (brown algae) is a photosynthetic stramenopile class that plays important roles in marine ecosystem as well as high economical values as food and seaweed industry. Phylogenetic relationship between the classes shows the brown algae are closely related to the Schizocladiophyceae, Phaeothamniophyceae, Aurearenophyceae, Chrysomerophyceae and Xanthophyceae. Phylogenetic relationships within the Phaeophyceae, however, are still controversial especially in the early diverged lineages. Because of its conserved genetic feature, organelle gene markers were frequently used in phylogenetic reconstruction, and recently organelle genome data are increasingly applied to reveal evolutionary history. Organelle genome data, however, are reported mainly from few particular groups including kelps (Laminariales), Ectocarpales, and Fucales, hence it is necessary to have data from broader taxa which are representatives of major brown algal lineages. To resolve phylogenetic relationships and investigate complex history of the brown algal evolution, we newly sequenced 14 plastid and 12 mitochondrial genomes of brown algal species from major orders. We reconstructed the phylogenetic trees with concatenated plastid and mitochondrial protein coding sequences and revealed that the topology of trees is not congruent each other. From genome structure comparison between the organelle genomes, we found some rearrangement events within the genome. We will discuss about the evolutionary history of brown algae based on plastids and mitochondria genome data.

## OR 21-1

### Comparative characterization of putative chitin deacetylases from *Phaeodactylum tricornutum* and *Thalassiosira pseudonana* highlights potential for distinct chitin-based metabolic processes in diatom

**Zhanru Shao**[*1], Yann Thomas[2], Lea Hembach[3], Xiaohui Xing[4], Delin Duan[1], Bruno Moerschbacher[3], Vincent Bulone[4], Leila Tirichine[2], Chris Bowler[2]

[1] Key Laboratory of Experimental Marine Biology, Institute of Oceanology, CAS, China
[2] Institut de Biologie, Ecole Normale Supérieure, France
[3] Institute of Plant Biology and Biotechnology, Westphalian Wilhelm's-University Münster, Germany
[4] Division of Glycoscience, Royal Institute of Technology, Sweden

Chitin is generally considered to be present in centric diatoms but not in pennate species. Many aspects of chitin biosynthetic pathways have not been explored in diatoms. We retrieved chitin metabolic genes from pennate (*Phaeodactylum tricornutum*) and centric (*Thalassiosira pseudonana*) diatom genomes. Chitin deacetylase (CDA) genes from each genome (PtCDA and TpCDA) were over-expressed in *P. tricornutum*. We performed comparative analysis of their sequence structure, phylogeny, transcriptional profiles, localization and enzymatic activities. The chitin relevant proteins show complex subcellular compartmentation. PtCDA was likely acquired by horizontal gene transfer from prokaryotes, while TpCDA has closer relationships with sequences in Opisthokonta. Using transgenic *P. tricornutum* lines expressing CDA-GFP fusion proteins, PtCDA predominantly localizes to Golgi apparatus whereas TpCDA localizes to ER/cERM. CDA-GFP overexpression up-regulated the transcription of chitin synthases and potentially enhanced the ability of chitin synthesis. Although both CDAs are active on GlcNAc5, TpCDA is more active on the highly acetylated chitin polymer DA60. We have addressed the ambiguous characters of chitin deacetylases from *P. tricornutum* and *T. pseudonana*. Differences in localization, evolution, expression and activities provide explanations underlying the greater potential of centric diatoms for chitin biosynthesis. This study paves the way for in vitro applications of novel CDAs.

## OR 21-2

### Genomic analysis of thermoacidophilic environmental adaptation of Cyanidiophyceae (Rhodophyta)

**Seung In Park**[*1], Chung Hyun Cho[1], Claudia Ciniglia[2], Hwan Su Yoon[1]

[1] Biological science, Sungkyunkwan University, Republic of Korea
[2] Department of Environmental, Biological and Pharmaceutical Science and Technologies, University of Campania "L. Vanvitelli", Italy

Cyanidiophyceae is the only one eukaryotic lineage that thrives in highly acidic, high temperature, and heavy-metal rich extreme environments found around volcanic hot springs around world. Although some bacteria and archaea are reported from extreme environments, there are any eukaryotes, except Cyanidiophyceae, reported from these harsh conditions. In addition, they show trophic differences being either autotroph or mixotroph. From previous researches, the genomes of Cyanidiophyceae are highly reduced, but horizontally acquired bacterial gene set to adopt in extreme habitats. To better understand genome evolution of the Cyanidiophyceae, we produced two high quality nuclear genome data from *Galdieria maxima* 8.1.23 and *Galdieria sulphuraria* SAG 108.79. We conducted comparative genome analysis with three available genomes of *Cyanidioschyzon merolae*, *Galdieria sulphuraria*, and *Galdieria phlegrea*. In this presentation, we will discuss about genomic differences in five Cyanidiophyceae genomes in terms of gene contents, mutation rates, and repeat regions. Furthermore, we found unique horizontally transferred gene set that related to heavy metal reduction (mercuric reductase, arsenite methyltransferase) that likely related to the adaptation in this harsh condition for *Galdieria maxima* 8.1.23.

## OR 21-3

### Genomic analyses of unique carbohydrate and phytohormone metabolism in the macroalga *Gracilariopsis lemaneiformis* (Rhodophyta)

**Nianjun Xu**[*1], Xue Sun[1], Guangce Wang[2], Xiaodong Zhao[3]

[1] Department of Marine Sciences, Ningbo University, China
[2] Experimental Marine Biotechnology Laboratory, Institute of Oceanology, Chinese Academy of Sciences, China
[3] Shanghai Center for Systems Biomedicine, Shanghai Jiao Tong University, China

Red algae are economically valuable for food and in industry. However, their genomic information is limited, and the genomic data of only a few species of red algae have been sequenced and deposited recently. In this study, we annotated a draft genome of the macroalga *Gracilariopsis lemaneiformis* (Gracilariales, Rhodophyta). The entire 88.98 Mb genome of *Gp. lemaneiformis* 981 was generated from 13,825 scaffolds (≥500 bp) with an N50 length of 30,590 bp, accounting for approximately 91% of this algal genome. A total of 38.73 Mb of scaffold sequences were repetitive, and 9281 protein-coding genes were predicted. A phylogenomic analysis of 20 genomes revealed the relationship among the Chromalveolata, Rhodophyta, Chlorophyta and higher plants. Homology analysis indicated phylogenetic proximity between *Gp. lemaneiformis* and *Chondrus crispus*. The number of enzymes related to the metabolism of carbohydrates, including agar, glycoside hydrolases, glycosyltransferases, was abundant. In addition, signaling pathways associated with phytohormones such as auxin, salicylic acid and jasmonates are reported for the first time for this alga. As a conclusion, we sequenced and analyzed a draft genome of the red alga *Gp. lemaneiformis*, and revealed its carbohydrate metabolism and phytohormone signaling characteristics. This work will be helpful in research on the functional and comparative genomics of the order Gracilariales and will enrich the genomic information on marine algae.

## OR 21-4

### Identification of candidate SNPS regions related to red mutation in *Pyropia yezoensis* by QTL-seq

**Xinzi Yu**[*1], Yunxiang Mao[1]

[1] College of Marine Life Sciences, Ocean University of China, China

Because of the special heteromorphic life cycle and monoecious nature of *Pyropia yezoensis*, pigment mutations are powerful signals for successful crossbreeding and genetic studies. However, the genes underlying *Pyropia* coloration have yet to be identified. QTL-seq, in combination with next-generation sequencing (NGS), can be generally applied in population genomics studies to rapidly identify genes responsible for phenotypes showing extreme opposite trait values. The pure line red mutant HT (♂) was crossed to wild-type RZ (♀) to generate a lot of F1 sectored blades (chimeras) consisting of 1–4 sectors. DNA of two populations with opposite colors was pooled respectively; each population was composed of 24 same-color and same-genotype sectors from the F1 generation's sectored blades. QTL-seq and whole-genome resequencing was applied to detect a genomic region of *P. yezoensis* harbouring the red color causal QTL. Using PacBio and Hi-C methods, we got the reference assembly for the pure RZ line, comprised of three chromosome-scale pseudomolecules (named chromosome1-3). After fine mapping and genotyping, 30,519 SNPs and InDels were identified to further analysis and a graph relating SNPs or InDels positions and SNP-index was generated for all 3 chromosomes. One genomic position exhibiting the highest (ΔSNP-index) values was identified: the region on chromosome

1 from 41.0 to 43.1 Mb (statistical significance under the null hypothesis: $P < 0.01$), including 30 SNPs and 15 InDels. Among these variations, 27 SNPs and 12 InDels were located in intergenic regions related to 24 genes, 2 SNPs and 1 InDel were in exonic regions, and others were in intronic regions. Of two SNPs in exonic regions, a SNP at nucleotide position 42,835,120 was nonsynonymous; this should be further confirmed first using populations with more individuals. Herein, we identified for the first time, a candidate region coding for coloration in *P. yezoensis*. However, further studies are needed to functionally validate causal genes which regulate pigment coloration in *P. yezoensis*.

## OR 22-1

### Certification of environmental sustainable and social responsible seaweed production

**Patricia Bianchi**[*1], Mark Seo[2]

[1] *Seaweed Standard, Aquaculture Stewardship Council, Uruguay*
[2] *Marine Stewardship Council, Republic of Korea*

The Aquaculture Stewardship Council and Marine Stewardship Council have developed the environmentally sustainable and socially responsible Seaweed Standard. The ASC-MSC Seaweed (Algae) Standard applies globally to all locations and scales of seaweed operations, including both harvesting of wild population and cultivation. The Seaweed Standard also covers both marine and fresh water algae, and both macroalgae and microalgae. The ASC-MSC Seaweed Standard is the first third party certification scheme to address a full set of environmental and social issues related to wild harvest and cultured production of seaweed. The standard comprises five core principles: Principle 1, Harvesting and farming of seaweeds are conducted in a manner that does not lead to depletion of the exploited wild populations; Principle 2, Harvesting and farming activities allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the activity depends; Principle 3: Harvesting and farming activities are subject to an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable; Principle 4, Harvesting and farming activities operate in a socially responsible manner; and Principle 5, Harvesting and farming activities operate in a manner that minimizes impacts on other farms, activities and communities. The ASC-MSC standard enables producers to verify their production unit meets the environmental sustainability and socially responsible management of their resources by using a credible, independent third-party assessment process. Certified harvesters and farms can carry the ASC and MSC labels, which are recognised and rewarded in the marketplace, giving assurance to consumers that their products come from well-managed and sustainable sources.

## OR 22-2

### Net-works(TM): making seaweed farming positive for the ocean and people

**Amado Blanco**[*1], Heather Koldewey[2], Justin Dekoszmovszky[3], Miriam Turner[2], Nicholas Hill[4]

[1] *Net-Works, ZSL-Philippines, The Philippines*
[2] *Conservation & Policy, Zoological Society of London, United Kingdom*
[3] *Net-Works, Azao, United Kingdom*
[4] *Conservation & Policy, Zoological Society of London, Australia*

By 2025 some estimate that there will be one tonne of plastic for every three tonnes of fish in the ocean, with huge consequences for the health and wellbeing of millions of marginalised coastal people in Southeast Asia. Widely promoted as an alternative livelihood to unsustainable fishing practices, seaweed farming has largely failed in it's promise to provide coastal communities with a better life. Growing awareness of the negative social and environmental impacts of this "green" alternative have led to increasing accusations that it is becoming the "oil palm of the sea". But it does not have to be this way. Net-Works(TM) was developed following a science-based approach to leverage seaweed farming for positive social and environmental change. Our business model is a simple, scalable way to deliver an ocean with less fish and more plastic, and lift coastal communities out of poverty across Southeast Asia. Applying the principles of fair trade and inclusive business, we create efficient community-based supply chains for seaweed and link them to conservation actions that replenish fish stocks and reduce plastic pollution. We sell this seaweed into global supply chains giving international brands the chance to source the highest quality seaweed with a positive social and environmental story, and giving fishing communities access to a fair price, technical support and financial services, including insurance, that drives improvements in wellbeing. Having prototyped this approach in the Philippines we now aim to scale the model across Southeast Asia, better protecting 1 billion m2 of the ocean, providing 10,000 families with better access to finance, and increasing the socio-ecological resilience of 1 million marginalised coastal people by 2025. In this presentation we will describe the model, our experiences with implementing a restorative supply chain for seaweed, and the opportunities for seaweed to deliver on the SDGs.

## OR 22-3

### Feminisation of seaweed industry?

**Josephine Tsui**[*1], Jee Suyo[2], Virginie LeMasson[1], Adibi Nor[3], Anicia Hurtado[2], Louise Shaxson[1]

[1] *RAPID, Overseas Development Institute, United Kingdom*
[2] *Institute of Aquaculture, College of Fisheries and Ocean Sciences, University of Philippines Vasayas, The Philippines*
[3] *International Institute of Public Policy and Management, University of Malaya, Malaysia*

Women's roles in agriculture are changing in response to men's labour market activities and women pursuing their own aspirations. We are seeing an increase prevalence of women known as feminisation. Feminisation can change women's ability to control their own labour and assume authority in certain areas of decision-making. A similar trend may be occurring in seaweed farming at the global scale. In the past, seaweed farming has provided important income in coastal communities, but changes in the productivity of seaweed farming, and global demand for seaweed products, have been disruptive to farmers' livelihoods. In Tanzania, seaweed farmers are predominantly women, as men have found the tourism and fishing industries more profitable. In some villages, women do not have alternative sources of income, and their access to growing seaweed fluctuates with tidal changes and trade. Further, women's economic activities are restricted to seascapes closer to land such as mangroves forest and seagrass beds. Alternatively, men are not faced with the same restrictions and are able to engage with economic activities in all seascapes. Gender relations are different in the Philippines, Indonesia and Malaysia. Gendered responsibilities are split dependent on tasks, rather than commodities. In the

Philippines, while both men and women work in seaweed, women's roles have generally been confined to lower-paid jobs. In Indonesia, communities would often see women as merely "helpers" instead of farm owners, despite husbands and wives owning separate farms. Meanwhile, in Malaysia the women choose to perform seaweed tasks at their houses because they have to manage between helping the men and manage household chores. More gender disaggregated data is needed to determine if there is a feminisation of the seaweed industry. Further research could help to determine if the increase participation of women may be due to distress in the trade.

## OR 22-4

### A systematic analysis of national biosecurity framework of seaweed aquaculture in Indonesia

**Cicilia Selviane Kambey**[*1], Iona Campbell[2], Elizabeth Cottier-Cook[2]

[1] *Global Seaweed STAR, Sam Ratulangi University, Indonesia*
[2] *Department of Blue Economy, Scottish Association for Marine Science, United Kingdom*

Biosecurity in the seaweed aquaculture industry is playing an increasingly important role for structuring and establishing the sustainability of the system in Indonesia. Alongside, the significant growth in seaweed *Kappaphycus /Eucheuma* production over the last ten years, problems such as 'ice-ice' disease/symptoms, epiphyte blooms and the difficulty in obtaining healthy seedlings are becoming an increasing challenge to the industry. In order to address these negative impacts, the Indonesian government has released a number of policies, however, only a few focus on biosecurity. Using a systematic analysis based on methodology of Dahlstrom et al (2011), the national policy and regulatory framework was assessed to identify the current status of biosecurity usage in the Indonesian seaweed aquaculture industry. The results showed that in Indonesia, biosecurity was established in multiple authorities. However, seaweed terminology is ill-defined in the national framework, biosecurity perception is poor and programmes have been established to prevent the introduction of pests and disease without addressing mitigation measures once a disease has become established. In addition, there is insufficient inclusion of scientific information and guidance in precautionary methods included in the current legislative frameworks. Several recommendations, based on current status and deficiencies in the legislative frameworks are made to support the establishment of more robust biosecurity policies and practices for the seaweed industry in Indonesia.

## OR 22-5

### Providing alternative options to the traditional *Ascophyllum nodosum* harvesting method in ireland: advantages and challenges under a non-regulated harvest

**Raul Ugarte**[*1], Micheal MacMonagel[2]

[1] *Research and Development, Acadian Seaplants Limited, Canada*
[2] *Research and Development, Arramara Teoranta, Ireland*

Seaweed have been utilized in the west coast of Ireland for centuries to fortify soils, to fertilize gardens and to supplement the diets of animals. During the last 50 years, *Ascophyllum nodosum* has been the dominant commercial species. The traditional *A. nodosum* harvesting method in Ireland consists of cutting the seaweed during low tide by hand with a sickle or knife. Harvesters maximize their productivity during the low tide by cutting the seaweed below 25 cm and more than 95% of the biomass in patches that vary from 100 $m^2$ to 400 $m^2$. Depending on their experience, harvesters can harvest between 2000 kg to 8000 kg in a single tide. After the seaweed is cut, it is pitchforked into two to three tonnes bundles or *climíní*, tied off with ropes and allowed to float to the top of the shore and towed by boats to nearby piers. The seaweed is then collected by trucks and transported to the processing plant. In general, this harvesting activity is physically demanding and requires a harvester to labour more than 10 hours from start to finish. In 2016, Arramara Teoranta, the main seaweed processing company in the region, introduced a Canadian hand harvesting method consisting in a 3-4 tonnes capacity boat and a specially designed cutting rake (B&R method). The objective was to facilitate the harvesters' job and minimize the impact of the harvest on the resource. *A. nodosum* is a slow growing seaweed and requires between five to eight years to recover the original biomass when harvested patches using in the traditional method. Despite prolonged acceptance of the B&R method, the harvesters are increasingly adopting this new approach, which under a non-regulated and increasingly competitive harvest, is a viable alternative to reduce the impact on the resource.

## OR 23-1

### Development of functional fish sausage using seaweed dietary fibre

**Jesmi Debbarma**[*1], Viji Pankiyamma[1], B Madhusudana Rao[1], Murthy Lakshmi Narasimha[1], Ventakeshwarlu Gudipati[2], Ravishankar C. N.[1]

[1] *Fish Processing Technology, ICAR-CIFT, India*
[2] *Division of Agricultural Education, Indian Council of Agricultural Research (ICAR), India*

Dietary fibre (DF) from seaweeds have increasingly attracted researcher's attention due to its health benefits. The study was carried out with the objectives to optimize extraction conditions of DF from red seaweed, *Gracillaria edulis* using response surface methodology (RSM) and development of functional fish sausage using seaweed DF. DF was extracted from *G. edulis* using the combination of enzymatic and chemical methods. The extraction parameters such as enzyme concentration, hydrolysis temperature and time for extraction of dietary fibre was optimized by RSM using a Box-Behnken design. DF extracted from *G. edulis* was incorporated in fish (*Pangasianodon hypophthalmus*) sausage at 1-5% and analyzed its gel strength, textural properties, sensory qualities and microstructure using SEM. The results revealed that the optimal extraction conditions were enzyme concentration of 0.78%, hydrolysis temperature of 56.58°C and hydrolysis time of 87.23 min. Under these conditions, the yield, total dietary fibre, water holding capacity, oil holding capacity and swelling capacity were 42.49%; 96.30%; 18.93g/g; 1.55g/g and 17.71ml/g, respectively. The addition of 1% DF significantly ($p<0.05$) increased the gel strength compared to control sausage and up to 3 % of DF can provide good textural and organoleptically acceptable fish sausage. DF incorporation in fish sausage appeared to interfere with the three-gelation mechanism of myofibrillar proteins, as evidenced by the formation of distorted matrix in the SEM images. Seaweed as source of DF could be effectively used to fortify fish sausages not only to improve the functional properties, but also as an approach to develop functional food with health benefits.

## OR 23-2

### Metabolic engineering of *Escherichia coli* for efficient biosynthesis of fluorescent phycobiliprotein

**Huaxin Chen**[*1], Peng Jiang[1,2]

[1] *Key Lab of Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China*
[2] *Laboratory for Marine Biology and Biotechnology, Qingdao National Laboratory for Marine Science and Technology, China*

Phycobiliproteins (PBPs) are light-harvesting protein found in cyanobacteria, red algae and the cryptomonads. They have been widely used as fluorescent labels in cytometry and immunofluorescence analysis. A number of PBPs has been produced in metabolically engineered *Escherichia coli*. However, the recombinant PBPs are incompletely chromophorylated, and the underlying mechanisms are not clear. In this work, pathway for SLA-PEB (a fusion protein of streptavidin and allophycocyanin that covalently binds PEB) biosynthesis in *E. coli* was constructed using a single-expression plasmid strategy. Compared with a previous *E. coli* strain transformed with dual plasmids, the *E. coli* strain transformed with a single plasmid showed increased plasmid stability and produced SLA-PEB with a higher chromophorylation ratio. To achieve full chromophorylation of SLA-PEB, directed evolution was employed to improve the catalytic performance of lyase cpcS. In addition, the catalytic abilities of heme oxygenases from different cyanobacteria were investigated based on BV and PEB accumulation. Regulation of the heme biosynthesis pathway was also carried out to increase heme availability and PEB biosynthesis in *E. coli*. Fed-batch fermentation was conducted for the strain V5ALD, which produced recombinant SLA-PEB with a chromophorylation ratio of 96.7%. The results suggested that both the plasmid instability and the limited activity of lyase and availability of PEB resulted in the incomplete chromophorylation of SLA-PEB. In addition to reporting the highest chromophorylation ratio of recombinant PBPs to date, this work demonstrated strategies for improving the chromophorylation of recombinant protein, especially biliprotein with heme, or its derivatives as a prosthetic group.

## OR 23-3

### Innovative product development at ALGAIA: alginate-based mucoadhesive films

**Benoit Queguineur**[*1], Fabien Canivet[1], Valentine Le Carour[1], Yaelle Salaun[1], Marion Rodrigues[1], Frederic Faure[1], Revital Mashal[2], David Gabbay[3]

[1] *Research and Development, ALGAIA, France*
[2] *Research and Development, ANLIT Ltd, Israel*
[3] *Research and Development, MAABAROT products, Israel*

ALGAIA is the main processor of brown seaweeds in France, producing and commercializing alginates and other bioactive ingredients for the global market. ALGAIA is also providing R&D services on macro- and micro-algae to many companies in the world in order to sustain novel extract development for further valorization of algal wild stocks or cultivated resources. Mucoadhesive film offer many advantages as drug delivery such as a rapid onset of action, a lower dose and a non invasive administration route among others. Alginates are large phycocolloids of guluronic and mannuronic acid blocks, with a broad range of size and viscosity. They also are tasteless, odorless, transparent, food safe, and used as medical device. Therefore they are suitable candidates for the development of mucoadhesive films, where alginates act as a drug filled reservoir for controlled drug delivery. The films can cover large areas, have a long shelf-life, are scalable and cost-effective. The production process of alginate films involve hydration of the forming polymer, incorporation of bioactive and non active ingredients, casting of active mass, drying on continuous belt, cutting and packaging. The influences of film composition, drying time, thickness have been monitored during the development. The use of natural plasticising compounds increased the flexibility of the films without affecting porosity, hence optimizing drying process and maximizing drug delivery efficiency. A selection of in house alginates have been targetted for optimum drug delivery through oral mucoadhesive films. ALGAIA is now producing more than seventy types of alginates in its 50-year old factory and thrives on innovation as the last 2 years have seen the development of over 20 new products.

## OR 23-4

### Review on indonesian *Sargassum* species bioprospecting: potential applications of bioactive compounds and challenge for sustainable development

**Maya Puspita**[*1], Nur Azmi Ratna Setyawidati[2], Valérie Stiger-Pouvreau[3], Laurent Vandajon[4], Ita Widowati[5], Ocky Karna Radjasa[5], Gilles Bedoux[4], Nathalie Bourgougnon[4]

[1] *Coastal Resources Management, Diponegoro University, Indonesia*
[2] *Agency of Research and Development for Marine and Fisheries, Ministry of Marine Affairs and Fisheries, Indonesia*
[3] *Laboratoire des Sciences de l'Environnement Marin, Université Bretagne Occidentale, France*
[4] *Laboratoire de Biotechnologie et Chimie Marines, Université Bretagne Sud, France*
[5] *Marine Science and Fisheries, Diponegoro University, Indonesia*

Due to the urge of human interest in isolating natural products from marine biodiversity for food or health commercial and industrial purposes, marine bioprospecting has increased rapidly in recent years and holds important promise in the future. Indonesian *Sargassum* species are one of marine species of brown algae with substantial value/s. Their wide range of potentiality, especially their bioactive compounds, make them a natural resource for various applications in food, cosmetic and pharmacology sectors. Thus, bioprospecting of *Sargassum* species becomes an interesting topic to discuss, especially for Indonesia where only the red alga *Kappaphycus* and *Gracilaria* are exported. This review illustrates the potential applications of *Sargassum* species concerning their bioactive chemodiversity. Further, possible challenges for sustainable development of Indonesia will also be described.

## OR 23-5

### Novel antioxidants from seaweed- source, extraction and application

**Susan Løvstad Holdt**[*1], Charlotte Jacobsen[1], Ann-Dorit M. Sørensen[1], Casimir C. Akoh[2], Ditte B. Hermund[1]

[1] *The National Food Institute (DTU Food), Technical University of Denmark, Denmark*
[2] *Food Science and Technology, University of Georgia, Athens, United States of America*

Industries are currently searching for efficient natural antioxidants to replace synthetic antioxidants, due to a general demand for clean labels

on food and cosmetic products. Seaweeds could be the answer to this since they contain several compounds with antioxidative properties such as phlorotannins, pigments, tocopherols, and polysaccharides. These compounds are located differently in the seaweed biomass, and different extraction techniques are optimal for each compound. These different techniques and solvents, but also the source of seaweed are discussed in this review. Some seaweed may have high concentration of a certain interesting antioxidant, but if this seaweed is of low abundance and not possible to cultivate, there is no future feasibility for commercial utilization. Among the antioxidative compounds studied, phlorotannins most likely have the highest antioxidative potential of seaweed extracts, and the current knowledge are presented of the antioxidant properties in in vitro studies as well as in food systems. After reviewing the studies on food models, the antioxidative effect of extracts from *Fucus vesiculosus* are among the most studied in in vitro food systems and applications. However, the very interesting characteristics and functionalities of these antioxidants, this seaweed is not as available worldwide compared to *Ascophyllum nodosum*, which also has high phlorotannin content. We recommend that more studies should be performed on the characterization, extraction and applicability of this latter commercial seaweed species.

## OR 24-1

### Draft genome of the brown alga, *Nemacystus decipiens*, Onna-1 strain: fusion genes related to sulfated fucan

**Koki Nishitsuji**[*1], Asuka Arimoto[1], Noriyuki Satoh[1], Eiichi Shoguchi[1]

[1] *Marine Genomics Unit, Okinawa institute of Science and Technology Graduate University, Japan*

The brown alga, *Nemacystus decipiens* ("ito-mozuku" in Japanese), is one of the major edible seaweeds, cultivated principally in Okinawa, Japan. *N. decipiens* is also a significant source of fucoidan, which has various physiological activities. To facilitate brown algal studies, we decoded the draft genome of *N. decipiens* Onna-1 strain. The genomic DNA and RNA were isolated from protonemas and sequenced using Illumina MiSeq and HiSeq 4000. The genome size of *N. decipiens* was calculated as ~154Mb by counting k-mer frequency of the paired-end read data. The genome was estimated to contain 15,156 protein-coding genes, ~78% of which were substantiated by corresponding mRNAs. Molecular phylogeny of mitochondrial genes and the analysis for extracellular matrix-related proteins indicated a close relationship between *N. decipiens* and another brown alga, *Cladosiphon okamuranus*. Comparisons with the *C. okamuranus* and *Ectocarpus siliculosus* genomes identified a set of *N. decipiens*-specific genes. Gene ontology annotation showed that more than half of these are classified as molecular function, enzymatic activity, and/or biological process. Characterization of genes that encode enzymes involved in the biosynthetic pathway for sulfated fucan showed two sets of genes fused in the genome. One is a fusion of L-fucokinase and GDP-fucose pyrophosphorylase genes, a feature shared with *C. okamuranus*. Another fusion is between an ST-domain-containing gene and an alpha/beta hydrolase gene. Although the function of fused genes should be examined in future, these results suggest that N. decipiens is another promising source of fucoidan.

## OR 24-2

### Complete plastid genome of the *Saccharina* cultivar "Rongfu" and its phylogenetic analyses

**Jing Zhang**[*1], Tao Liu[2], Yahui Yu[2], Shangang Jia[3], Guoliang Wang[4], Yuemei Jin[2], Zhenhui Jin[5], Hongze Song[6], Xumin Wang[3]

[1] *College of Biological Engineering, Qi Lu University of Technology (Shandong Academy of Sciences), China*
[2] *College of Marine Life Sciences, Ocean University of China, China*
[3] *College of Life Sciences, Yantai University, China*
[4] *Beijing Institute of Genomics, Chinese Academy of Sciences, China*
[5] *Fujian Xinhai Aquatic Fingerlings Co., Ltd., China*
[6] *Rongcheng Haixing Fisheries Co., Ltd., China*

"Rongfu"(*Saccharina japonica×lattissima*) is one of the most important commercially cultured *Saccharina* varieties in China. In this report, the complete plastid genome was fully sequenced. The plastid genome of "Rongfu" was characterized by the circular molecule with the length of 130,583 bp. It contains a large single-copy (LSC, 77,379 bp) and a small single-copy region (SSC, 43,175 bp), separated by two inverted repeats (IRa: 5,015 bp, and IRb: 5,014 bp). The genome encodes139 protein-coding, 29 tRNA, and 3 rRNA genes; none of these genes contains introns. Organization and gene contents of the "Rongfu" plastid genome were similar to those of *Saccharina japonica*. There is a co-linear relationship between the plastid genome of "Rongfu" and that of previously sequenced Laminariales species. Phylogenetic analyses showed that all taxa were clearly divided into two distinct lineages. Secondary plastid-containing groups including "Rongfu" and red algae formed one clade. Green algae and land plants formed another clade.

## OR 24-3

### Transcriptome of *Paulinella micropora* under high light stress condition

**Duckhyun Lhee**[*1], Khaoula Ettahia[1], Debashish Bhattacharya[2], Hwan Su Yoon[1]

[1] *Biological science, SungKyunKwan University, Republic of Korea*
[2] *Department of Biochemistry and Microbiology, Rutgers University, United States of America*

Photosynthetic *Paulinella* is a good model organism for understanding plastid organellogenesis because the primary endosymbiosis of *Paulinella* occurred relatively recently (90-140 Mya), compared to primary endosymbiosis that gave rise to the Archaeplastida (~1,500 Mya). Previous study using *Paulinella* chromatophora showed that this species is light sensitive and lacks light-induced transcriptional regulation of plastid genes and most EGT-derived nuclear genes. Moreover, expansion of the nuclear high light inducible gene family and its regulation may reflect the incomplete integration of host and plastid metabolisms. In this study, *Paulinella micropora*, which is sister species to *P. chromatophora*, were cultivated under two environmental conditions: low light as a control and high-light with light/dark reversal by 12-h period transition for a complete 42 hours. Seven-time points were sampled for both conditions with each alteration of light/dark cycle. Each condition was subjected to a high-throughput RNA sequencing analysis to investigate the molecular adaptation of high-light stress. Sequencing results provide a significant change in gene expression between control versus high-light condition from each time points. How photosynthetic *Paulinella* deal with photo-oxidative damage were investigated in this study.

## OR 24-4

## Mitogenome characteristics of crucial *Saccharina* cultivars in china

**Yahui Yu**[*1], Jing Zhang[2], Shangang Jia[3], Guoliang Wang[4], Tao Liu[1], Xumin Wang[3]

[1] *College of Marine Life Sciences, Ocean University of China, China*
[2] *College of Biological Engineering, Qi Lu University of Technology, China*
[3] *College of Life Sciences, Yantai University, China*
[4] *CAS Key Laboratory of Genome Sciences and Information, Beijing Key Laboratory of Genome and Precision Medicine Technologies, Beijing Institute of Genomics, Chinese Academy of Sciences, China*

*Saccharina* is a large seaweed with important economic and ecological value. So far, more than twenty varieties have been bred and used subsequently in China. To futher identify the genetic relationship between different *Saccharina* cultivars, we sequenced the complete mitogenome of six crucial Saccharina cultivars in China, 'Pingbancai', 'Hainong No. 1', 'Ailunwan', 'Zaohoucheng', 'Fujian' and 'Rongfu' , using the HiSeq×Ten system.The mitogenomes of the six cultivars all encoded 66 genes which consisted of 35 protein-coding genes, three rRNA genes, three ORFs and 25 tRNA genes. Compared with other clutivars, the mitogenome of the oldest cultivar 'Fujian' and 'Rongfu' lacked a non-coding region of 19 nucleotides, which was located between rRNA small subunit gene 3 and rRNA small subunit gene 9. The results suggested that the mitogenomes of different varieties show differences mainly in non-coding regions. The mitogenomes of rongfu's three continuous generations are identical showed the conservative evolution of mitogenome. The phylogenetic tree constructed from the amino acids by Bayesian method separated the six cultivars into two groups. The cultivars 'Ailunwan', 'Zaohoucheng', 'Pingbancai' and 'Hainong No. 1' were clustered with *S. japonica* which supported their parental origin. 'Rongfu' and 'Fujian' were clustered together and formed a separate cluster from other cultivars. So the variation of lacking non-coding region of 19 nucleotides can be used in germplasm identification of *Saccharina* cultivars. The study on mitogenomes of *Saccharina* cultivars confirm the current interpretation of the genetic relationships among *Saccharina* cultivars and provide important basis for the breeding of new varieties.

## OR 24-5

## Progress in QTL mapping for blade length and width of *Saccharina japonica*

**Xiuliang Wang**[*1], Zhihang Chen[1], Jie Zhang[1], Zhanru Shao[1], Jianting Yao[1], Delin Duan[1]

[1] *Key Lab. of Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China*

*Saccharina japonica* is one of the most important marine crops in China, Japan and Korea. Candidate genes associated with blade length and blade width have not yet been reported. Here, based on SLAF-seq, the 7627 resulting SNP loci were selected for genetic linkage mapping to 31 linkage groups with an average spacing of 0.69 cM, and QTL analyses were performed to map the blade length and blade width phenotypes of *S. japonica*. In total, 12 QTLs contributing to blade length and 10 to width were detected. Some QTL intervals were detected for both blade length and width. Additive alleles for increasing blade length and width in *S. japonica* came from both parents. After the QTL interval regions were comparatively mapped to the current reference genome of *S. japonica* (MEHQ00000000), 14 Tic20 (translocon on the inner envelope membrane of chloroplast) genes and three peptidase genes were identified. RT-qPCR analysis showed that the transcription levels of four Tic20 genes were different not only in the two parent sporophytes but also at different cultivation times within one parent. The SNP markers closely associated with blade length and width could be used to improve the selection efficiency of *S. japonica* breeding.

## OR 24-6

## Synergistic effects of HSE and LTR elements from HSP70 gene promoter of *Ulva prolifera* (Ulvaphyceae, Chlorophyta) upon temperature induction

**Chunhui Wu**[*1], Peng Jiang[1,2,3]

[1] *CAS Key Laboratory of Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China*
[2] *Laboratory for Marine Biology and Biotechnology, Qingdao National Laboratory for Marine Science and Technology, China*
[3] *Center for Ocean Mega-Science, Chinese Academy of Sciences, China*

Besides heat stress, the 70 kDa heat shock proteins (HSP70s) have been proved to respond to cold stress. However, the involved cis-acting elements remained unknown. The *hsp70* gene from green macroalga *Ulva prolifera* (*Uphsp70*) had been cloned from which one heat shock element HSE and one low temperature responsive element LTR were found in the promoter. Using the established transient expression system and quantitative GUS assay, series of element deletion experiments were performed to determine the functions of HSE and LTR in response to temperature stress. The results showed that under cold stress, both HSE and LTR were indispensible, since deletion leads to complete loss of promoter activity. Under heat stress, although the HSE could respond independently, coexistence with LTR was essential for high induced activity of the *Uphsp70* promoter. Therefore, synergistic effects exist between HSE and LTR elements in response to temperature stress in *Ulva*, and extensive bioinformatics analysis showed that the mechanism is widespread in algae and plants, since LTR coexists with HSE in the promoter region of *hsp70*. Our findings provided important supplements for the knowledge of algae and plant HSP70s response to temperature stress. We speculated that for plant domestication and artificial breeding, HSE and LTR elements might serve as potential molecular targets to temperature acclimation.

## OR 25-1

## Prospects for upgrading european seaweeds; a value chain perspective

**Sander Van den Burg**[*1], Trond Selnes[1], Ana Dias[2], Liliana Alves[3], Gohar Nuhof--Isakhanyan[1], Roel Helmes[1], Ana Daniel[3]

[1] *Wageningen Economic Research, Wageningen University and Research, Netherlands*
[2] *Departamento de Ambiente e Ordenamento / CESAM, University of Aveiro, Portugal*
[3] *Dep. Ciências Sociais, Políticas E Do Território, University of Aveiro, Portugal*

In Europe, seaweeds are considered a future source for food and feed. This instigated scientific and commercial endeavors to develop seaweed aquaculture and products. Prepared under H2020 GENIALG, this paper assesses prospects for economically viable seaweed value-chains. The global value chains framework is used to analyze how local actors (firms, communities, workers) are linked to and affected by major transformations in the global economy, using the core concepts of governance and upgrading – activities aimed at generating higher value for a product (Gereffi and Fernandez-Stark, 2011). Upgrading strategies followed in

Europe are identified. These are assessed by looking closer at the value chain through the features of the market, governance and context. Two upgrading strategies are used by the European sector: 1. Develop high-value markets for seaweed, including food, pharmaceuticals and cosmetics 2. Creating higher value by demonstrating value adding characteristics of European seaweed (sustainability performance, better quality, food safety) The European sector focuses on into niche markets and development of new markets. Analysis of published research articles, showing increasing European efforts to develop new markets confirms this. Developing new standards for seaweed is another attempt differentiate from 'global' seaweeds. Critical issues remain. Researchers and companies outside Europe are stronger in filing patents to protect inventions. European climatologic and geographical conditions are not always favorable. The small scale experimental nature of seaweed aquaculture leads to high productions costs. European seaweed aquaculture and industry currently lives from wild harvests and small-scale aquaculture for high-value local markets. The ambition is to make a meaningful contribution to the provision of food and feed. The seaweed sector should aim to create additional value by showing and capitalizing the contribution of seaweed to public policy objectives (food security, support local business, societal, ecological, regional development).

## OR 25-2

### Seaweed governance for sustainability: a case study of using the triple helix approach in Malaysia

**Adibi Nor**[*1], Tim Gray[2], Gary Caldwell[3], Selina Stead[4]

[1] *International Institute of Public Policy and Management, University of Malaya, Malaysia*
[2] *School of Geography, Politics and Sociology, Newcastle University, United Kingdom*
[3] *School of Natural and Environmental Sciences, Newcastle University, United Kingdom*
[4] *Institute of Aquaculture, Faculty of Natural Sciences, University of Stirling, United Kingdom*

Successful seaweed production depends inter alia upon effective institutions of governance. Understanding how to create and maintain good governance is the focus of this paper. In the two countries where seaweed production has been most successful – the Philippines and Indonesia – it is noteworthy that they have established mechanisms of good governance: a top-down system in the Philippines and a bottom-up system in Indonesia. In Malaysia, seaweed production has been less successful, and it is arguable that this is partly because of poor governance. The Sabah Fisheries Department (SFD) managed the seaweed industry in Malaysia from the late 1970s until the 1990s, but adopted a largely hands-off approach that failed to get to grips with the problems which faced the industry. From the 1990s onwards, a variety of government agencies at both federal and state levels have become involved with the industry, some of which have introduced seaweed farming in areas such as Sabah as part of poverty alleviation and alternative livelihood programme. This government intervention has not, however, prospered and many of the commercial-scale seaweed farming projects established since 2012 have failed. This research project used a mixed-methods approach to examine the relationships between the actors involved in the so-called triple helix (i.e., scientists, government and industry) at multiple levels in order to determine why these projects failed. The study concluded that the main reason for failure was an inadequate legal and policy framework. In particular, there was a lack of integration between agencies which manifested both a silo mentality and an unwillingness to take responsibility for, or ownership of, seaweed projects. Also, the implementation of the seaweed projects was hampered by the limited capability of officials and the lack of stakeholder participation in decision-making processes. The state agencies should improve institutional capability by adopting good governance in managing the seaweed industry.

## OR 25-3

### Tanzania seaweed value chain assessment

**Msafiri Andrew**[*1], Flower Msuya[1], Rusekwa Sadock[1], Ivy Matoju[1], Virginie Le Masson[2], Josephine Tsui[2]

[1] *Botany, University of Dar Es Salaam, United Republic of Tanzania*
[2] *GlobalSeaweedStar Project, Scottish Assocciation of Marine Science (SAMS), United Kingdom*

Almost30 years after seaweed farming was introduced on the island of Zanzibar, it is still growing very rapidly. The sector provides employment most notably to the women and increased household income Seaweed farmers are now able to support their families and change their lifestyle from income generated from seaweed farming. Most of farmers have been selling their dried seaweed to the buyers without adding value and therefore ending up with very low returns. Due to that many farmers are considering the sector as a non paying business and hence majority of them especially men have left seaweed farming for other higher paying business. After the year 2006 when Zanzibar Seaweed Cluster Initiative (ZaSCI) was formed, farmers started to add value to their seaweed, get higher profit, and thus improve their livelihoods. However, there has been limited study on the seaweed value chain in Tanzania and the exact role of it in improving peoples' livelihoods. Therefore, this study aims at assessing the roles of each actor in the Tanzania seaweed value chain. We are using semi structured questionnaire to inquire information from these actors including producers, collectors, institutions, and policy makers, with the aim of identifying the issues most seriously affecting products demand, the marketing structure of the products and acceptability of value added products. The preliminary results in Zanzibar showed that most of farmers are women (more than 80%), the price of the dried seaweed per kilogram is TSh 600. Many farmers are doing both farming and processing to produce value added products like soaps, body lotion, cakes, breads, juices etc. After harvesting and drying, farmers sell their seaweed to the buying company which export it abroad. The findings from this project will provide important information for the better planning and development of seaweed sector in Tanzania.

## OR 25-4

### Model management for sustainable seaweed farming in Pulau Sembilan Island, Sinjai District, Indonesia

**Nurlita Pertiwi**[*1], Mashur Razak[2], Djusdil Akrim[3]

[1] *Public Administration Studies, Universitas Negeri Makassar, Indonesia*
[2] *Business Management, STIE Nobel Indonesia Makassar, Indonesia*
[3] *Environment Education Studies, Universitas Negeri Makassar, Indonesia*

Sustainable seaweed management is a solution to improving the welfare of farmers and as an effort to maintain the existence of seaweed cultivation in southern Sulawesi. Researcher chose Pulau Sembilan as the focus of development with consideration of seaweed potential and the spreading of seaweed cultivation. This study uses the R and D technique with the approach of Borg and Gall. The results of the need assessment study show that grass cultivation is very conventional, namely the low quality of crop

yields, limited market access and the existence of conflicts of interest between cultivation areas and tourist areas. Furthermore, in developing the seaweed management model, researchers found the importance of training centers, post harvesting management and responsible management as the main supporting factors in seaweed cultivation. The results of field trials show that farmers in general assess that a sustainable seaweed management model can be applied on Pulau Sembilan and can contribute to the management of seaweed cultivation.

## OR 25-5

### Entrepreneurial capacity of the seaweed farmers in South Sulawesi, Indonesia

**Gufran D. Dirawan**[*1], Djusdil Akrim[2], Siti Fatmah Hiola[3]

[1] *Public Administration Studies, Universitas Negeri Makassar, Indonesia*
[2] *Environment Education Studies, Universitas Negeri Makassar, Indonesia*
[3] *Environmental Science and Horticulture, Universitas Negeri Makassar, Indonesia*

The purpose of this study is that entrepreneurial capacity enables seaweed farmers to utilize the potential of their resources as an alternative solution in building competitiveness seaweed cultivation. This study is measuring the entrepreneurial capacity of seaweed farmers from several aspect as farming management, technical base cultivation and independence business. This study uses field survey and the quantitative descriptive approach with a total sample of 100 seaweed farmer which is located from Takalar, Bantaeng, Bone, Wajo and Pangkep. The analysis use in this study is quantitative descriptive and correlation analysis by ANOVA test. The results assumes that the entrepreneurial capacity of seaweed farmers affected by characteristic of seaweed farmers such as age, farming experience and side jobs. While the category of entrepreneurial capacity still low. The study also confirmed that the entrepreneurial capacity of seaweed farmers affected significantly from farming experience and side jobs.

## OR 25-6

### A systematic analysis of policies protecting the seaweed industry of the Philippines

**Jonalyn Mateo**[*1], Iona Campbell[2], Elizabeth Cottier-Cook[2], Anicia Hurtado[1], Maria Rovilla Luhan[1]

[1] *Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC/AQD), The Philippines*
[2] *Blue Economy, Scottish Association for Marine Science, United Kingdom*

The seaweed industry in the Philippines has been one of the most significant reasons why aquaculture has remained as the highest producer in the fisheries sector in this country for the last 4 decades. Since the 1970s, seaweed, especially *Kappaphycus* and *Eucheuma* spp. has been farmed throughout the Philippines. Unfortunately, a decreasing trend in production has been observed since the mid-2000s. Different factors have been pointed out, but diseases and pests have been the main cause attributing to this decline. Biosecurity has gained increased attention over the last few years, due to growing demand of certain food sources and a greater incidence of disease threatening the sustainability of the industry in the country. As a farmed commodity, however, seaweed is given little attention compared with other forms of aquaculture. This paper reviews national policies and legislation in the Philippines relevant to the seaweed industry following the procedure of Dahlstrom et al. (2011). A total of seven policies and legislative frameworks, which included biosecurity, were compared. Biosecurity measures were found to be limited to aquaculture commodities, such as tuna, milkfish, shrimp and agriculture crops, such as coconut and corn. Only one legislative framework (Code of Good Aquaculture Practices (GAqP) for Seaweed (PNS/BFS 208:2017) was found to be exclusive to seaweed, but it did not contain a strong biosecurity component. It is, therefore, recommended that a new national policy is produced for the Philippines, that is exclusive to seaweed and which includes practical measures to minimize the introduction of diseases and pests to seaweed farms.

## OR 26-1

### Application of various types of local seaweed extract to the growth and yield of shallot (*Allium wakegi* A.)

**Ramal Yusuf**[*1], Abdul Syakur[1], Yulianti Kalaba[1], Hidayati Masud[1], Fatmawati Fatmawati[1]

[1] *Faculty of Agriculture, University of Tadulako, Indonesia*

This study aims to determine the effect of various types of local seaweed extract on the growth and yield of shallot (Allium wakegi A.) varieties of lembah palu. This research was conducted in the field in Jone Oge Village, Sigi Biromaru, Palu. The research design was using Randomized Block Design. With treatment: P0 = (control), P1 = NPK fertilizer 1.25g/plant, P2 = (*Caulerpa* sp.) extract 100 ml/plant/week, P3 = (*Sargassum* sp.) extract 100 ml/plant/week, P4 = (Euchema cattonii) extract 100 ml/plant/week, P5 = (*Ulva* sp.) extract 100 ml/plant/week. Therefore, there are 6 treatments, each treatment was repeated 4 times so that the whole was 24 units of experiment. The results showed that application of seaweed extract had significant effect on all parameters including height of plant (cm), number of leaves, fresh weight of plant (g), dry weight of plant (g), fresh weight of bulb (g), dried weight bulb (g), and tuber diameter (cm). The results showed that Ulva sp. extract better compared to control and others seaweed extract.

## OR 26-2

### Targeted enzymatic modification of seaweed hydrocolloids

**Nanna Rhein-Knudsen**[*1], Anne S. Meyer[1]

[1] *DTU Bioengineering, Technical University of Denmark, Denmark*

Carrageenans and agar are red seaweed hydrocolloids composed of galactopyranosyl and anhydro-galactopyranosyl residues. The biosynthetic route for these hydrocolloids is proposed to include three classes of enzymes; galactosyl transferases (α and β), catalyzing the polymerization of the galactose backbone, sulfotransferases, adding sulfate substitutions to the newly synthesized galactose chains, and Gal-6-sulfurylases, catalyzing the removal of sulfate at position 6 in the α-galactopyranosyl monomer and subsequent formation of the 3,6-anhydro bridge. The formation of the anhydro-galactopyranosyl moieties in the final step of the carrageenan and agar biosynthetic route confers the gelling properties of the two hydrocolloids, as the chair conformation changes to the helix compatible 1C4, which is essential for gel-formation. The sulfurylases have the ability to specifically convert these hydrocolloids into high-gelling products and thus offers the possibility to use them for modification during processing and production of hydrocolloids. Based on the publicly

available genome sequence data of the red seaweed *Chondrus crispus*, this study was conducted in order to obtain recombinantly expressed sulfurylase enzymes, which potentially could be used for sustainable and selective modification of seaweed hydrocolloids. Inherently, successful de-sulfatation of galactopyranosyl 6-sulfate would in turn be expected to change the macromolecular hydrocolloid properties. In this presentation the data obtained of the enzyme analyses and enzymatic treatments will be presented and discussed.

## OR 26-3

### Advances in knowledge of seaweed as a natural alternative to sub-therapeutic antibiotics in livestock production

**Jason Sands**[*1], Augustine Owusu-Asiedu[1], Marc Kinjet[1], Graham Ellis[1], Elijah Kiarie[2], Dan Bussières[3]

[1] *Ocean Feed, Ocean Harvest Technology, United Kingdom*
[2] *Animal Sciences, University of Guelph, Canada*
[3] *Group Ceres, Group Ceres, Canada*

Antibiotic microbial resistance has been identified as a threat to human health. Globally, governments are seeking means to reduce subtherapeutic use of antibiotics in animal production. Macroalgae containing unique bioactive compounds with prebiotic, antibiotic, anti-viral, anti-inflammatory and antioxidative properties have been identified as potential alternatives. However, data supporting their bioefficacy as natural alternatives in livestock and poultry production remains scarce. The potential for using a unique blend of red, brown and green seaweed species as a natural additive replacing subtherapeutic antibiotics was investigated in both poultry and swine. In poultry, the bioefficacy of seaweed was tested in a 42-d trial with 2 treatments; standard diet (CON) and CON with seaweed blend dosed at 0.5%, using 432 d-old broiler chicks. Body weight and feed intake were monitored and weight gain and feed conversion ratio calculated. All mortalities were recorded. In swine, three diets were compared, 1) an industry standard diet with sub therapeutic antibiotics and high zinc oxide (2500 ppm), 2) As diet 1, but without sub therapeutic antibiotics and 3) As diet 1, but without sub therapeutic antibiotics and high zinc oxide and added seaweed blend. Diets were fed to 936 weaned pigs (13 replicate pens per treatment, 26 pigs/pen) for 56 days. Feed intake, bodyweight and mortalities were recorded. The severity of diarrhea was assessed and scored on a 0-5 point scale for each pen. Data was analyzed as complete randomized design by GLM of SPSS. The macroalgae blend supplementation in both trials improved ($P<0.05$) growth performance by 3-5% and resulted in 2-6% lower death loss. The current studies suggest that the use of macroalgae containing a blend of red, brown and green species potentially enhances gut health, leading to improved nutrient utilization and overall performance and may be a viable natural alternative to sub therapeutic antibiotics.

## OR 26-4

### Individual and combined effects of heavy metals (HM) and polycyclic aromatic hydrocarbons(PAH) toward spore release, settlement and germination of brown kelps *Lessonia spicata* and *Macrocystis pyrifera*

**Andrés Meynard**[*1], Camila Espinoza[1,2], Alejandra Nuñez[1,2], Javier Zapata[1,2], Francisco Castañeda[1,2], Cristian Bulboa-Contador[1,2], Loretto Contreras-Porcia[1,2,3]

[1] *Ecology and Biodiversity, Universidad Andres Bello, Chile*
[2] *Centro de investigaciones Marinas (CIMARQ), Universidad Andres Bello, Chile*
[3] *Center of Applied Ecology and Sustainability (CAPES), Pontificia Universidad Católica de Chile, Chile*

In comparison to individual toxicity, interactions between heavy metals (HM) and polycyclic aromatic hydrocarbons (PAH) toward seaweeds is scarcely documented. Notwithstanding seaweeds are essential to coastal community functioning, only studies on microalgae exist showing that PAH toxicity diminishes abundances, viability and chlorophyll-a concentration. Furthermore, individual toxicity of HM have been reported; for example, copper and cadmium were shown to inhibit spore settlement and gametophyte development in the kelps *L. spicata* and *M. pyrifera*. In central Chile, where these two kelps are key species of coastal ecosystems, previous researches in the industrial area of Puchuncavi-Ventanas (32°S, 44'W) evidenced high concentrations of HM and PAH in the seawater and high HM bioconcentration. Accordingly, to determine the sensitivity of these seaweeds to the combined effects of HM and PAH, we first established copper, cadmium and PAH (16 compounds mixture) concentrations causing 20% (IC20) arrested spore release (after 1, 2, 3, 5 and h) settlement and germination (3 days), under controlled conditions. Dose-response analyses were carried using DRC in R software. The Cu, Cd and PAH treatments included seven (5-200 µg L-1), eight (1-1000 µg L-1) and nine concentrations (0.05-100 µg L-1) respectively; and a control condition. Individual and combined effects of toxics (using IC20 values) were both species-, and time-dependent. For example, IC20 results revealed that concerning settlement, *L. spicata* was more tolerant to PAH and cadmium and sensitive to copper than *M. pyrifera*. Moreover, the combined HM and PAH treatments toward spore release in *M.pyrifera*, for example, varied from being antagonistic to additive or sinergistic, from hour 1 to 7, whereas the Cd+PAH treatment was always antagonistic, in *L. spicata*. The results suggest both macroalgae respond differently in a time dependent manner, and both are more sensitive/tolerant during specific life cycle stages.

## OR 26-5

### Antioxidant responses and phenolic compounds of *Palisada perforata* (Rhodomelaceae, Rhodophyta) against environmental stressors from different microhabitats of a tropical reef

**Juliane Bernardi**[*1], Edson Vasconcelos[1], Adilma Cocentino[1], Fungyi Chow[2], Mutue Fujii[3]

[1] *Oceanography, Universidade Federal de Pernambuco, Brazil*
[2] *Instituto de Biociências, Universidade de São Paulo, Brazil*
[3] *Núcleo de Pesquisa em Ficologia, Instituto de Botânica, Brazil*

Tropical reefs are extremely dynamic and stressful habitats for intertidal seaweeds, since they must cope with a constantly changing environment due to tidal fluctuations. Successful adaptive strategies related to oxidative stress impairments must be effective to protect the algal cellular structures and homeostasis. The cosmopolitan Rhodophyta *Palisada perforata* dominates algae communities in Brazilian tropical reefs, so it should display an efficient and dynamic antioxidant defense system that allows it to cope with desiccation and fluctuations in radiation, temperature and salinity. Therefore, antioxidant responses and total phenolic compounds of *P. perforata* collected on four different reef microhabitats (sheltered, tide pool, plateau and exposed) were investigated. Additionally, two laboratory experiments were conducted to assess the influence of abiotic stressors (temperature, salinity and desiccation) on antioxidant responses and photosynthetic performance. The microhabitats showed little influence

on the antioxidant potential, which varied among exposure gradient as following: exposed ≥ plateau > sheltered > tide pool. Under experimental conditions, photosynthesis was not affected by temperature or salinity, as effective quantum yield decreased approximately 2.5% from maximum quantum yield, with almost a complete recovery of photosynthesis, probably associated to the significant antioxidant capacity and phenolic compounds content exhibited by *P. perforata*. *Palisada perforata* was most affected by desiccation (decreasing 23% of photosynthesis), when compared to temperature or salinity laboratory experimental conditions. Algae from plateau and exposed reef microhabitats are more susceptible to the influence of air and UV radiation during low tides, demanding higher antioxidant defense systems to protect themselves from oxidative damage. The capacity to produce antioxidants to protect its photosynthetic apparatus makes *P. perforata* an adapted seaweed to inhabit harsh environments as the intertidal reefs of tropical regions.

## OR 26-6

### Chemical analysis of iodine in fermented seaweed salad and human risk assessment in relation to total intake of iodine

**Susan Løvstad Holdt**[*1], Azadeh Bahmani[1], Jens J. Sloth[1], Max Hansen[1]

[1] *The National Food Institute (DTU Food), Technical University of Denmark, Denmark*

Regular excessive intake of iodine might be associated with thyroid dysfunction and as a consequence several other serious adverse effects in some individuals. Seaweed consumption has become more common in the European countries and some large brown species have a high content of iodine. The aim of this study was to determine the iodine concentration of a commercial fermented seaweed salad (Nordisk Tang in Denmark), the effect of the processing steps on the iodine concentrations, and risk characterization and recommendation on intake of the seaweed salad. The iodine reduction was determined (ICP- MS technique) at different production process steps of two fermented seaweed salad batches (n=3 of each) with the main ingredients; *Saccharina latissima* and *Alaria esculenta* (ratio 2:1). Data showed the same trend of reduction of iodine concentration in defrosting, blanching (83°C, 3 min), and fermentation processes. Iodine concentrations decreased by 59- 74% and up to 62% in the blanching steps of respectively batch 1 and 2 ($p<0.01$). Moreover, the fermentation step caused 55-75% decrease in iodine concentration, due to the soaking of seaweeds in 35°C water for 10-20 hours. As a result, the iodine concentration of finished product of batch 1 and 2 were 177±6 and 514±33 µg/g respectively. The Tolerable Upper Intake Level (UL) of 1,000-1100 µg/day iodine considered to be reasonable for this study, assuming that the target individuals consuming seaweed are adults, and taking EFSA (European Food and Safety Authority) UL factors into account. The recommendation is a moderate single serving of fermented salad once a week that is considered acceptable for healthy adults. However, the consumption of fermented salad should be avoided during pregnancy, lactation, and for all children under 3 years old, due to excessive iodine can have adverse effect on the fetus, newborns and children organ development.

## OR 27-1

### Co-occurrence patterns of bacteria, archaea, and phytoplankton in *Cochlodinium polykrikoides* bloom in South Sea of Korea

**Chi-Yong Ahn**[*1], Yingshun Cui[1], Seong-Jun Chun[1,2], Seung Ho Baek[3], Moonho Son[4], Hee-Mock Oh[1]

[1] *Cell Factory Research Center, Korea Research Institute of Bioscience and Biotechnology (KRIBB), Republic of Korea*
[2] *Department of Environmental Biotechnology, KRIBB School of Biotechnology, Korea University of Science and Technology (UST), Republic of Korea*
[3] *South Sea Environment Research Center, Korea Institute of Ocean Science and Technology (KIOST), Republic of Korea*
[4] *South Sea Fisheries Research Institute, National Institute of Fisheries Science (NIFS), Republic of Korea*

Harmful algal blooms (HABs) of the *C. polykrikoides* cause huge economic and ecological damages, thus are of environmental problems in Korea. Previous studies uncovered that the formation and collapse of phytoplankton blooms could be closely related to their associated microbes, while almost no reports to elucidate the roles of microbes in *C. polykrikoides* blooms in field. To explore the potential links between *C. polykrikoides* and other microbes, we collected water samples in different size-fractions when *C. polykrikoides* blooms were occurred in South Sea of Korea. Bacteria, archaea, and phytoplankton community structures were deep-sequenced using next-generation sequencing approach. Compared with the non-bloom samples, Marine group I (archaea), Micrococcaceae and Piscirickettsiaceae (bacteria), and Syndiniales group I (phytoplankton) were more enriched in *C. polykrikoides* bloom period. Network analysis showed that *C. polykrikoides* module compositions significantly differed from those of other modules that included Alexandrium, *Chaetoceros* or *Chattonella,* indicating specific microbial clusters were related to *C. polykrikoides* bloom. Among the OTUs directly correlated with *C. polykrikoides*, Marine group I could supply vitamin B12, the essential element for *C. polykrikoides* growth, while the potential fish pathogens (Micrococcaceae and Piscirickettsiaceae) could contribute to massive fish death together with *C. polykrikoides* itself. In addition, the zoospore of Syndiniales might be related to the sudden collapse of *C. polykrikoides* blooms. Collectively, our results showed new insight into the mechanism of rise and fall in *C. polykrikoides* blooms in the aspect of microbial interaction.

## OR 27-2

### The management of harmful algal blooms in newly constructed weirs/dams

**Heesuk Lee**[*1], Yeon-jeong Park[1], Seungyoon Lee[1], Kwangsoon Choi[1], Suna Chong[1], Hye-suk Yi[1], Seungryong Baek[1], Jisun Yu[1], Yu-sik Jeong[1], Soohyun Kim[1], Hojoon Kim[1]

[1] *K-water Institute, K-water, Republic of Korea*

The spread of harmful algal blooms (HABs) is a global issue due to temperature increases that are attributed to climate change and the inflow of pollution sources due to industrial development. Every summer in Korea, harmful algal blooms are a serious/major issue for several reasons. Although harmful algal blooms are a natural phenomenon that occur when trigging conditions in a water body are adequate, there are several concerns related to harmful algal blooms such as drinking water safety and recreational use of water. In this study, phytoplankton variations found near newly constructed weirs and dams were surveyed to research the factors of harmful algal blooms. Blue-green algae that causes harmful algal blooms in reservoirs and streams are known for producing odorous compounds and toxins. Therefore, HABs should be controlled near the intake structures for water treatment plants. The areas surveyed in this study were the Nakdong

River and Bohyun reservoir. Also, the effects of controlling stratification using surface or underwater mixers and HAB blocking curtains were surveyed. During the survey period, harmful algal blooms occurred every summer in the study area. Most of the HABs were revealed as Microcystis spp. and Aphanizomenon spp. Physical and chemical factors such as precipitation and nutrients sources could be the main factors of their succession. The equipment such as surface mixers and underwater mixers showed effective results for their control and management. Point or non-point sources of contamination from large urban centers were identified as being the cause of phytoplankton population increase following nutrients levels. Therefore the polluted sources should be controlled to manage HABs.

## OR 27-3

### Green tide dynamics revealed by tracking the floating ecotype of *Ulva prolifera* in the Yellow Sea

**Peng Jiang**[*1]

[1] *CAS Key Laboratory of Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China*

A unique floating ecotype of *Ulva prolifera* (Ulvophyceae, Chlorophyta) has been confirmed to be responsible for the world-largest green tide occurred in the Yellow Sea, and a SCAR genetic marker specific to this ecotype has been developed. To re-evaluate the Subei Shoal as the origin of *Ulva* bloom, a SCAR-based investigation was conducted in this research, with thousands of green seaweed individual samples collected from two stages, i.e. the attaching stage on *Pyropia* aquaculture rafts and the subsequent free drifting stage northward. Here we showed that there were diversity and succession of *Ulva* species attached on the *Pyropia* rafts, in which the floating ecotype of *U. prolifera* appeared in late March when water temperature increased. Despite a low species proportion close to 5%, this floating ecotype dominated the *Ulva* bloom soon after being discarded to the sea. In the drifting stage, the ratio of floating ecotype reached to almost 100% in 2016, and nearly 70% in 2017 when a golden tide by *Sargassum* happened in same region. Based on the synchronous investigation to the diversity of attached *Ulva* along the Yellow Sea coastal line, there were no notable settlement of floating ecotype by far. In conclusion, the population dynamics for this floating ecotype during green tide was described for the first time. It was not the coastal line but the Subei Shoal that served as the seed origin for the *Ulva* bloom in the Yellow Sea.

## OR 27-4

### Assessment of salinity tolerance based on physiological and oxidative stress responses in *Ulva* and *Pyropia*

**Palas Samanta**[*1], Sookkyung Shin[1,2], Sojin Jang[1,2], Jang K Kim[1,2]

[1] *Reseaech Institute of basic sciences, Incheon National University, Republic of Korea*
[2] *Department of Marine Science, Incheon National University, Republic of Korea*

Present study was designed to assess physiological and oxidative stress [reactive oxygen species (ROS), lipid peroxidation (LPO), superoxide dismutase (SOD), catalase (CAT), glutathione reductase (GR), glutathione peroxidase (GPx) and glutathione S-transferase (GST)] responses in *Ulva* and *Pyropia* to salinity stress. *Ulva* and *Pyropia* were exposed to three salinity conditions (5, 30 and 55 psu) in von Stosch Enriched medium for 1, 7, 14 and 28-days at 15 ℃ under 100 µmol photons $m^{-2}$ $s^{-1}$ of irradiance with 12:12 light-dark photoperiod. Growth rate was significantly ($p < 0.05$) reduced at 28-day under hyposaline condition compared with control (30 psu). Chlorophyll a and carotenoids contents were reduced at hyposaline condition, whereas its level increased at hypersaline condition. Phycoerythrin and phycocyanin contents in *Pyropia* decreased at hyposaline condition, whereas its level increased at hypersaline condition. Enhanced LPO level with increasing exposure periods could be correlated with ROS level, which suggested oxidative damage (5 psu > 55 psu). At hyposaline condition, SOD, CAT, GR and GPx activities in Pyropia increased at 1- and 7-days but only SOD, CAT and GPx activities increased at 1-day in *Ulva*. At hypersaline condition, enzyme activities increased in both species at 28-day indicating that ROS scavenging enzymes played prominent role for salinity tolerance at hypersaline condition. GST activity was reduced at hyposaline condition while its activity increased at hypersaline condition in both species. These results revealed that *Ulva* and *Pyropia* respond differently to salinity stress and lower salinity is more stressful. These results suggest the potential role of antioxidant enzymes to combat salinity-induced oxidative stress.

## OR 27-5

### The development of bioactives from blooming seaweeds in Normandy, France: the Enteromorphe and SNOTRA projects

**Benoit Queguineur**[*1], Jeremy Brebion[1], Marine Dehail[1], Franck Hennequart[1], Véronique Lavatine[2], Vanessa Reynier[2], Coralie Delaunay[3], Sebastien Pien[3]

[1] *Research and Development, ALGAIA, France*
[2] *ACTALIA, France*
[3] *SMEL, France*

ALGAIA is the main processor of brown seaweeds in France, producing and commercializing alginates and other bioactive ingredients for the global market. ALGAIA is also providing R&D services on macro- and micro-algae to many companies in the world in order to sustain novel extract development for further valorization of algal wild stocks or cultivated resources.With its R&D facilities located in Normandy, France, ALGAIA aims at adding value to local seaweeds with local stakeholders using the strength of their industries (oyster and mussel farming) and turning threats of algal blooms into opportunities. After a previous project investigating the standing stocks of Sargassum muticum (Yendo) blooms, harvesting techniques and harvesting license implementation, the SNOTRA project has generated extracts and targeted bioactivities in cosmetics such as anti-inflammatory, antioxidant (IC50 of 1 to 1,5 mg/ml) and antiaging (40% inhibition at 1 mg/ml) and as biostimulant in agriculture applications. The initial lab extracts have now been upscaled to pilot scale production. On the other hand, the Enteromorphe project is dealing with the opportunistic *Ulva* sp. (Linnaeus), growing on oyster tables, affecting the growth of oysters. The project tested various conservation methodology, developed polysaccharide extracts, and assessed the antiviral properties of the latter. One extract showed antiviral activity with an EC50 of 74,25 µg/ml. Besides, specific food products have also been developed on the basis of the high concentration of Magnesium in the seaweed, and its role in muscular tonicity. ALGAIA is developing extracts at laboratory and pilot scale, with bioactivity assays to bring added value to local seaweeds and support the industry.

## OR 27-6

## Socioeconomic dimension of the *Sargassum* blooms: the mexican experience during the last four years

**Daniel Robledo**[*1], Katia Frangoudes[2], Denis Bailly[2], Julia Fraga[3]

[1] *Marine Resources, CINVESTAV, Mexico*
[2] *AMURE-UIEM, University of Occidental Brittany, France*
[3] *Human ecology, CINVESTAV, Mexico*

The Mexican Caribbean started to fight the proliferation of pelagic *Sargassum (fluitants* and *natans)* the last four years. The influx of these species of brown seaweed washed ashore in almost 500 kilometers, from Cancun to Mahahual in the state of Quintana Roo in the Yucatan Peninsula. In 2018 more than 200 tons of *Sargassum* by kilometer of beach shoreline were harvested between May to October. It has been estimated that more than 12,000 people participated in the clean-up effort for a total cost of 302 million Mexican pesos, whereas another 610 million were use for the mitigation of the problems associated (*circa* one million US dollars). This study identifies the socioeconomic aspects in relation to the proliferation of *Sargassum* between 2015 and 2018. With an ethnographic methodology we applied 45 interviews and 90 surveys to 8 groups (fishermen, snorkelers, scuba divers, hotels, academic institutions, local collectors, civil society, governmental officials). Workshop and snowball methods with seven informants who helped identifying the main socioeconomic actors was applied. The results demonstrated academic fragmentation and a slowly integration between private sector from the tourism industry and national environmental officials from the government. The social perception of the interviewers took two orientations: the pollution comes from Brazil and the Gulf of Mexico and the reaction of mother nature is imminent. Our study suggests that we need to go from a negative perception of the *Sargassum* blooms to a positive valorization (i.e. start up enterprises) taking into account community based organization considering the three states of the Yucatan Peninsula (Campeche, Yucatan and Quintana Roo). We are promoting a collaborative research between French and Mexican Institutions with a high orientation in DSS (Decision Support System) balancing social and natural scientists.

## OR 28-1

## Study on the underlying mechanism of the thermotolerance strains of *Pyropia haitanensis*

**Wenlei Wang**[*1], Yan Xu[1], Dehua Ji[1], Changsheng Chen[1], Chaotian Xie[1]

[1] *Fisheries College, Jimei University, China*

*Pyropia haitanensis*, a high-yield commercial seaweed in China, is currently undergoing increasing levels of high-temperature stress (HTS) due to gradual global warming. HTS has caused a severe reduction in *P. haitanensis* by inhibiting survival of the conchospores recently, enhancing premature senility, as well as inducing germinating disease. Based on mutation breeding and cross-breeding, a thermotolerant strain of *P. haitanensis* ('Minfeng No. 1', MF1) was selected. We used a wild-type line (♂), YSIII, and a red-type artificial pigmentation mutant line (♀), RTPM, as the parental lines for cross-breeding. After treatment at 30 °C for 8 days, more needle-like white spots appeared in MF1 thallus and disappeared after thallus was transferred into moderate temperature culture, while wild-type almost completely decayed after treatment at 28 °C for 6 days. Additionally, MF1 had a long growth cycle, matured late, and was not easy to age and rot, which leads to increasing the number of harvests. Compared with traditional wild type, the content of total phycobiliprotein and chl a in MF1 were 2.14 times and 59.2% higher respectively, which results in good gloss, and delicious. Furthermore, the thermotolerance mechanism of MF1 was investigated by integrating physiological measurements, omics analysis and transformation verification. The results suggested that the Ca2+ signal triggered the resistant genes or metabolisms in the response of MF1 to HTS. MF1 could establish acclimatory homeostasis more quickly by reducing reactive oxygen species via inhibiting photosynthesis, increasing the activities of energy metabolism, and heat shock proteins, and accelerating ubiquitin-mediated proteolysis for repairing or clearing the unfolded and damaged proteins. The present results may facilitate further studies on the molecular mechanisms underlying thermotolerance tolerance in *Pyropia*, as well as allow improvement of breeding schemes for thermotolerance tolerant macroalgae that can resist global warming.

## OR 28-2

## Characterization of the improved strain (HR-5) of *Pyropia haitanensis* and its pilot cultivation in mariculture farm

**Hong-chang Ding**[*1], Xing-hong Yan[1,2,3]

[1] *Key Laboratory of Exploration and Utilization of Aquatic Genetic Resources, Ministry of Education, Shanghai Ocean University, China*
[2] *National Demonstration Center for Experimental Fisheries Science Education, Shanghai Ocean University, China*
[3] *Shanghai Engineering Research Center of Aquaculture, Shanghai Ocean University, China*

The characteristics of the improved strain (*HR-5*) were evaluated and compared with the wild type strain *(WT*) in *Pyropia haitanensis* according to the results of the laboratory studies and pilot scale tests in mariculture farm. The results showed that, at the suitable temperature (23 °C) and high temperature (27 and 29 °C) for 7 days, the survival rates of conchospores were 86.6, 73.5 and 42 % in *HR-5*, which was 1.0-, 1.1- and 1.0-fold of that of *WT*, respectively. When the F1 gametophytic blades of *HR-5* and *WT* were firstly cultured at 23 °C for 25 days, and then cultured at 23, 27 and 29 °C for another 20 days, respectively, the mean blade length increased by 13.1, 8.7 and 6.4 times for *HR-5*, and only 8.9, 4.6 and 3.5 times for *WT* compared with the original lengths, respectively. Three times of the blade harvests were done in sea cultivation, and the mean wet weight of HR-5 blades was 0.17, 0.27 and 0.42 g per blade, which was 2.4-, 1.5- and 1.4-fold of that of *WT*; the mean thickness of *HR-5* blades was 26.0, 28.5 and 29.6 μm, decreasing by 31.9, 40.2 and 46.5% in contrast with that of WT, respectively; and the phycobiliprotein content of HR-5 blades was 80.6, 75.3 and 61.8 mg/g, increasing by 12.2, 26.0 and 30.9% in contrast with that of WT, respectively. The above results confirmed that, the high-temperature resistance of *HR-5* conchospores was similar to *WT*, while the blades of *HR-5* were thinner, faster grew with higher contents of the major photosynthetic pigments as compared with *WT*. It is therefore potential to be developed into a new variety with thin thallus suitable for cultivation along the coast of South China, and promote the transformation and development of the industry of *P. haitanensis.*

## OR 28-3

## Development of a new cultivar with high yield and high-temperature tolerance by crossbreeding of *Undaria pinnatifida* (Laminariales, Phaeophyta)

**Kyosuke Niwa**[*1], Atsushi Kobiyama[2]

[1] *Department of Marine Biosciences, Tokyo University of Marine Science and Technology, Japan*
[2] *School of Marine Biosciences, Kitasato University, Japan*

Recent production of the marine crop *Undaria pinnatifida* in Japan has become unstable due to rising temperatures caused by global climate change. The cultivar HGU-1 was bred in a previous study to achieve early cultivation. A new cultivar, NW-1, was bred for improved yield and stress tolerance. This was achieved by crossbreeding using male and female gametophytes, each isolated from a single zoospore. To evaluate whether the cultivar NW-1 is superior to the cultivar HGU-1, we compared their growth characteristics in an *Undaria* farm in the eastern Seto Inland Sea of Japan. Despite the early start of nursery cultivation, due to a high seawater temperature of 24.5 ℃, many young sporophytes of NW-1 grew on strings wound around the collector, whereas most of the HGU-1 sporophytes fell from the strings. After nursery cultivation, seawater temperature during rope cultivation was remarkably higher than usual. Nevertheless, the mean total length and weight of NW-1 sporophytes were 115.5 cm and 140.1 g, respectively, at the end of December. In contrast, the mean total length and weight of HGU-1 sporophytes, at the corresponding time, were 85.4 cm and 58.1 g, respectively. Moreover, the growth and weight of the NW-1 sporophytes were significantly higher than those of HGU-1 throughout the experimental cultivation. These results demonstrate that NW-1 is an excellent cultivar with a high yield and high-temperature tolerance.

## OR 28-4

### Heterosis breeding for upper temperature tolerance in *Laminaria*

**Neusa Martins**[*1], Gareth A. Pearson[1], Ester A. Serrão[1], Inka Bartsch[2]

[1] *Centre of Marine Sciences (CCMAR), University of Algarve, Portugal*
[2] *Alfred-Wegener-Institute, Helmholtz Center for Polar and Marine Research, Germany*

The inheritance of important traits in kelps (Laminariales) is poorly understood, but is of utmost interest to seaweed farmers wishing to select offspring with superior performance and resilience to environmental change. To investigate the inheritance of thermal tolerance in kelps, the interfertile species *Laminaria digitata* (N-Atlantic) and *Laminaria pallida* (S-Atlantic) were selected to compare reciprocal interspecific crosses (*L. digitata*♀ × *L. pallida*♂, *L. pallida*♀ × *L. digitata*♂) with intraspecific controls. For all cross combinations, we compared the rate of gametogenesis and level of reproductive success of gametophytes and the upper thermal resilience of F1 sporophytes along thermal gradients. Both interspecific hybrids between *L. digitata* and *L. pallida* showed significant mid-parent (MPH) and higher parent heterosis (HPH) for heat-tolerance and had a 2-3°C higher upper thermal tolerance than either intraspecific sporophytes. Furthermore, the phenotypic response of hybrids under thermal stress appeared partially sex-dependent, with female parents being more important in determining the thermal-response phenotype than male parents. Despite many kelp hybridization studies having shown F1 hybrid vigor, this is the first evidence for HPH in *Laminaria*. It will help to integrate and improve heat-tolerance characteristics through breeding selection and thus expanding the kelp aquaculture industry in the face of a changing climate.

## OR 28-5

### Building chimeric kelps (*Lessonia* spp.) to restock overharvested populations along Central Chile

**Alejandra V. Gonzalez**[*1], Fadia Tala[2,3], Julio A Vasquez[2,4], Bernabe Santelices[5]

[1] *Departamento Ciencias Ecologicas, Universidad de Chile, Chile*
[2] *Departamento de Biologia Marina, Universidad Católica del Norte, Chile*
[3] *Centro de Investigación y Desarrollo Tecnológico en Algas (CIDTA), Universidad Católica del Norte, Chile*
[4] *Centro de Estudios Avanzados en Zonas Aridas, Universidad Católica del Norte, Chile*
[5] *Departamento Ciencias Biologicas, Pontificia Universidad Católica de Chile, Chile*

Along the Chilean coastline, kelp forests (*Lessonia- Macrocystis*) sustain a broad diversity of marine organisms and are a source of raw materials for several types of industries (alginates, biofuels, and feed for abalone rearing). Annual harvests of up to 400,000 dry tons provide 10% of the total biomass of brown algae worldwide. However, the frequent harvesting results in populations reduction and fragmentation. At present they are considered exploited marine fishery resources. Consequently, this increased demand is leading to the introduction of management plans and bonuses for culture and restock. In this sense, a key restoration factor is the conservation of genetic diversity. Kelps can coalesce among genetically different individuals, forming chimeric plants with increased intraorganismal genetic diversity. In this study, we evaluate whether chimeric kelps exhibit higher genetic diversity and increased fitness compared to genetically homogenous plants. To this, we compare survival rates, morphology, and genetic characteristics between laboratory-built chimeric plants (Patent Nº 1827-2017) versus laboratory built genetically homogenous plants of *L. spicata*. Our data indicate that chimeric plants grown in hatchery facilities, increase four times their survival rate, duplicate the number of axes, and triplicate intraorganismal genetic diversity compared to genetically homogenous plants. In addition, experimental field transplants of chimeric plants have higher survival and growth rate compared to genetically homogenous plants. Results, thus suggest that chimeric kelps are better suited for culture and restocking programs, probably maximizing long-term population sustainability. Future work would evaluate the significance of chimeric plants as sources of genetic diversity and their impact as genetic rescue in seaweed species that suffer inbreeding depression due intense harvesting.

## OR 29-1

### Bioremediation and carbon sink effects of large-scale cultivation of *Gracilaria lemaneiformis*, a case study in Nanao, South China

**Yufeng Yang**[*1]

[1] *Institute of Hydrobiology, Jinan University, China*

Seaweed *Gracilaria lemaneiformis* cultivation areas form special ecosystems that are artificially controllable and produce huge biomass in a short time with tremendous impact on aquatic environments. The recent results show that cultivation of *Gracilaria* can improve DO, pH, decrease N, P, POM concentrations and then purify water quality. The cultivation of *Gracilaria* could enhance the biodiversity of eukaryotic plankton community, which provides further support for using the massive cultivation of *G. lemaneiformis* in coastal regions as an effective approach for environmental bioremediation, controlling harmful microalgal blooms, and promoting ecosystem stability. The harvest production of *G. lemaneiformis* in Nanao was 49, 729 t in 2015, removing N of 2, 212 t, P of 174 t and C of 13000 t from seawater. The results show that large-scale cultivation of *G. lemaneiformis* could effectively remove N, P nutrients and $CO_2$, with the potential to

control ocean eutrophication, increase carbon sink, prevent hypoxia and harmful algal blooms in Chinese coastal waters.

## OR 29-2

### Maximising the productivity of *Ulva tepida* by effectively using the three-dimensional culture space

**Andrew Cole**[*1], Christina Praeger[1], Matthew Vucko[1], Rocky de Nys[1]

[1] *MACRO- The Centre for Macroalgal Resources and Biotechnology, James Cook University, Australia*

The viability of the land-based seaweed cultivation of seaweeds is closely linked to the high areal productivity of the biomass and is best suited for species that grow vegetatively and unattached. The aim of this study was to develop land-based cultivation strategies for attached species, characterised by short growth cycles with periodic reproduction. To do this ropes were seeded with zoids of the green seaweed *Ulva tepida* and stacked vertically in the water column from one to four layers deep, spanning a culture depth from 50 to 350 mm below the surface of the water. After an initial grow-out period of 10 days, the biomass was continuously harvested on a rolling 4-day cycle which maintained the biomass in an actively growing state, over the 62-day cultivation period. The vertical stacking of seeded ropes, in combination with frequent harvesting, effectively increased the areal productivity of *U. tepida* by 40% compared with the single layer treatment, and achieved productivities > 20 g dw $m^{-2}$ $day^{-1}$, while the maturation of biomass was delayed and reproduction was observed from 46 days onwards. Notably, productivities were similar between stacking treatments comprising multiple layers regardless of whether there were two, three, or four layers due to decreasing availability of light with increasing number of layers and depth in the water column. Consequently, the most effective method of cultivation, factoring in the maximum productivity and diminishing returns in productivity, was to stacking two layers of ropes in combination with the vertical movement of the layers through the water column and frequent harvesting that reduced the likelihood of reproduction.

## OR 29-3

### The relationship between heavy metals and the seaweed *Gracilaria lemaneiformis*

**Hongtian Luo**[*1], Qing Wang[1], Yufeng Yang[1]

[1] *Institute of Hydrobiology, Key Laboratory of Aquatic Eutrophication and Control of Harmful Algal Blooms, Jinan university, China*

The purpose of this study was to evaluate both the bioremediation of heavy metals (HMs) in seawater and sediment by cultivated *Gracilaria lemaneiformis* from Nan'ao Island, China, and also the antagonism of selenium (Se)-enriched *G. lemaneiformis* to cadmium (Cd). Samples were collected from December 2014 to July 2015 from five zones: *G. lemaneiformis* cultivation zone (G), fish culture zone (F), control zone (C), shellfish culture zone (S), and transition zone (T). Over a period of 28 days of exposure, the protection of Se-enriched *G. lemaneiformis* against Cd toxicity in the abalone, *Haliotis discus hannai*, was assessed using indices such as HMs, growth rate, GPx, and metallothionein (MT) concentration. The results showed that *G. lemaneiformis* can decrease the comprehensive HMs pollution and purify the water quality in coastal mariculture zone, and decrease the surface sediments of Cd, Pb, Cu and Zn concentrations resulting in lower HMs than the sediment quality guidelines (SQG) values and the geoaccumulation index (Igeo) in most stations. The hierarchical cluster and principal component analyses (PCA) indicate that *G. lemaneiformis* cultivation may influence and decrease the HMs concentrations of sediment in the open sea mariculture zone. Dietary Se-enriched *G. lemaneiformis* protected abalone against Cd toxicity, and promoted abalone growth significantly. Cd-induced toxicity was alleviated by enhanced MT generation and the activity of GPx enzymatic antioxidants. This indicated that dietary Se-enriched *G. lemaneiformis* could act as an antidote for Cd poisoning in mollusc, fish, human beings and potentially other organisms. Overall, our study demonstrated that *G. lemaneiformis* cultivation was a bioremediator of HMs in seawater and sediment. The antagonistic effects on waterborne Cd-induced toxicity occurs via both enzymatic and non-enzymatic antioxidative (MT) mechanisms by Se-enriched *G. lemaneiformis*.

## OR 29-4

### Estimation of production and bioremediation of seaweed *Kappaphycus alvarezii* in an IMTA system using a STELLA model

**Cicilia Selviane Kambey**[*1], Ik Kyo Chung[2]

[1] *Division Of Earth Environmental System Oceanography major, Pusan National University, Republic of Korea*

[2] *Department of Oceanography, Pusan National University, Republic of Korea*

Integrated multi-trophic aquaculture (IMTA) has been widely used for nutrient balancing of fed aquaculture. Incorporation of seaweed *Kappaphycus alvarezii* in the aquaculture system with fish or other fed aquatic animals is poorly observed. On the same time, the STELLA model is developed to investigate the role of this seaweed by converting fish derived nitrogen in seaweed biomass with the help of adequate variables and parameters. We have designed a simple and strategic seaweed growth model with components of N-uptake, N-growth, N-store, N-fixed, and biomass harvest as well as variable parameters of temperature, salinity, and light irradiance. The rates of dissolved inorganic nitrogen (DIN) released from fish was modeled with five different rates (0.01, 0.05, 0.1, 0.5, and 1.0 g N $m^{-3}$ $d^{-1}$) and three different seaweed stock biomass of 100, 500 and 1000 g FW $m^{-2}$. Based on our model, N lost through DIN excretion by fish with low to high rates has significant control on seaweed growth, harvest period and nutrient removal efficiency. A low DIN excretion rate of 0.01 g N $m^{-3}$ $d^{-1}$ can be removed by *K. alvarezii* up to 45% while a high rate of 0.5 g N $m^{-3}$ $d^{-1}$ can do up to 39%. Low DIN rate of 0.01 g N $m^{-3}$ $d^{-1}$ combined with low biomass of 100 g FW m-2 has experienced a nitrogen deficiency in N-store component, therefore, there was delayed in seaweed growth which turn a longer harvest period than usual. An increase in harvest frequency and seaweed biomass can be other solutions for mitigating N load in an aquaculture system such as IMTA. This model can give suggestions to obtain the best condition for culturing seaweeds based on harvesting effort, production, and nitrogen removal efficiency.

## OR 29-5

### Cultivation potential and bioremediation efficiency of the brown seaweed *Halopteris scoparia* (Ochrophyta)

**Rita F. Patarra**[*1], Ana S. Carreiro[2], Anna L. Lloveras[3], Rui Pereira[4], Maria H. Abreu[4], Alejandro H. Buschmann[5], Ana I. Neto[1]

[1] *Centre for Ecology, Evolution and Environmental Changes/ Azorean Biodiversity Group and University of Azores, Faculty of Sciences and Technology, Organic Unit of Biology, Portugal*
[2] *Department of Biology, University of Azores, Portugal.*
[3] *Facultad de Biologia, Universidad de Barcelona, Spain.*
[4] *ALGAplus, Prod. e Comerc. de Algas e Seus Derivados, Lda., Portugal*
[5] *Centro i-mar & CeBiB, Universidad de Los Lagos,Chile*

Common in warm and cold temperate waters around Europe the cosmopolitan *Halopteris scoparia* (Linnaeus) Sauvageau is present in a broad temperature range, being harvested for commercial purpose in some locations. Several studies reported the importance of this species to the nutraceutical and cosmetics industries. The impact of its overexploitation can be minimized through sustainable harvesting practice and aquaculture. To achieve effective culture of this species, clarification of the most relevant factors for its production is needed. Laboratory experiments were run to select the best growth/productivity relationship across distinct ranges of temperatures, irradiances and stocking densities. *H. scoparia* grew healthy in a wide range of stocking densities (SD), light and temperature conditions, provided that irradiance was kept under 150 µmol photons $m^{-2}$ $s^{-1}$ to restrain the development of epiphytes. The best growth/productivity relationship was obtained at a SD of 2 g fw L-1 which indicates these conditions as ideal for upscaling the cultivation of the species. The cultivation potential using seabream effluents in a land-based tank systems was studied for the first time. An orthogonal experimental design was used to test the effect of stocking density (SD; 2 and 5 g $L^{-1}$) and water flow (WF; CF - closed by night flow, OF - open flow) on *H. scoparia* relative growth rate (RGR), productivity and biofiltration capacity, using 230 L seaweed culture tanks, for a 4-weeks period. Results revealed that it is possible to cultivate *H. scoparia* in such a system within the conditions tested. The best results were achieved at a stocking density of 2 g fw day-1 reaching a weekly productivity of 13.28 ± 2 g dw $m^{-2}$ $wk^{-1}$ and removing 3.63 ± 0.47 g $m^{-2}$ $day^{-1}$ of total ammonium nitrogen. This brown alga is, therefore, a good candidate to land-based IMTA culture systems set at these latitudes, thus with potential for commercial cultivation in large enough scale to interest seaweed farmers.

## OR 29-6

### Colonized zooplankton communities on cultivated seaweeds in a typical mariculture zone, China

**Qing Wang**[*1], Hui Ren[1], Yufeng Yang[1]

[1] *Department of Ecology, Jinan University, China*

The zooplankton communities on floating cultivated seaweeds were studied by both field surveys and experiments in order to analyze community structure in a typical mariculture zone, Nanao, South China. Samples of zooplankton were collected from the water and the thalli of the seaweeds, *Gracilaria lemaneaformis* and *G. chouae*. The results showed that both species were rapidly colonized by zooplankton after being introduced into the mariculture region. Eight species including 4 copepods were identified on the seaweed thalli; most were nauplius larvae. The <200-µm fraction of copepods represented between 50% and 70% of the zooplankters. The communities on the seaweeds were significantly different from those in the ambient waters. Zooplankton abundance was much higher in the seaweed than in the plankton. Experimental *G. lemaneaformis* and *G. chouae* thalli placed in the seawater of the mariculture zone were rapidly colonized by zooplankton. After 6 days afloat, the densities and species diversity in the experimental seaweeds were similar to that in the control cultivated seaweeds. The high proportion of larvae indicates that these species are using the seaweed thalli as a platform for reproduction. Therefore, large-scale seaweed cultivation is beneficial for colonization of zooplankton and shelters higher numbers of copepod larvae than in the sea. This drives ecological changes in the zooplankton communities in coastal ecosystems and facilitates interactions with other communities and higher trophic levels in the cultivated seaweed food web. It is likely that rafting of floating seaweeds detached from the cultivation zone facilitates long distance dispersal of zooplankton. We propose a conceptual model that summarizes the results from this study and guides future studies on the relationships between seaweed and the zooplankton community.

## OR 30-1

### Genetic tools for the development of improved cultivars of *Saccharina latissima*

**Zofia Nehr**[*1], Komlan Avia[2,3], Stéphane Mauger[2], Bertrand Jacquemin[4], Emilie Gouhier[2], Delphine Scornet[1], Jérôme Coudret[2], Stéphane Loisel[2], Susana M. Coelho[1], Christophe Destombe[2], Philippe Potin[1], Myriam Valero[2], J. Mark Cock[1]

[1] *Laboratory of Integrative Biology of Marine Models, CNRS-Sorbonne Université, France*
[2] *Evolutionary Biology and Ecology of Algae, CNRS-Sorbonne Université, France*
[3] *Grapevine Health and Vine Quality (SVQV), INRA-Université de Strasbourg, France*
[4] *Seaweed Raw Material (AMP), CEVA Pleubian, France*

In Europe, the development of *Saccharina latissima* farms and biorefineries relies on the ability to cultivate improved cultivars that express desirable traits. To maintain genetic diversity/balance in natural populations surrounding seaweed farms, the cultivation of improved, diversified crops should rely on the identification and selection of interesting progenitors from local populations. To facilitate this we need to select desirable traits in a cost- and time-effective way. Since the mid-80s, the development of genetic molecular markers associated with genes or quantitative trait loci (QTL) of interest has made it possible to apply Marker Assisted Selection (MAS). One of the aims of the European Union GENIALG project is to identify the loci underlying desirable traits that could be selected. We applied a QTL approach to a segregating family derived from a cross between local strains to map both agronomic traits (biomass, growth, size, heat-stress resistance) and traits of industrial interest (biomolecule content) using a segregating family derived from a cross between local strains. One hundred twenty-nine individuals were derived from the cross between two sporophytes belonging to two differentiated genetic groups from Northern and Southern Brittany, respectively. The progeny has been phenotyped for morphometric traits: width, length, stipe length and for heat stress tolerance and resilience. All of these traits behaved as quantitative traits. The progeny showed diverse responses to heat stress: tolerance, sensitivity but also diverse abilities to recover following a stress treatment. Genotypic and phenotypic data are currently being analysed to identify QTL. The results of this work will allow us to better understand the genetic basis of the different traits studied and provide tools to identify wild individuals carrying alleles that confer desirable traits.

## OR 30-2

### Analysis of gene expansion and expression profiles in the siphonous macroalga, *Caulerpa lentillifera*

**Asuka Arimoto**[*1], Koki Nishitsuji[1], Noriyuki Satoh[1], Eiichi Shoguchi[1]

[1] *Marine Genomics Unit, Okinawa Institute of Science and Technology Graduate University, Japan*

Green algae display various body plans including unicellular, multicellular, and siphonous. Macroscopic and complex structure without multicellularity are prominent characters of some siphonous algae. The mechanisms regulating morphogenesis may differ between siphonous algae and multicellular organisms including plants and animals, however, the understanding of morphogenesis of siphonous algae is still limited. To address the question, we analyzed gene constitution, expansions and expressions in a siphonous alga, *Caulerpa lentillifera*. We decoded the genome of *C. lentillifera* to capture the gene space using hybrid assembly techniques combining Illumina and PacBio data. We compared *Caulerpa* and other green algal gene models to explore *Caulerpa*-specific gene expansions. Gene functions were predicted based on protein domain search and gene ontology (GO) analysis. In addition, we performed differential gene expression analysis using RNA-seq data. These results were combined to identify genes assigned to expanded GO with preferentially expression. We obtained ~26 Mb assembled genome. 36 scaffolds cover 95% of the assembled length. 9,311 protein-coding genes were predicted on the genome and 8,734 loci were expressed in the macroscopic stage. 74% and 61% of predicted genes were annotated based on protein domain search and GO analysis, respectively. Comparative analysis of abundance of gene functions among green algae suggests that ~140 categories of GO were significantly expanded in the *Caulerpa* genome. 25% of genes assigned to expanded categories were preferentially expressed in specific parts of *C. lentillifera*. Our present genome assembly provides platforms for genomic and developmental studies on siphonous algae. Preferentially gene expressions of expanded gene families may reflect their functionalizations and associate with evolution of a macroscopic and complex body plan. Moreover, preferentially gene expression in the siphonous alga suggests that the presence of mechanisms involving molecular transportation and localization without membrane systems.

## OR 30-3

### Identification and characterization of the centromere-associated protein Nuf2 in the kelp *Saccharina japonica* (Phaeophyta)

**Zhi-Gang Zhou**[*1], Wu-Shan Dong[1], Peng-Fei Liu[1], Yu Liu[1], Yan-Hui Bi[1]

[1] *College of Aqua-life Sci. & Technol., Shanghai Ocean University, China*

Nuf2, a centromere-associated protein, is an indispensable component of Ndc80 complex which is important for stable microtubule-kinetochore attachment, chromosome pairing, and also spindle checkpoint activation in mitosis. Based upon contigs coding for Nuf2 from a pyrosequencing transcriptome of *Saccharina japonica*, gene-specific primers were designed for the centromere specific protein gene cloning. One gene, named as SjNuf2, was cloned from *S. japonica* by using the technique of PCR. The open reading frame of SjNuf2 was 1 365 bp in length, encoding a putative protein composed of 454 amino acids. Homologous sequence alignment showed the main domains of SjNuf2 are Nuf2, Spc7 and SPT2. To obtain the location information of SjNuf2, its ORF sequence was cloned and inserted into a prokaryotic expression vector to generate pET-28a-SjNuf2. Then the recombinant SjNuf2 was induced to be expressed in Escherichia coli. The expressed recombinant SjNuf2 was verified by Western blot with the commercial anti-His-tag antibody. The recombinant SjNuf2 was purified by using immobilized metal ion affinity chromatography (IMAC) cartridges. The polyclonal antibody of anti-SjNuf2 was obtained from immunized rabbits with the purified recombinant protein. SjNuf2 was proved to be present in the gametophytes of *S. japonica* by Western blot with this prepared antibody. To illustrate the chromosomal location of SjNuf2 by immunoflorescence technique, the gametophytes were fixed with 2% paraformaldehyde and 0.5% glutaraldehyde and embedded in paraffin. SjNuf2 and α/β-tubulin were subsequently co-localized to *S. japonica* gametophyte chromosomes, suggesting SjNuf2 should be at the centromeres. The present study provides evidence for the location of centromeres in the gametophytes of *S. japonica*, thus laying the foundation for karyotype analysis of this kelp.

## OR 30-4

### Piloting genome editing of the brown algal model *Ectocarpus*

**Yacine Badis**[*1], Delphine Scornet[2], Celine Caillard[2], Claire Gachon[1], Susana Coelho[2], Mark Cock[2]

[1] *Macroalgal Pathology, Scottish Association for Marine Science, United Kingdom*
[2] *Algal Genetics, Station Biologique de Roscoff, France*

The burgeoning seaweed industry is facing a number of economic and environmental challenges. Several academic laboratories are working to provide R&D support to the industry, both through applied and through more fundamental research approaches. Fundamental approaches have so far focused on the model brown alga *Ectocarpus* but exploitation of this system is currently hampered by the absence of key molecular tools. In particular, despite more than two decades of investment aimed at developing genetic transformation for this species, the inability to disrupt, modify, or insert genes into the genomes of marine brown algae considerably hinders research in brown algal genetics and biotechnology. Recently, CRISPR-Cas9 technology has been successfully implemented for other stramenopiles. Building on these advances, alternative genome editing strategies for the model brown alga Ectocarpus based on the direct delivery of ribonucleoprotein (RNP) particles are currently being developed. This presentation will describe the diversity of genetic screens and RNP delivery strategies that are now available to pilot RNP mediated gene knock-outs in *Ectocarpus*.

## OR 30-5

### Non-coding RNAS involved with Aureochrome and regulation of CRY-DASH in the early development and growth of *Saccharina japonica* (Laminariales, Phaeophyceae)

**Delin Duan**[*1], Xiaoqi Yang[1,2], Wei Li[1,2], Lu Li[1,2], Jianting Yao[1,2,3], Xiuliang Wang[1,2,3]

[1] *Key Laboratory of Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China*
[2] *Qingdao National Lab for Marine Science and Technologyo, China*
[3] *Center for Ocean Mega-Science, Chinese Academy of Sciences, China*

Blue light is predominant under the seawater, and plays a critical role in regulating the growth and development of photosynthetic of Stramenopile. Less are known about the mechanism of blue light influence on the *Saccharina japonica*, here we screened the total of 449 unique known miRNAs (belonging to 13 conserved miRNA families) and 945 novel miRNAs

were expressed differentially between the control (darkness, DK) and treatment (blue light irradiation, BL) groups. One novel-m3234-5p, was believed to targeting the 3' UTR region of sjCRY-DASH, decreased with the increasing of sjCRY-DASH in transcription. One miRNA-sjCRY-DASH-lincRNA network was constructed for sjCRY-DASH regulation. Gene function and pathway analysis showed that these Non-coding RNAs were involved in the transcription factors, circadian rhythm etc. Our study proved that Non-coding RNAs are highly involved with CRY-DASH regulation to the growth and early development of *S. japonica*.

## OR 31-1

### Newly restored kelp beds reveal rapid recovery of food web complexity

**Moon Jung Kim**[*1], Young Hee Yoon[2], Min Seob Kim[3], Dong Seok Lee[1], Seok Woo Hong[1], Kwon Mo Yang[1], Young Wook Ko[4], Jeong Ha Kim[1]

[1] *Biological Sciences, Sungkyunkwan University, Republic of Korea*
[2] *Marine Sciences and Convergent Technology, Hanyang University, Republic of Korea*
[3] *Environmental Measurement & Analysis Center, National Institute of Environmental Research, Environment Research Complex, Republic of Korea*
[4] *Korea Polar Research Institute, Republic of Korea*

This study is to investigate how fast the food web stability/complexity is recovered in newly restored subtidal algal community. For the comparison of food web complexity, we chose 3 types of community (restored, natural, barrens) and sampled most species of macroalgae, benthic organic matter and invertebrates, and used those samples for stable isotope(δ13C & δ15N) analysis. Community parameters such as abundance, richness, diversity and dominance are also compared. Average biomass of macroalgae among the 3 types of community was highest in natural beds, followed by 1 year old restored beds and barren ground. Total area of Layman metrics on each community indicated that food web complexity of the restored bed has been recovering dynamically in 1 year. Based on δ13C - δ15N bi-plot of each community, we infer that the main source of carbon for Strongylocentrotus nudus could be various depending food availability. In natural bed, S. nudus mainly consume brown algae as a carbon source. In restored bed, they are likely to prefer macroalgae depending on class(Brown>Green>Red). In barrens, they consume organic matter because of low algal biomass. In the next spring with the samples of 2 years old restored beds, we could explain how the stability of food web changes with the maturity of newly restored algal community and provide a meaningful suggestion regarding ecologically successful restoration of kelp forests and its' sustainability.

## OR 31-2

### 30 years revisit survey for the long term changes in the Antarctic subtidal algal community

**Dong Seok Lee**[*1], Young Wook Ko[2], Jeong Ha Kim[1], Han-Gu, Choi [2], SangHee Kim[2], In-Young Ahn[2]

[1] *Biological Science, Sungkyunkwan University, Republic of Korea*
[2] *Korea Polar Research Institute, Republic of Korea*

This is a comparative study for a long term community change of subtidal zone in Maxwell Bay, King George Island (KGI) of Antarctic coast. The 1st survey was carried out in 1988-1993 focusing on seaweed distribution and biomass. The 2nd survey was done in 2016-2018 at the selected 6 sites, focusing on the long term changes for 30 years at the same sites as well as providing more detail ecological data on vertical and spatial distribution at present as a baseline information for future monitoring. The total number of macroalgal species was similar between the 1st and the 2nd survey by 24 and 26 species, respectively. Macroalgal assemblage within-site level changed substantially with the average similarity of 38.3% between the 1st and 2nd survey. Also, the abundance of component species showed a high variability. Dissimilarity was mainly caused by the algal assemblage in deeper zone (10-25m) rather than the shallower zone (1-5m). On the other hand, the long term period did not cause the changes at between-site level hierarchical structure based on community similarity. Results indicate that the community itself changes very dynamically, but the similarity or dissimilarity between sites, influenced by various environmental conditions, remain largely constant for 30 years.

## OR 31-3

### Characterize of a type III polyketide synthase (PKS1) response to light intensity in the brown alga *Saccharina japonica*

**Jing Li**[*1], Shaojun Pang[1]

[1] *Key Laboratory of Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China*

Phlorotannins, only from brown algae, are one of the most important defensive molecular in kelp. The synthesis pathways of phlorotannins are complicated and most relative genes and their functions are not clearly understood. Type III polyketide synthase, an important enzyme which catalyzes a major step in the biosynthetic pathway of phlorotannins, has been identified and characterized in the model organism of brown seaweed, *Ectocarpus siliculosus*. While the concentrations of phlorotannin seems to be positive related to the light intensity, which might due to the change of type III polyketide synthase activities. Less phlorotannins content in the brown alga *Saccharina japonica* under weak light intensity would directly lead to green-rotten disease, according to our previous investigation. In this study, a type III polyketide synthase gene (PKS1), was isolated and characterized in the brown alga *Saccharina japonica*. PKS1 contained an open reading frame (ORF) of 1,245 bp in length and encoded a protein of 414 amino acids. The ORF of PKS1 in *Saccharina japonica* were 87% identical at the nucleotide level and shared 93% identical residues in the protein of 414 amino acids compared to *Ectocarpus siliculosus*. A real-time quantitative PCR analysis showed gene expression level of PKS1 was significantly affected by light intensity. This study deeply broaden our understanding of the function of PKS1 and the phlorotannin biosynthesis processes in brown seaweeds.

## OR 31-4

### Calcium carbonate productivity by *Halimeda macroloba* in the tropical intertidal ecosystem; the significant contributor to global carbonate budgets

**Jaruwan Mayakun**[*1], Anchana Prathep[1,2]

[1] *Biology, Prince of Songkla University, Thailand*
[2] *Excellence Centre for Biodiversity of Peninsular Thailand, Prince of Songkla University, Thailand*

*Halimeda* is a potential carbon sink species and important player in the

global carbonate budget. The objectives of this study were to: 1) examine the $CaCO_3$ and sediment productions of *H. macroloba* by measuring the density, growth rate, and recruitment, 2) quantify the numbers of aragonite crystals, 3) document reproductive events, and 4) determine the life-span. This study was carried out at Lidee Lek Island, Satun, Thailand during July 2015-April 2016. The density was measured using quadrats (0.25 $m^2$) and three 50 m line transects. Alizarin Red-S marking technique was used for the growth rate and $CaCO_3$ accumulation rate assessments. The recruitment, reproduction and life-span were measured by tagging 500 individuals. Tagged individuals and new plants were counted. In this study, mean and the highest density of *Halimeda* were 44.42±13.95 and 138.22±11.68 thalli $m^{-2}$, respectively and Halimeda produced 1-2 new segments.thallus$^{-1}$-day-1 or 0.021±0.001 g dry weight.thallus$^{-1}$.day$^{-1}$. The annual biomass production was 1910-5950 g.$m^{-2}$ $yr^{-1}$. There was low rate of occurrence of sexual reproduction, observing in late July-September, ranging from 0.17-1.92%. For the mortality and recruitment rates, around 70-80% of individuals were lost during July-September 2015 probably from sexual reproduction and the recruitment rate varied from 5.36±0.79%–21.03±2.33%. The highest density of new recruits was found in September 2015 right after the sexual reproductive event occurred. New recruits have been found till April 2016 without any reproductive events suggesting that both sexual and asexual reproduction help maintaining population. The life span of *Halimeda* was 8-12 months. In addition, *Halimeda accumulate* $CaCO_3$ around 0.018 g CaCO3. thallus$^{-1}$.day$^{-1}$ and produce $CaCO_3$ around 291.94-908.11 g.$m^{-2}$.$y^{-1}$ indicating that *Halimeda* contribute to CaCO3 and help sink carbon through their calcification. The results in term of the density, growth rate, and $CaCO_3$ accumulation rate can be used to calculate the mass of carbonate sediment contributed by *Halimeda*.

## OR 31-5

### An extremophile terrestrial chlorophyte growing on galvanised iron lamp posts

**Raymond J. Ritchie**[*1], Muhammad Heemboo[2]

[1] *Technology and Environment, Prince of Songkla University-Phuket, Thailand*
[2] *Department of Biology, Faculty of Science, Prince of Songkla University-Hat Yai, Thailand*

The very common green alga, provisionally identified as *Trentepohlia* sp. (Ulvaphyceae) was found growing as a biofilm on galvanized iron lamp posts where it was exposed to high zinc levels and periodic desiccation (a high metal/high desiccation environment). Its sole water sources were rainfall and dewfall. Photosynthesis studies using PAM techniques showed that the alga was a shade adapted species with a very low optimum irradiance of ≈90 µmol photon $m^{-2}$ $s^{-1}$ (PPFD), and ETRmax ≈ 80 µmol $e^-$ $g^{-1}$ Chl a $s^{-1}$ and photosynthetic oxygen evolution rate (POER) of ≈ 20 µmol $O_2$ $g^{-1}$ Chl a $s^{-1}$ but was able to rapidly (in minutes) recover from desiccation (homiochlorophyllous). The alga has a high Chl b/a ratio (0.47 ± 0.016) and conspicuous Chl b absorption in vivo but no measureable Zn-Chl derivatives were found. Mannitol experiments up to 1.5 Osmol $kg^{-1}$ showed that photosynthesis of the alga was highly resistant to water stress. Photosynthesis of the alga was unaffected by pH even though the abundance of $CO_2$ in the experimental medium dropped from 477 mmol $m^{-3}$ at pH 5 to less than 1 mmol $m^{-3}$ at pH 9 and so the alga can use both $CO_2$ and $HCO3^-$ as inorganic carbon sources. Acid pH (pH 5) did not increase the toxicity of Zn. The alga is very resistant to added Zn with little effect on photosynthetic parameters even at 30 mol $m^{-3}$ Zn.

## OR 32-1

### Evaluation of bioactivities and cream mask formulation from Vietnamese seaweeds

**Dang Diem Hong**[*1], Ngo Thi Hoai Thu[1], Nguyen Cam Ha[1], Tran Xuan Khoi[1], Hoang Thi Minh Hien[1], Luu Thi Tam[1]

[1] *Algal Biotechnology, Institute of Biotechnology, Vietnam Academy of Science and Technology, Vietnam*

Vietnam has a 3200 km coast line with great diversity in its algal flora. Vietnamese seaweed is rich source of natural bioactive compounds that could be exploited as functional ingredient for cosmetic applications. The aim of this study is to evaluate the biochemical compositions and bioactivities of ten seaweeds collected from coastal waters of Vietnam. The present study also prepared and evaluated cream masks made from mixture of seaweeds extracted with water. The results showed that *Caulerpa lentillifera, Sargassum crassifolium*, *Ulva reticulata* and *Kappaphycus alvarezii* among studied ten seaweed species are potential rich sources of protein, polysaccharide, carotenoids and vitamins with high antioxidant, antibacterial, cell proliferation, moisture retention and tyrosinase inhibitory activities. The mixture of these seaweed extracts was found to increase in antioxidants activity (72%), stimulate the proliferation of fibroblasts (22%) and inhibit tyrosinase activity (28%) in the cream mask. The hydration effect was enhanced by 35% using seaweed cream mask and the hydration percentage of skin was very high at 80.1%. Better skin hydration (up to 1.5 times) was obtained using seaweed cream mask as well. Physicochemical analysis of the cream mask from mixture of these seaweed extracts indicated that it is yellowish brown color with specific odor of seaweed, the extracts are stable and can retain homogeneity for up to 12 months of storage, have a pH of 6.1 and high spread and adhesive abilities. No total aerobic mesophilic microorganisms, *Staphylococcus aureus, Pseudomonas aeruginosa, Candida albicans* and heavy metals were detected in the seaweed mask cream. The seaweed cream mask was safe and causes no irritation to normal human skin. The cream mask product has satisfied provisions of Circular No. 06/2011/TT-BYT dated 25/01/2011 of the Vietnam Ministry of Health, providing cosmetic management for the cosmetic products with anti-aging and moisturizing effects.

## OR 32-2

### Inhibitory effects of tropical seaweed on tyrosinase activity and melanogenesis in B16F10 melanoma cells

**Pradtana Choosuwan**[*1], Jantana Praiboon[1], Anirut Klomjit[1], Korawinwich Boonpisuttinant[2]

[1] *Fishery Biology, Kasetsart University, Thailand2 Thai Traditional Medicine College, Rajamangala University of Technology Thanyaburi, Thailand*

Tyrosinase is a well-known key enzyme in melanin biosynthesis and its inhibitors have become increasingly important because of their potential use as whitening agents in cosmetic products. In this study, the ethanolic extract of twelve seaweeds in Thailand were determined for tyrosinase inhibitory activity by cell-free mushroom tyrosinase assay followed by cell viability assay and melanin content assay using B16F10 murine melanoma cells. The tyrosinase inhibitory activity was correlated to the inhibition melanin production in α-MSH (melanocyte-stimulating hormone)-stimulated and unstimulated B16F10 cells. The ethanolic extract of the brown seaweed *Lobophora* sp. showed highest inhibitory effect on mushroom tyrosinase with the IC50 (half maximum inhibitory concentration) value of 119.12 µg/

mL. Moreover, the ethanolic extract of *Lobophora* sp. was also able to inhibit basal and α-MSH-stimulated melanin production in B16F10 cells and its activity was comparable to kojic acid (positive control). The results of our study indicate that the ethanolic extract of *Lobophora* sp. might be a great source of the natural inhibitors from tyrosinase and has the potential to be used as a whitening agent in the future.

## OR 32-3

### Phenolic compounds from *Sargassum fusiforme* and their application in cosmetics

**Xiaoting Fu**[*1], Liying Ni[1], Ming Chen[1]

[1] *Food Science and Engineering, Ocean University of China, China*

*Sargassum fusiforme*, a brown algae, had been consumed as a traditional food for thousands of years. Its wild resource mainly distribute in warm temperate zone of the western North Pacific. The main aquaculture area in China is Dongtou County in Zhejiang Province. In this study, the phenolic compounds with a high purity were isolated from *S. fusiforme*. The structures of the phenolic compounds were analyzed using a modified UHPLC-QQQ-MS method, the antioxidant and anti-inflammatory activities were characterized by cells and zebrafish models both in vitro and in vivo. Finally, emulsification system containing the phenolic compounds was established. The particle size, microstructure and rheological properties of self-made phenolic facial cleanser were analyzed. The results indicated that phenolic compounds at 200 μg/mL had the best inhibitory effect on NO production (53.66% inhibition rate), which exhibited superior activity than the positive control dexamethasone (47.20% inhibition rate). Pre-treatment with different concentrations of phenolic compounds could significantly improve the survival rate of embryos, reduce the heart rate and promote embryonic normal development. The rheological properties of phenolic facial cleanser were analyzed. The EMIII with the ratio of glycerol and propylene glycol 1: 1 and stirring speed of 300 rpm was the most stable facial cleanser. It provided a stable system for the industrial application of phenolic compounds in cosmetics. The research revealed the strong bioactivity of phenolic compounds of *S. fusiforme* and its potential application in cosmetic industry.

## OR 32-4

### Whitening activity of fucoidans extracted from polar *Ascophyllum nodosum* and valorisation of process by-products in cosmetic applications

**Jeremy Brebion**[*1], Marine Dehail[1], Benoit Queguineur[1], Stig Hjelmevoll[2], Franck Hennequart[1]

[1] *R&D, Algaia, France*
[2] *Polar Algae, Norway*

ALGAIA is the main processor of brown seaweeds in France, producing and commercializing alginates and other bioactive ingredients for the global market. ALGAIA is also providing R&D services on macro- and micro-algae to many companies in the world in order to sustain novel extract development for further valorization of algal wild stocks or cultivated resources. The present study shows results from a collaboration between ALGAIA and Polar Algae (a Norwegian start-up dedicated to the valorisation of polar seaweed in the North of Norway). The main target was to demonstrate a biorefinery concept for the valorization of *Ascophyllum nodosum* by showing different bioactivities of each fractions for cosmetic applications. After production of a crude extract from fresh seaweed, fucoidans were purified using a three steps process. All fractions (fucoidans and by-products) were tested for bioactivities targeting cosmetic applications (Anti-oxidant, anti-inflammatory, whitening, anti-UV, etc.). After identifying bioactive compounds, the focus was on upscaling select fractions. Purified fucoidan fractions showed interesting levels of whitening activity (inhibition of tyrosinase, IC50=73 μg/ml). Interestingly, by-products generated during the purification process also showed potential in cosmetic application but on other activities (anti-aging, anti-UV, etc.) due to a different composition. Pilot extraction highlighted the difficulties to upscale from laboratory to semi-industrial process. Each fraction showed different compositions hence different bioactivities. A first pilot scale production has been done to estimate the production cost of the process developed resulting in 5 valuable fractions and no wastes.

## OR 33-1

### *Palmaria palmata* (Dulse) cultivation in Denmark – new strategies for hatchery optimization

**Mette Møller Nielsen**[*1], Peter Søndergaard Schmedes[1]

[1] *National Institute of Aquatic Resources, Technical University of Denmark, Denmark*

Interest in *Palmaria palmata* for human consumption has increased in Europe lately, indicated by high market prices reaching 245 € per dry kg. As demands go up, focus on cultivation rather than wild harvest is important to avoid diminishment of wild populations and to secure a sustainable production. However, low spore-to-seedling efficiency, imposing a high requirement of sori for seeding in large-scale cultivation, points to a need for developing current hatchery techniques. In a step-wise approach focusing on spore release, spore seeding, and seedling development, we have developed new protocols to optimize cultivation practice for *P. palmata*. In a line of setups, we have investigated the effect of parameters, such as substrate type and water agitation, on the spore release rate, the spore settlement and the seedling development. Also, in a new approach using released spore aggregates as inoculum, we have tested the ability of these to re-attach using high agitation seeding as an alternative to the normally used gravity-based seeding method. Finally, a first attempts to seed on nets in a high-agitated flow-through system has been carried out. The level of water agitation had a strong positive effect on the settlement and dispersal of spores and seedlings in general, with a further implication for the ability of macerated spore aggregates to re-attach. Aggregates germinating into a mixture of spores and sporelings during 30 days showed an ability of discoid re-attachment and growth after maceration pretreatment, and applying high water agitation resulted in 39% survival of seedlings which is to be considered high for this species. Based on this study, we suggest new versatile strategies for *P. palmata* cultivation including the use of germinated spore aggregates showing the ability of discoid re-attachment on twine, and high-agitated seeding systems for improved spore use and spore dispersal on cultivation lines.

## OR 33-2

### Advancements in Canadian on-land seaweed cultivation

**Jeff Hafting**[*1]

[1] *Food Science, Acadian Seaplants Limited, Canada*

The cultivation of seaweeds on-land can result in high quality, standardized biomass for use as food, and as raw material for the extraction of bioactive compounds. The highly controlled and traceable nature of on-land cultivation systems allows optimal expression of target species' genetic potential. High value products can be produced with the efficient use of labour and energy, resulting in successful operations. In Nova Scotia (Canada) Acadian Seaplants Limited has established itself as a world leader in high quality, cultivated seaweed food for Asian markets, produced in a large, highly controlled on-land system. Here, an overview Acadian Seaplants' on-land process is presented, and recent advancements are discussed.

## OR 33-3

### Land-based cultivation of the atlantic nori species *Porphyra dioica* in Portugal

**Helena Abreu**[*1], Rui Pereira[1], Sara Morgado[1], Andreína Azevedo[1], Bárbara Pitarma[1], Andreia Rego[1]

[1] *Algaplus Lda, Portugal*

*Porphyra* (some of them now *Pyropia*) species are among the most valued seaweeds in the world. Aquaculture production of *Pyropia* in Asia is responsible for the world supply of the most appreciated nori sheets. In Europe, the local supply of organic certified nori species, such as *P. dioica* and *P. umbilicalis*, is totally dependent on the wild-harvest occurring mainly in France, northern Spain, the UK and Ireland but is not enough to meet an increasing demand from the food (mainly) and cosmetic markets. In the early 2000s, a few papers were published on several ecophysiological aspects of *P. dioica* thriving in the northwestern coast of Portugal, including its life-cycle. Based on this knowledge, a cultivation program for *P. dioica* and *P. umbilicalis* was started by ALGAplus in early 2014. Taking advantage of the optimal temperature, light and nutrient conditions existent at ALGAplus site (land-based integrated fish and seaweed farm in Ria de Aveiro lagoon, Portugal), the full control of the life cycle has been successfully achieved. Twenty-four conchocelis strains (21 from *P. dioica* and 3 from *P. umbilicalis*) were first selected and are kept in the company's collection. Nonetheless, the focus is currently on the production of *P. dioica*, using 2 strains (P1.05.7.1, P1.02.10.4). In the lab, the formation of conchosporangia, release of spores and first stages of blade germination occurs continually, lasting on average between 6-7 weeks. The indoor and outdoor blade grow-out phase typically lasts around 8 weeks. During 2018 an average of 0.55 kg fw/month of young blades was transferred to a small outdoor area (max. 48m2) yielding an average of 60.2 kg fw/month during spring/summer and 66.0 kg fw/month during autumn/winter months. The potential to grow Atlantic *Porphyra* species in nutrient rich-waters of the Ria de Aveiro lagoon is now validated and opens the door for a commercial scale operation.

## OR 33-4

### Thermo-physical properties and stickiness of sugar kelp influence process parameters during drying

**Balunkeswar Nayak**[*1], Peter VanWalsum[1], Praveen Sappati[1], John Belding[1]

[1] *Food Science, School of Food and Agriculture, University of Maine, United States of America*

Post-harvest processing of sugar kelp in the state of Maine, United States of America is extremely important considering the recent increase in the number of producers in the state. The processing steps with various treatments, including drying, influence the development of new products from kelp as well as their long-term preservation and long shelf-life. Although drying has been used in a classical manner (i.e. under the sun or hot air convective drying in a shed or other storage location) by most of the producers and processors, effects of these drying methods on the safety and quality of the developed products has not been well tested. In a controlled drying system with multiple sensors attached to the kelp blades and dryer, relative humidity and drying temperature data, in addition to other process parameters, were collected in the chamber. In our initial test, the drying system could dry the kelp within 2 hours from fresh (92%) to ~15% moisture. The experimental data were used to validate a multiphysics software model simulating the drying dynamics with consideration of the product composition and process parameters. It was found that stickiness and adhesion of the kelp blades to each other is critical to the diffusion and evaporation of water from the blades in the drying chamber. Information on the stickiness will be valuable in estimating critical moisture content and/or moisture transfer during the falling rate of drying.

## OR 33-5

### Preliminary performance assessment of *Kappaphycus alvarezii* mechanical harvester prototype

**Leila Hayashi**[*1], André Luís Tortato Novaes[2], Alex Alves dos Santos[2]

[1] *Aquaculture Department, Federal University of Santa Catarina, Brazil*
[2] *Centro de Desenvolvimento em Aquicultura e Pesca, Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina, Brazil*

This work presents the first results of a trial using a mechanical harvester prototype to harvest *K. alvarezii* cultivated in Brazil. This prototype is a modification of the mechanical harvester used in mussels farms cultivated in a continuous system. Using the same system, seedlings of *K. alvarezii* were cultivated in the summer using tubular nets in the summer time, in rafts floated with specifically designed buoys. When the seedlings achieved the harvesting size, preliminary field trials were carried out to assess the operational performance of the mechanical harvester. Data of a) Operational Production Capacity (OPC), which corresponds to the amount of seaweed the prototype can harvest per unit of time; b) Seaweed Damage Index (SDI), and c) Return Index (RI), the later corresponding to the amount of seaweed remaining in the tubular nets during the mechanized harvest, were assessed. The tubular nets had a mean length of 2.6 m and a mean weight of 30.6 kg with the seaweed at the moment of the harvest. The average OPC assessed was 1.8 kg $s^{-1}$ (SD = 0.27) which corresponds to 6,624.2 kg $h^{-1}$ (SD = 987.4); the SDI was 0% and the average RI was 11.6% (SD = 1.47). Based on these preliminary results, we believe that an OPC around of 11,000 kg $h^{-1}$ could be achieved when considering an average of 11.8 kg $m^{-1}$ biomass contained in the tubular nets, in an individual or in a continuous tubular net.

## OR 34-1

### Probiotic fortified marine silage as supplement in marine fish hatchery

**Charles Santhanaraju Vairappan**[*1], Hsin Lin Tan[1], Sangeetha Priya Anandan[1]

[1] *Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Malaysia*

Marine capture fisheries constitute close to 87% of Malaysia fish landing and coastal fisheries holds a major share. Effort to enhance marine aquaculture hatcheries is being intensified however, low hatching rates and high

mortality is still an impending issue that needs to be solved. Hence, we report the production and utilization of probiotic fortified seaweed silage produced using carragenophyta powder (*Eucheuma denticulatum* Doty) and a cocktail of probiotic microbes consisting of *Lactobacillus casei*, *Lactibacillus plantarum*, *Lactobacillus fermentum*, *Lactobacillus sakei* and *Saccharomyces cerevisiae* (yeast). Mixture was subjected to liquid fermentation or the period of 10 days, that facilitated production of protoplasmic and spheroplasmic detritus via microbial and enzymatic degradation of microalgae fronds, called "single cell detritus" (SCD). Seaweed powder exhibited a size reduction from 80~90 mm to 2.0~3.0 mm, in addition to a two-order increase in probiotic microbes. Drop in fermentation pH value and production of bioactive peptides caused a drastic drop in marine bacteria population that was present in the initial mixture prior to fermentation. Developed marine silage was used directly for rotifer (*Brochionus* sp.) production and formulated as fish feed with the addition of aquaculture binder to evaluate their suitability as probiotic fortified fish feed in *Epinephelus fuscoguttatus* hatchery.

## OR 34-2

### How suitable are seaweed as a feed ingredient for salmon? - the feed industry's experiences and insights

**Celine Rebours**[*1], Bjørn Tore Nystrand[1], Jan Sunde[1]
[1] *Ålesund, Møreforsking AS, Norway*

Feed consumption in Norwegian aquaculture reached 1.74 million tonnes in 2017 and is expected to increase to 6 million tonnes by 2050. Fish meal and soy protein concentrates (SPC) are the main protein sources, both representing large environmental sustainability challenges. As the industry grows, feed producers search for new sustainable feed ingredients. Seaweed protein concentrates (SWPC) is one potential feedstock considered. In-depth interviews of Norwegian aquafeed producers were conducted to a) describe present use of traditional and alternative feed ingredients; b) define advantages and disadvantages of using SWPC in feed, reasons for use, as well as volumes of SPC used in feed in 2017; and c) assess their knowledge and experience of seaweed as a feed ingredient in general and as a protein source in specific. The validated transcriptions were imported into NVivo11 Version 11.4.1.1064 (QSR International) for analysis (data reduction, data display, and conclusion-drawing). Norwegian aquafeed producers identify adoption of seaweed as feed raw material as having positive effects on their image, by shifting their reputation from an industry using ingredients extracted from wild resources or from intensive agriculture to one based on qualities such as sustainability, marine origin and proximity to resource. However, barriers such as low production volume and low protein content, as well as knowledge gaps in digestibility and health effects of seaweed for salmon, so far hinders adoption of seaweed in industrial feed recipes. The in-depth interviews provided useful information for further work on seaweed as feed ingredient and insight into criteria considered important in the composition of sustainable and efficient feed. This study can also serve as a baseline for detecting future shifts in attitudes towards this novel protein source and highlight opportunities and challenges in using SWPC to replace current protein sources.

## OR 34-3

### Optimization of algal culture medium capable to higher biomass and lipid content in diverse types of algae

**Vijetna Singh**[*1], Bhumi Nath Tripathi[1]
[1] *Biotechnology, Indira Gandhi National Tribal University, India*

The society of facing several interconnected challenges, such as, climate changes, food and energy security. Global energy production mainly depends on the fossil fuel, which are being depleted at an alarming rate. Excessive utilization of fossil fuel also cause the release of harmful compounds and thereby leads to environmental degradation. Therefore, alternative sources of energy production are being explored throughout the world. Among these sources, algae have received great attention because of its great potential of producing biofuel without compromising the agricultural land. Freshwater algal species range from simple Cyanophyta to well-developed Rhodophyta and their ability of producing lipid (required for biofuel production) also vary vastly. Therefore, the present study was aimed to screen the high lipid producing freshwater algal species and subsequent standardization of culture medium for their optimum biomass production. Large number of algal species from various parts of the Central India were isolated and screened for their ability to produce lipid. Among tested algal species, members of Bacillariophyta were noted as the best candidates for the lipid production followed by the members of Chlorococcales (Chlorophyta). Apart from higher lipid content, high biomass of the algae is also required for algal biofuel production. Despite the availability of several nutrient media, obtaining an optimum biomass of high lipid producing algae is the major challenge. Most of the nutrient media are either algal group- specific or unable to support the luxuriant growth of diverse kinds of algal groups. To overcome this problem, a new recipe of algal culture medium was optimized, which is very much analogous to natural environment and hence supports the rapid and higher growth of most of the freshwater algal species. The proposed culture medium is comprised of most of the macro and micro-elements without supply of any vitamins or organic substance. This medium was recorded as the best nutrient medium to support the higher growth as well as lipid production in most of the freshwater algal species.

## OR 34-4

### Evaluation of seaweed *Gelidium latifolium* as potential medicinal food

**Eka Prasedya**[*1], Candra Dwipayana Hamdin[2], Selamet Kurniawan Riandinata[1], Masao Miyake[3], Daisuke Kobayashi[3], Akihiro Hazama[3], Haji Sunarpi[1]
[1] *Biology, University of Mataram, Indonesia*
[2] *Pharmacy, University of Mataram, Indonesia*
[3] *Cellular and integrative Physiology, Fukushima Medical University, Japan*

Trends in uses of complementary medicines which include dietary supplements to prevent several diseases such as cancer continue to increase. Red seaweed *Gelidium latifolium* is commonly found in Indonesian coastal areas. However, it remains largely unexplored. This study aims to evaluate Gelidium latifolium (GLE) for its potential in medicinal and pharmaceutical uses. For preliminary screening of GLE bioactive compounds, GLE was subjected to extraction with ethanol solvent. Phytochemical profiling was conducted with GCMS and LCMS analyses. Antioxidant activity of GLE was evaluated with DPPH assay. Antiproliferative and cytotoxic activity of GLE against human cancer cells was determined by MTT assay. Further evaluation of GLE apoptotic activity was conducted with viability staining Calcein-AM/PI and DNA fragmentation assay. Immune promoting activity of GLE was determined by phagocytic activity in BALB/C

mice via carbon clearance assay. Blood profile and histological observation was also conducted to evaluate the immunomodulatory activity of GLE. GCMS and LCMS analysis of GLE revealed presence of various bioactive compounds. Furthermore, GLE demonstrated high antioxidant activity (EC50= 162 µg/mL) analysed by DPPH assay. Cytotoxic assay via MTT assay revealed that GLE demonstrated antiproliferative activity in HeLa, HEK293, SW480, and Caco2 cells with IC50 of 175 ± 23 µg/mL, 153 ± 56 µg/mL, 250 ± 15 µg/mL, and 150 ± 23 µg/mL respectively. Furtermore, GLE potentially induces apoptosis in HeLa, HEK293, and Caco2 cancer cells analysed by DNA fragmentation assay. Evaluation of in vivo GLE immunomodulatory activity in BALB/C mice shows effective dose of 100 mg/kgbw GLE significantly increases macrophage phagocytic activity and leukocyte content, particularly neutrophils. In addition, toxicity analysis via histological observation suggested that GLE has good safety profile. Thus, GLE provides further utilization as health promoting substance in foods with medicinal purposes both potent as an antitumor and immune-enhancing agent.

## OR 34-5

### *Kappaphycus alvarezii* hatchery: a micropropagation production system

**Simon Davis** [*1]

[1] *Seadling. Kota Kinabalu, Malaysia*

The seaweed *Kappaphycus alvarezii* has significant commercial demand, mainly as a hydrocolloid in food products, and also as a fertilizer, animal feed additive and source of bioactive compounds. The seaweed is farmed using traditional methods that are unsophisticated and consequently farmers suffer many challenges of seed quality and supply. The protocol for production of *Kappaphycus* seedlings by micropropagation has been successfully reported by multiple groups however the system has yet to be scaled up to a size that can deliver the quantity of seedlings that farmers require and at a price that they can afford. Trials were undertaken at University Malaysia Sabah by representatives of the company Seadling in consultation with members of the Biotechnology Research Institute. The aim was to develop a prototype modular system that can be scaled to produce 50MT a year of *Kappaphycus* seedlings at a price that seaweed farmers could afford. Due to a series of innovations in tank culture and nutrient addition that produce growth advantages and allow cost savings, a prototype system has been successfully developed that can produce 50MT a year of high-health, high-growth seedlings. A system has now been established that produces large quantities of *Kappaphycus* seedlings in a cost-effective manner that can support farmers in their production needs. This solution provides a range of options, whether for governments wanting to boost their production or for seaweed processors who require a stable supply of high quality raw material.

## ST 01-1

### Environmental effects on potentially valuable components of *Ulva Intestinalis* along the Swedish coast

**Joakim Olsson**[*1], Sofia Raikova[2], Joshua J Mayers[1], Christopher J Chuck[2], Göran M Nylund[3], Eva Albers[1]

[1] *Biology and Biological Engineering, Chalmers University of Technology, Sweden*
[2] *Department of Chemical Engineering, University of Bath, United Kingdom*
[3] *Department of Marine Sciences, University of Gothenburgh, Sweden*

Seaweed biomass has the potential to become an important raw material for production of chemicals and commodities in a future where refinement of biomass replaces oil. This transition could be aided by growing seaweeds at conditions that boosts the valuable content of the biomass. Therefore, this study aimed to map the biochemical content of *Ulva intestinalis* around the Swedish coast to find out how potentially valuable compounds, such as rhamnose, iduronic acid and PUFAs, varies. Along the Swedish coastline the salinity varies drastically, but eutrophication and pollution are also different between the east and west coasts of the country. By how the content varies future cultivation sites can be chosen to maximize the value of the produced biomass. Biomass of *Ulva intestinalis* was collected in eight locations between the northern West Coast to Stockholm on the East Coast and analyzed for monosaccharide and lipid composition as well as ash and protein content. The data was further analyzed with cannonical analysis of principal components to highlight multivariate differences in the data. The results showed that all monosaccharides increased on the east coast with a two-times difference in the content of rhamnose and iduronic acid, implying and increase in the cell wall polysaccharide ulvan. Consistent with an increase in ulvan levels, elevated sulfur content for biomasses from the East Coast was also observed. In conclusion, we showed that the growth conditions on the Swedish East Coast causes an increase in potentially valuable rhamnose and iduronic acid. Thus, site selection will be important for the economy of seaweed farming of *Ulva intestinalis* in Sweden.

## ST 01-2

### Production of bio-hydrogen from macroalgae following hydrothermal treatment

**Aaron Brown**[*1], Miller Camargo-Valero[2], Gillian Finnerty[1], Andrew Ross[1]

[1] *School of Chemical and Process Engineering, University of Leeds, United Kingdom*
[2] *School of Civil Engineering, University of Leeds, United Kingdom*

Macroalgae has the potential to be utilised as a bioenergy feedstock; eliminating land-use management issues associated with terrestrial biomass. Conventional anaerobic digestion (AD) of macroalgae has been studied extensively, with increasing interest in thermochemical pre-treatments to enhance methane yields. Hydrothermal treatment (HTT) involves the heating of biomass in hot compressed water at temperatures between 150-250°C. Higher-end HTT temperatures generates two products; a high energy density bio-coal which has been assessed as a solid fuel [1] and a process water. The process waters are rich in solubilised organics and can be treated by AD to produce biogas. A limiting factor is the formation of inhibitory compounds during HTT which can lower the biodegradability of the process waters; particularly at higher HTT temperatures. An alternative approach is to treat the process waters by dark fermentation (DF) producing bio-hydrogen, as this is thought to be less effected by the presence of inhibitory components. DF follows similar biochemical pathways to AD, however the final stage of AD is inhibited to allow for bio-hydrogen accumulation. Hydrogen is a versatile gaseous fuel with the ability to decarbonise the energy sector. This study has investigated the potential for generating bio-hydrogen by DF from process waters derived from different macroalgae (*Saccharina latissima, Fucus serratus* and *Laminaria digitata*). HTT of each biomass sample was conducted at 150°C, 200°C and 250°C using a 600mL Parr reactor. Batch mesophilic (37°C) digestions were conducted on the process waters using an AMPTS II (Bioprocess Control). Inoculum was heat treated at 115°C for 30 minutes prior to bio-hydrogen tests to inhibit methanogen activity. The effect of pre-treatment temperature on hydrogen yields and the influence of inhibition is discussed.

## ST 01-3

### Opportunities for energy and resource recovery from macroalgae using sequential hydrothermal conversion

**Iram Razaq**[*1], Andrew Ross[1], Patrick Biller[2]

[1] *Chemical and Process Engineering, University of Leeds, United Kingdom*
[2] *Engineering, Aarhus Institute of Advanced Studies, Denmark*

There is an increasing interest in the use of macroalgae for the production of high energy density biofuels, such as bio-coal and bio-crude via hydrothermal processing. There are however, certain drawbacks to using macroalgae as it contains high levels of ash and contaminants, effecting the quality of the final fuel streams. The presence of high levels of ash and heteroatoms such as nitrogen in the products restricts their use and complicates upgrading into final fuels. Processing high ash feedstocks at high temperature also leads to problems associated with corrosion. Hydrothermal pre-treatment at lower temperatures has the potential to remove problematic inorganic components from macroalgae and open up alternative processing options of the aqueous products. The separation and recovery of inorganics useful in fertilisers from the aqueous products producing a cleaner intermediate for biofuel production. This study has investigated the sequential hydrothermal processing of a green macroalgae, *Ulva lactuca* and subsequent upgrading of the solid residues by hydrothermal liquefaction. The aqueous products and residues from hydrothermal treatment from 100-200°C have been analysed by a range of chromatographic and spectroscopic analysis. The residual matter has been further processed by hydrothermal liquefaction in high pressure batch reactors. The quality of the biocrude and the potential advantages of pre-treatment have been assessed. The recovery of phosphorus via adsorption from the aqueous products have been assessed and the potential for further upgrading of the aqueous products is assessed. The results indicate that hydrothermal processing is a feasible pre-treatment method for improving the quality of bio-oils produced from hydrothermal liquefaction. The hydrothermal pre-treatment step reduces the levels of problematic inorganics in the macroalgae improving the quality of the intermediates following hydrothermal liquefaction. This approach also has potential for application to other high nutrient and high ash containing feedstocks such as microalgae, and aquatic biomass.

## ST 01-4

### Effect of blanching on the metabolites profiling in Wakame and Mekabu

**Shahlizah Sahul Hamid**[*1], Masataka Wakayama[1,2], Yujin Ashino[1], Rie Kadowaki[1], Tomoyoshi Soga[1,2], Masaru Tomita[1,2]

[1] *Institute for Advanced Biosciences (IAB), Keio University, Japan*
[2] *Systems Biology Program, Graduate School of Media and Governance, Keio*

University, Japan

*Undaria pinnatifida* (Laminariales, Phaeophyta) is native seaweed in Japan, where it is cultivated and sold commercially as foods. Fresh seaweed commonly blanched before been consumed, which the colour changes from brown to green. However, the effect of blanching on the comprehensive metabolites profiling on different parts of *U. pinnatifida*; Wakame (b lade) and Mekabu (sporophyll) are still not well understood. Here, we investigate the metabolites profiles changes in different parts of *U. pinnatifida* after blanched in boiling water. Five replicates of samples were immersed into boiling water at each different time interval ranging from 20 to 420 sec. The blanched samples were quickly quenched into liquid nitrogen before freeze-dried. The methanol-water extraction method was used to extract water-soluble metabolites. Metabolites concentration were evaluated and quantified using liquid chromatography-mass spectrometry (LC-MS) and capillary electrophoresis-mass spectrometry (CE-MS). Among all the metabolites, Ala and mannitol were detected the highest concentration in both Wakame and Mekabu. The blanching process was not significantly affected the amino acid and sugar component ratio. As the blanching duration was increased, the metabolites concentration leaching into the blanching water was increased, but metabolites concentration in the sample were decreased. This study suggests that blanching time 20 sec for Wakame and 40 sec for Mekabu were able to preserve the highest concentration of most metabolites in the sample, which can apply for the consumption purposed.

## ST 01-5

### Protective effect of sulfated polysaccharides from *Hizikia fusiforme* against ultraviolet b-induced skin photoaging

**Lei Wang**[*1], BoMi Ryu[1], You-Jin Jeon[1]

[1] *Department of Marine Life Sciences, Jeju National University, Republic of Korea*

Ultraviolet (UV) irradiation from sunlight is the primary environmental factor that induces human skin aging and results in pigment accumulation and wrinkle formation. Many studies have reported that polysaccharides from *Hizikia fusiforme* possess various bioactivities such as antioxidant, anti-inflammatory, and anticancer, however, the protective effect of polysaccharides from *Hizikia fusiforme* against UVB-induced skin photoaging have not yet been reported. Thus, the purpose of the present study was to investigate the protective effect of polysaccharides from *Hizikia fusiforme* against UVB-induced skin photoaging. Sulfated polysaccharides from *Hizikia fusiforme* (HFPS) were obtained by Celluclast-assisted hydrolysis and ethanol precipitation and its UV protective effects were evaluated in UVB-irradiated human dermal fibroblasts (HDF cells) and zebrafish. HFPS contains 63.56±0.32% sulfated polysaccharides and scavenged DPPH, alkyl, and hydroxyl radicals at IC50 values of 0.81±0.02, 0.25±0.02, and 0.21±0.03 mg/mL, respectively. HFPS significantly reduced intracellular reactive oxygen species (ROS) level and improved the viability of UVB-irradiated HDF cells in a dose-dependent manner. In addition, HFPS significantly inhibited intracellular collagenase and elastase activities, remarkably protected collagen synthesis, and reduced matrix metalloproteinases (MMPs) expression by regulating nuclear factor kappa B (NF-κB), activator protein 1 (AP-1), and mitogen-activated protein kinases (MAPKs) signaling pathways in UVB-irradiated HDF cells. Furthermore, the in vivo test results demonstrate that HFPS significantly reduced intracellular ROS level, cell death, NO production, and lipid peroxidation level in UVB-irradiated zebrafish in a dose-dependent manner.In conclusion, these results suggest that HFPS possesses strong *in vitro* and *in vivo* photo-protective effects, and can be a potential ingredient in the pharmaceutical and cosmetic industries.

## ST 01-6

### Key factors to test before formulating a cosmetic emulsion using active phenolic compounds from a brown macroalga: seasonal variability and stability of compounds

**Leslie Gager**[*1], Solène Connan[1], Stéphane Cérantola[2], Céline Couteau[3], Laurence Coiffard[3], Valérie Stiger-Pouvreau[1]

[1] *LEMAR, IUEM/UBO, France*
[2] *NMR service, UBO, France*
[3] *LPiC (MMS), University of Nantes, France*

Brown algae have an interesting potential of valorization because of their richness in compounds like phlorotannins. In this study, a Fucales species was harvested during one year along the coasts of Brittany to study the seasonality of its total phenolic content (TPC), but also associated activities. A second part was carried out to study the stability of active molecules in a cosmetic emulsion. For the first time, molecule profiles within the emulsion were analyzed thanks to Nuclear Magnetic Resonance (NMR) approach completed with a colorimetric assay of phenolics. Firstly, seaweed extracts obtained through maceration and then purified by a liquid/liquid extraction showed a high level of TPC whatever the season. Nevertheless, variations were observed with highest TPC, antioxidant and Sun Protection Factor (SPF) in autumn. Secondly, a phlorotannin-enriched extract, obtained through Accelerated Solvent Extraction, was included in a cosmetic emulsion and stored under four different conditions (light or darkness at room temperature, 4°C and 50°C) during 6 months to follow the stability of phenolics. Surprisingly after a 1-month storage of the emulsion, a huge decrease, 63 and 83% of TPC, was highlighted at 4°C and 50°C, respectively. Afterwards, the TPC decreased more weakly until more than 90% after 6 months. Temperature had an impact on the stability of TPC meanwhile the light appears to do not affect the TPC. Our results showed that the species in concern could be harvested all year round and represents valuable source of active phlorotannins which could be included within cosmetic galenic. Interestingly, we were able to follow the decrease in TPC using NMR fingerprints which open new and rapid way of traceability of active ingredients within cosmetic products.

## ST 01-7

### Vortex-assisted solid-liquid microextraction methodology for rapid HPLC/PDA determination of fucoxanthin in seaweed biomass

**Nuno Nunes**[*1], João M. Leça[2,3], Ana C. Pereira[2,4], Vanda Pereira[2,3], Sónia Ferraz[1], Maria Carmo Barreto[5], José C. Marques[2,3], M.A.A. Pinheiro de Carvalho[1,6]

[1] *Faculdade de Ciências da Vida, University of Madeira, Portugal*
[2] *Faculty of Exact Sciences and Engineering, University of Madeira, Portugal*
[3] *Institute of Nanostructures Nanomodelling and Nanofabrication (I3N), University of Aveiro, Portugal*
[4] *Department of Chemical Engineering (3CIEPQPF), University of Coimbra, Portugal*
[5] *CE3C–Centre for Ecology, Evolution and Environmental Changes / Azorean Biodiversity Group and Faculty of Sciences and Technology, University of Azores, Portugal*
[6] *ICAAM, University of Évora, Portugal*

Fucoxanthin comprises about 10% of total carotenoids found in nature and based on its unique molecular structure is considered an important nutraceutical bioactive compound with various health benefits. A simple and fast analytical methodology is proposed for fucoxanthin determination in seaweeds and beach-cast seaweed by vortex-assisted solid-liquid

microextraction followed by high-performance liquid chromatography (HPLC) with a photodiode array detector (PDA) set at 454 nm wavelength. This ecological microextraction uses minimized quantities of sample and solvent to efficiently extract this xanthophyll. Optimized extraction parameters were assessed using a Central Composite Design analysis, performing 32 individual experiments including replicates and considering 3 factors, sample weight, solvent volume and vortex time. The final optimized extraction conditions were 25mg of sample with 300 µL of ethanol and 15 min of vortex time. The HPLC separation uses methanol and 0,1% formic acid as mobile phases at a flow rate of 0,3mL/min, with 1 µL of sample injection volume. Column temperature was set at 30 ºC. The methodology validation was assessed for its linearity (R^2=0.99998) in a concentration range of 12 to 3600 µg.g-1. Also, good sensitivity was observed through LOD (3.33 µg.g-1) and LOQ (10.09 µg.g-1) assessment. Method accuracy was determined evaluating recovery, which varied from 95 to 97%. Furthermore, good precision was verified through intra-day (2.0 - 3.3% RSD) and inter-day (1.0 - 3.8% RSD) analyses. Matrix effect was also assessed with a maximum variation of 3.4%. The method applicability was confirmed by the analysis in 10 different seaweed species (12 samples), that varied their fucoxanthin content from 10.11 to 852.28 µg.g-1 and in 10 beach-cast seaweed, that varied their fucoxanthin concentration from 13.22 to 49.43 µg.g-1. This method demonstrated a good performance and can be successfully implemented for rapid and reliable fucoxanthin micro-extraction and quantification for seaweed biomass analysis.

## ST 01-8

### Antioxidant activity of sulfated polysaccharide extract from green seaweed (*Caulerpa lentillifera*) Makassar, Indonesia

**Ilmi Fadhilah Rizki**[*1], Ellya Sinurat[2], Sofa Fajriah[3], Endang Saefudin[1]

[1] *Chemistry, Universitas Indonesia, Indonesia*
[2] *Research and Development Center for Marine and Fisheries Product Processing and Biotechnology, Ministry of Marine and Fisheries, Indonesia*
[3] *Research Center for Chemistry, Indonesian Institute of Sciences, Indonesia*

*Caulerpa lentillifera* belong to *Caulerpa* genus which is commonly found in tropical and subtropical water. This seaweed has grass-green in color and usually consumed as vegetable or salad. The biggest constituent of seaweed is polysaccharide that has some biological activities as potential medicine, for example as antioxidant. The polysaccharide is mostly found in cell wall, therefore, the aim of this research was to extract the main constituent and evaluate the antioxidant activity. The research procedure was begin with proximate analysis on dry milled samples and showed that the constituent in *Caulerpa lentillifera* were ashes (46.41%), carbohydrates (26.56%), moistures (17.09%), protein (9.18%), fibre (8.49%) and fat (1.10%). Based on the proximate analysis result, the carbohydrate was become the second most abundant constituents. Furthermore, the sample continued to be extracted. The extraction was carried out by using water extraction. First, the *Caulerpa lentillifera* powder soaked with ethanol for overnight at room temperature. On the following day, the sample was added with aquades and placed in a water bath at 75oC for approximately six hours. After that, ethanol was added to precipitate the extract. The crude polysaccharide extract percent yield obtained 4.16% (w/v). The crude extract purified by using column with DEAE-Sepharose with percent yield obtained 14.8%. Both crude and pure extracts were characterized by analyzing the total carbohydrate and sulfate by using spectrophotometer, functional group by using FT-IR spectroscopy and sugar component by using HPLC. Based on those analyses, the polysaccharide was sulfated-xyloglucan with sugar components were glucose and xylose. Antioxidant activity was analyze by using FRAP method for both crude and pure extract. Moreover, the purification of polysaccharide extract gives the higher antioxidant activity than the crude extract.

## ST 02-1

### Variability in the composition of mycosporine-like amino acids (MAAS) in red macroalgae from Brittany (France)

**Fanny Lalegerie**[*1], Sirine Lajili[1], Valérie Stiger-Pouvreau[1], Solène Connan[1]

[1] *LEMAR (Laboratory of environmental marine sciences), Institut Universitaire Européen de la Mer, France*

Marine macroalgae living in coastal areas are subjected to different environmental constraints to which they have to adapt. They have thus developed defensive mechanisms including the synthesis of photoprotective molecules. Red macroalgae, a highly diverse phylogenetic group, are known to produce a large diversity of mycosporine-like amino acids (MAAs), whose main role is to protect the algae against the harmful ultraviolet radiation. To better understand this diversity, a screening has been realized on 40 red macroalgal species collected from three sites in Brittany (France), which constitutes a database for the species present in temperate European waters including some species for which MAA composition had never been studied before. Thus, a high variability has been demonstrated between the different species and 23 potential MAAs have been detected by HPLC, including 6 already identified by LC-MS with some not yet reported in the literature. The creation of a MAAs diversity index made it subsequently possible to distinguish 3 groups of red macroalgae: species with no MAA, with few MAAs or with many MAAs. Although there was no link to phylogeny, morphology, living area, or pigment composition of each macroalga, the results suggest that some species are more likely to cope with high levels of light radiation since those well exposed to solar light, like *Bostrychia scorpioides*, *Porphyra dioica*, *Gracilaria vermiculophylla* or *Vertebrata lanosa*, had various MAAs in addition to photoprotective pigments. In order to understand the impact of different environmental parameters on MAA content and diversity, two species of red macroalgae, the native *Palmaria palmata* and the invasive *Grateloupia turuturu*, have been studied in three sites in Brittany. A monthly field monitoring has already demonstrated a seasonal change in the MAAs composition and a first laboratory culture experiment has highlighted the role as nitrogen storage of the MAAs pool for *P. palmata*.

## ST 02-2

### Semi-dry storage as a maturation process to develop the sensory characteristics of the red seaweed dulse *(Palmaria palmata)*

**Pierrick Stévant**[*1,4], Aðalheiður Ólafsdóttir[2], Justine Dumay[3], Joël Fleurence[3], Bergrós Ingadóttir[2], Rósa Jonsdóttir[2], Émilie Ragueneau[3], Céline Rebours[1], Turid Rustad[4]

[1] *Møreforsking Ålesund, Norway*
[2] *Research and innovation department, Matís, Iceland*
[3] *Mer Molécule Santé (MMS), Université de Nantes, France*
[4] *Department of Biotechnology and Food Science, Norwegian University of Science and Technology (NTNU), Norway*

The potential of seaweeds as food is gaining increasing awareness among Western consumers. This trend is supported by nutritional benefits of

popular species such as *Palmaria palmata*. However, product flavor is a major factor governing consumer acceptance and a key issue to sustain the health food movement based on edible seaweeds currently ongoing in Europe. The objective of this study is to identify changes in the sensory properties, flavor-active compounds and nutrient profile of dried *P. palmata* during storage and test the hypothesis that increasing the moisture content (MC) of the biomass to a certain level, can act as a maturation process to develop the sensory characteristics of the product.The effects of different levels of MC (dried (D) and semi-dried matured (M)) during storage over a 12-, 61-, 126-days period, on the quality of *P. palmata* as food, was studied based on sensory and chemical analyses i.e. nutrient profile and flavor-active compounds such as free amino-acids, volatiles.Strong marine flavors and aromas, were identified from the sensory evaluation of the D- and shortly matured samples (M-12) as well as a tough and crunchy texture. On the other hand, the samples undergoing long maturation time (M-61, M-126) were characterized by hay and sweet aromas, rich and complex flavors and a tender texture. Sample groups were also distinguished by their color characteristics which can be related to the decrease in pigments (R-phycoerythrin) in M-samples over time. The results from the ongoing analyses (e.g. free amino-acids, volatiles) may give evidences of endogenous chemical and enzymatic reactions occurring during the process. The MC of the product is a key parameter influencing the sensory characteristics of *P. palmata* during storage. These results provide a basis which can be applied to control the storage conditions of seaweeds to produce flavor-rich ingredients attractive to Western consumers.

## ST 02-3

### 3-Hydroxy-5,6-epoxy-β-ionone isolated from Sargassum horneri protect MH-S mouse lung cells against fine dust induced inflammation and oxidative stress

**KK Asanka Sanjeewa**[*1], Hyun-Soo Kim[1], Thilina U. Jayawardena[1], You-Jin Jeon[1]

[1] *Marine Life Sciences, Jeju National University, Republic of Korea*

Air pollution is a process that mixing of pollutants into the atmosphere, which potentially harms to humans, and causes negative impacts to the surrounding environment. Due to the high exposure risk even at the low concentrations of fine dust (FD), which become a major health threat to human society. Specifically, dust storms originated in China and Mongolian desert areas bring a large amount of FD to Korean atmosphere. According to the recent findings, the major outcomes of FD exposure are inflammation and oxidative damage in the lungs. Other than the avoiding direct exposure to fine dust, use of functional foods to avoid inflammation and oxidative stress might be a possible long-term approach to reduce fine dust related health complications. Lung macrophages (CMT-93) were treated with 3-Hydroxy-5,6-epoxy-β-ionone (HEBI) a pure compound isolated from *Sargassum horneri* (Brown edible seaweed) and after 1 hr stimulated with fine dust (31.3 µg/ml). Then, inflammatory and antioxidant parameters were evaluated using western blots, ELISA, RT-qPCR, and MTT assays. According to the results, at the concentrations between 31.3 – 125 µg/ml significantly reduced the FD-induced NO, PGE2, and pro-inflammatory cytokine production, via blocking down-stream signal transduction of Toll-like receptor 2, 3, 4, and 7 in the fine dust-activated CMT-93 cells. In addition, HEBI treatment also induced the anti-oxidant protein expression levels of FD-exposed CMT-93 via P38/Nrf2/Keap1 mediated antioxidant pathway. The active compound; HEBI isolated from *S. horneri* has the potential to develop as a functional food or as an active ingredient in cosmeceuticals due to its profound effects against FD-induce inflammation, and oxidative stress in CMT-93 macrophages.

## ST 02-4

### The identification of pigment extract of green seaweed (*Ulva lactuca* L.) from Gunung Kidul, Yogyakarta using UHPLC-High resolution mass spectra

**Windu Merdekawati**[*1], AB Susanto[2], Tri Joko Raharjo[3], Kuwat Triyana[4], Sukarti Moeljopawiro[1]

[1] *Biological Science, Universitas Gadjah Mada, Indonesia*
[2] *Fisheries and Marine Science, Universitas Diponegoro, Indonesia*
[3] *Chemistry, Universitas Gadjah Mada, Indonesia*
[4] *Physic, Universitas Gadjah Mada, Indonesia*

Seaweed can be classified based on the pigment composition. Pigments are prospectives material for many applications. The objective of this research is to identification pigment composition of green seaweed (*Ulva lactuca* L.) which is collected from Gunung Kidul, Yogyakarta. Pigment extraction was prepared by homogenizing of 500 grams fresh seaweed in acetone: methanol (3:7 v/v) solution by ultra turrax. The extracts were filtration by a vacuum pump and then partition in the diethyl ether. The filtrate was dehydrated by rotary evaporator until getting dry pigment extract of *Ulva lactuca L* (PEU). Dry PEU was kept in the freezer in temperature (-80C). The identification of pigment composition was done by UHPLC-HRMS. The results showed there is a variation of PEU i.e., chlorophyll (*a, b, c1, c2, d*), phaeophytin (*a, b*), purpurin 18, bilirubin IXa, lutein, beta-caroten, zeaxanthin, siphonein, luteoxantin, siphonaxanthin, zeacaroten and many other carotenoid pigments.

## ST 02-5

### Cellulase-assisted *Ecklonia cava* extract prevents against diet-induced obesity in mice

**Xining Li**[*1], Hyo Geun Lee[1], Yu An Lu[1], Min Cheol Kang[1], You Jin Jeon[1]

[1] *Marine Life science, Jeju National University, Republic of Korea*

*Ecklonia cava* (E. cava) show beneficial effects in anti-inflammatory, anti-hyperlipidemic and anti-obesity due to its phlorotannins like dieckol and phlorofucofuroeckol. Polysaccharide extract from *E. cava* (ECE) also has significant effects on inhibiting adipogenesis. After 12 weeks of ECE (1% and 3%) treatment on the high-fat diet (HFD) mice, body weight was greatly decreased with no death comparing to other groups. In addition, blood glucose and serum insulin levels were reduced by ECE treatment in mice fed a high-fat diet. And total cholesterol and triglyceride levels was significantly decreased in high concentration of sample treatment compared with HFD groups, which confirmed by H&E staining. Besides, ECE groups suppress the expression of PPARγC/EBPα, SREBP-1 and FABP4 in 3T3-L1 adipocytes as examined by Western Blot analysis. These results indicate that *Ecklonia cava* prevents against the development of diet-induced obesity, and ECE supplementation would become an evolvable therapeutical material for treatment of obesity or other disease come from adiposity.

## ST 02-6

### Oral administration of *Sargassum hornerı* ethanol extract ameliorates atopic dermatitis in house dust

### mite/DNCB-stimulated NC/Nga mice model

**Eui Jeong Han**[*1], Eun Ji Shin[2], Min Ju Kim[1,2], Disanayaka Mudiyanselage Dinesh Madusanka[1], Mawalle Kankanamge Hasitha Madhawa Dias[1], Hyun-Soo Kim[3], Seo-Young Kim[3], You-Jin Jeon[3], Youngheun Jee[3], Ginnae Ahn[1,4]

[1] *Department of Food Technology and Nutrition, Chonnam National University, Republic of Korea*
[2] *Department of R&D, Nantapizza 5000, Republic of Korea*
[3] *Department of Veterinary Medicine and Veterinary Medical Research Institute, Jeju National University, Republic of Korea*
[4] *Department of Marine Bio-Food Sciences, Chonnam National University, Republic of Korea*

Here, we investigated the therapheutic effect of *Sargassum horneri* ethanol extract (SHE) in house dust mite (HDM)/DNCB-stimulated NC/Nga mice, an atopy mice model. The oral administration of SHE attenuated the atopic dermatitis symptoms, including the skin dermatitis severity, the scratching frequency and TEWL in HDM/DNCB-stimulated NC/Nga mice. The significant attenuation of the serum immunoglobulin (Ig)E, IgG1 and IgG2a levels was observed after the administration of SHE. The histological analysis also revealed that SHE inhibited the epidermal hyperplasia and hyperkeratosis with the dermal infiltrations of mast cells and eosinophil. In addition, SHE reduced the expression levels of cytokines (IL-4, IL-5, IL-6, IL-10, IL-13 and IFN-) and chemokines (RANTES, eotaxin and TARC) by decreasing mRNA expression levels of atopy initiators (IL-25, IL-33 and TSLP) as well as the regulation of the mRNA expression levels of T-bet, GATA-3 and STAT-3 in the affected skin. Moreover, the oral administration of SHE led to the reduction of spleen and lymph node size as decreasing the population of immune cells such as eosinophil, inflammatory monocyte, neutrophil and/or macrophage, as well as the mRNA expression levels of IL-4, IL-13, IFN-γ, and TARC. Taken together, these results suggest that the SHE has beneficial potentials for the treatment of allergic diseases. This work (Grants No. M01201820150306) was supported by Korea Institute of Marine Science & Technology Promotion (KIMST).

## ST 02-7

### Composition and seasonal variation of the metabolic profile of *Osmundea pinnatifida*

**Cecilia Biancacci**[*1], John Day[2], Gordon McDougall[3], Michele Stanley[4]

[1] *Microbial & Molecular Biology, SAMS, United Kingdom*
[2] *CCAP, SAMS, United Kingdom*
[3] *Environmental and Biochemical Sciences Group, The James Hutton Institute, United Kingdom*
[4] *Associate Director for Innovation, SAMS, United Kingdom*

*Osmundea pinnatifida* (pepper dulse) is a sought-after species, sold dried as seasoning due to its peppery taste (5g dry weight retails at £12), but has also been investigated as a source of bioactive compounds with antioxidant, antiviral, antibacterial and anticancer properties. We characterized the seasonal variation in the metabolic profile of *O. pinnatifida* across one year (August 2016-July 2017) and investigated the relationship between taste and metabolic profile. Each month, *O. pinnatifida* was harvested at the same site, freeze-dried, milled then extracted using a standard solvent procedure. Metabolic profiling was achieved using a HiLiC-based HPLC-MS method using a Dionex U3000 UHPLC/PDA and an LTQ-Orbitrap XL MS system. The seaweed extracts were analyzed in ESI positive and negative modes and identifications made on the basis of MS data, fragmentation data, predicted formulae and matches to databases. In general, the seaweed samples contained similar metabolites, but they varied in abundance across the different months of harvest. There were seasonal patterns with certain metabolites increasing over the summer months and others increasing in the autumn and winter. Particularly, components associated with stress alleviation and resistance were accumulated during the summer months when the seaweed would be subject to increased levels of ultraviolet light. Other components were identified that may be related to the particular flavor of this seaweed and their levels correlated against the known seasonal variation in flavor acceptability. These flavor-related components were also present in water-based extractions that more closely mimicked the relevant conditions in the mouth. The seasonal variation in the metabolic profiles of *O. pinnatifida* is reported for the first time which gives valuable information regarding the seasonal variation in composition as related to flavor and confirms the importance of harvesting time for the quality of this commercially-valuable product.

## ST 02-8

### Fucoidan from brown algae reduces cell migration in human bladder cancer T24 cells

**Chun-Ju Sung**[*1], Shye-Jye Tang[1]

[1] *Department of Bioscience and Biotechnology, National Taiwan Ocean University, Taiwan*

Brown algae are common higher multicellular algae in the ocean. Fucoidan, the extract from brown algae, is a polysaccharide. The structure is rich in L-fucose and sulfate ester group. Many researches prove its various biological activities, something like anti-cancer, anti-inflammatory, anti-oxidant, and anti-coagulant. Bladder cancer is a highly incidence of malignant tumors common in the urinary system. In human bladder cancer, CCL2 can stimulate its cell migration ability and tumorigenicity, which in turn promotes cancer metastasis. In order to determine what the role of fucoidan in human bladder cancer cell line T24. We have established an extraction method to obtain fucoidan from different brown algae. MTS assay, 2-well insert migration assay, transwell migration assay, qPCR, western blot use to observe the biological activity. In our current study, we found that the fucoidan extracted from *Sargassum hemiphyllum* has no obvious cytotoxicity against human bladder cancer cell line T24. However, it significantly inhibits the cell migration activity, but activates the RNA level expression of CCL2. The fucoidan extracted from *Sargassum hemiphyllum* has anti-cancer activity for human bladder cancer cell line T24. It may inhibit the cell migration activity in T24. Our findings reveal the fucoidan can be a candidate for cure the bladder cancer.

## ST 03-1

### Exploring ecological network structure, dynamics, and function of *Microcystis* genotypes and microbes

**Seong-Jun Chun**[*1], Yingshun Cui[1], Chi-Yong Ahn[1], Hee-Mock Oh[1]

[1] *Cell Factory Research Center, Korea Research Institute of Bioscience and Biotechnology (KRIBB), Republic of Korea*

*Microcystis*, major bloom forming cyanobacterium, interact with variety of microbes and their association networks have been revealed by recent studies, yet the ecological relationships between genotypes of *Microcystis* and microbes are largely unknown. Here, we investigated the dynamics of cyanobacteria, including genotypes of *Microcystis*, heterotrophic bacteria, and eukaryotes to elucidate the ecological connections among primary producers, consumers, and decomposers during cyanobacterial harmful algal blooms (cyanoHABs). Network analysis revealed that the overall transition patterns and the compositions of modules (microbial clusters)

that involved in the same phase of cyanoHABs showed resemblance in three different sites. Distinct clusters of *Microcystis* genotypes and microbes were observed in different types of *Microcystis* bloom, suggesting the alteration of *Microcystis* genotypes could mediate by their specific companions as well as environmental factors. Most of *Microcystis*-related microbes (16S rRNA based) were also directly linked to different genotypes of *Microcystis*. In addition, hidden members of bloom modules were also tightly coupled with genotypes of *Microcystis* and may support communities function profiles during *Microcystis* bloom periods. Therefore, to understand complex ecological interactions during *Microcystis* blooms, we should consider their interactions through a network and modular structures based on the *Microcystis* genotypes. Overall, the distinct modular structures and *Microcystis* genotype based network offer new insight into the dynamic of cyanoHABs.

## ST 03-2

### Responses of seaweeds that use $CO_2$ as their inorganic carbon source to ocean acidification: differential effects of fluctuating ph but little benefit of $CO_2$ enrichment

**Damon Britton**[*1], Craig Mundy[1], Christina McGraw[2], Andrew Revill[3], Catriona Hurd[1]

[1] *Institute for Marine and Antarctic Science (IMAS), University of Tasmania, Australia*
[2] *Department of Chemistry, NIWA/University of Otago Research Centre for Oceanography, University of Otago, New Zealand*
[3] *Oceans and Atmosphere, CSIRO, Australia*

Laboratory studies that test the responses of coastal organisms to ocean acidification (OA) typically use constant pH regimes which do not reflect coastal systems, such as seaweed beds, where pH fluctuates on diel cycles and these fluctuations can influence species' responses to OA. Seaweeds that use $CO_2$ as their sole inorganic carbon source (non-CCM species) are predicted to benefit from OA yet this prediction has rarely been tested, and no studies have tested the effect of pH fluctuations on non-CCM seaweeds. We conducted a laboratory experiment in which two ecologically dominant non-CCM red seaweeds (*Callophyllis lambertii and Plocamium dilatatum*) were exposed to four pH treatments: two static, $pH_T$ 8.0 and $pH_T$ 7.7 and two fluctuating, $pH_T$ 8.0 ± 0.3 and $pH_T$ 7.7 ± 0.3.Fluctuating pH reduced growth and net photosynthesis in *C. lambertii*, while *P. dilatatum* was unaffected. OA did not benefit *P. dilatatum*, while *C. lambertii* displayed elevated net photosynthetic rates. We reveal that carbon uptake strategy alone cannot be used as a predictor of seaweed responses to OA, and highlight the importance species-specific sensitivity to [H+]. Furthermore, we highlight the importance of including realistic pH fluctuations in experimental studies on coastal organisms.

## ST 03-3

### The effect of elevated $CO_2$ on production and respiration of *Sargassum thunbergii* communities

**Peeraporn Punchai**[*1], Atsushi Ishimatsu[2], Gregory Nishihara[2]

[1] *Graduate School of Fisheries and Environmental Sciences, Nagasaki University, Japan*
[2] *Institute for East China Sea Research, Nagasaki University, Japan*

Ongoing emissions of anthropogenic $CO_2$ to the atmosphere cause reduction in the global ocean pH, and also increase dissolved inorganic carbon in seawater that macroalgae use for their photosynthesis. The possible effects of this phenomenon, known as ocean acidification(OA), on the gross production(GMP), net production(NMP), and mesocosm respiration(MR) of temperate-brown algae *Sargassum thunbergii* communities were examined in 93 day-mesocosm experiment. Two mesocosm systems, control and low pH treatments, were set up to mimic fluctuating environments. Five replicates of each mesocosm tank contained a *S. thunbergii* community. The seawater for the control was ambient seawater while those in the low pH supply tank was directly bubbled by $CO_2$ to maintain 0.3-0.4 pH units below ambient, in accordance to IPCC projection for 2100. Dissolved oxygen was continually recorded in parallel with other environmental factors such as pH, light intensity, and water temperature.Elevated $CO_2$ enhanced daily NMP (control and low pH: 5.73 ± 1 and 6.23 ± 1 g $O_2$ $day^{-1}$). A net production irradiance model revealed that the net production rate increased linearly and saturated. The maximum daily GMP rate ($GMP_{max}$) and the MR rate of the low pH treatment was greater than the control. The mean difference (95% Bayesian credible interval) in $GMP_{max}$ was 1.49 (0.95 to 2.04) g $O_2$ $day^{-1}$ and for MR was 0.74 (0.44 to 1.01) g O2 day-1. Elevated $CO_2$ slightly reduced the sensitivity of GMP, since the initial slope of the curve was lower in the $CO_2$ enrichment treatment (0.871 g $O_2$ $day^{-1}$ (mol photons $m_{-2}$ $day^{-1})^{-1}$) than in the control (0.913 g $O_2$ $day^{-1}$(mol photons $m_{-2}$ $day^{-1})^{-1}$). Indeed, the compensation PAR and saturation PAR for the control were lower than that of the $CO_2$ enrichment treatment. In conclusion, *S. thunbergii* community seem to perform better in photosynthesis under high $CO_2$ environment.

## ST 03-4

### Transgenerational temperature effects in the kelp *Laminaria digitata*

**Daniel Liesner**[*1], Lisa N. S. Shama[2], Nora Diehl[3], Klaus-Ulrich Valentin[1], Inka Bartsch[4]

[1] *Polar Biological Oceanography, Alfred-Wegener-Institute, Helmholtz Centre for Polar and Marine Research, Germany*
[2] *Coastal Ecology, Alfred-Wegener-Institute, Helmholtz Centre for Polar and Marine Research, Germany*
[3] *Marine Botany, Institute of Biology and Chemistry, University of Bremen, Germany*
[4] *Functional Ecology, Alfred-Wegener-Institute, Helmholtz Centre for Polar and Marine Research, Germany*

Transgenerational effects (effects of parental environment on offspring traits) have recently gained attention as a means of fast response to changing environmental conditions, e.g. under climate change. In temperate and polar rocky coastal ecosystems, kelps form the base of complexly structured and highly diverse species associations. This study investigates the potential for temperature-mediated transgenerational plasticity along the development from haploid parents (gametophytes) to their juvenile diploid offspring (sporophytes) in a geographically isolated population of the brown alga *Laminaria digitata* from the island of Helgoland (North Sea). We sampled spores from wild donor sporophytes, which we raised at 5 and 15 ℃ during gametogenesis, and reared the resulting young sporophytes for three months in a full-factorial split design while keeping genetic lineages separate. A concluding 12-day experiment on growth, biochemistry (carbon, nitrogen, mannitol content) and photosynthetic characteristics (maximum quantum yield Fv/Fm, maximum electron transport rate rETRmax) of five genetic lineages allowed for the separation of late temperature (12 day) responses, within-generation plasticity (early temperature) and transgenerational plasticity (gametogenesis temperature) in response to 5 and 15 ℃. We observed significant two- and three-way interactions between gametogenesis temperature and early and late sporophyte temperatures for many parameters. While interactive effects

between early and late experimental temperatures probably represent acclimation processes, interactions involving gametogenesis temperature indicate transgenerational effects. The direction of these effects differed between parameters. A main effect is that only with a history of 5 ℃ as gametogenesis and early temperature, sporophytes are growing faster at 5 than 15 ℃ over 12 days late temperature. According to our results, the temperature experienced by parents during gametogenesis influences temperature reaction norms in three- to four-month-old *Laminaria digitata* sporophytes. This, to our knowledge, is the first evidence for transgenerational plasticity in kelps.

## ST 03-5

### Biotic and abiotic controls of *Saccharina latissima* gametogenesis

**Alexander Ebbing**[*1], Klaas Timmermans[1], Tjeerd Bouma[1], Jacco Kromkamp[1], Ronald Pierik[2]

[1] *Estuarine & Delta Systems, NIOZ, Netherlands*
[2] *Department of Biology, Utrecht University, Netherlands*

The lifecycle transitions of kelp's are complex and largely understudied. Understanding the microscopic part of the kelp's lifecycle is of key importance, as gametophytes are a critical phase influencing amongst others the distributional limits of the species. Many environmental factors have been identified as lifecycle controls, but the interactive role between them remain largely unexplored. Here we performed a full factorial experiment on the influence of light intensity, light quality, and Initial Gametophyte Density (IGD) on S. latissima gametogenesis and the subsequent vegetative growth of gametophytes. A total of 144 cultures were followed over a period of 21 days. The IGD was a key determinant for the success of gametogenesis, with increased IGD's (≥0.04 mg ml-1 DW) practically halting gametogenesis. Light intensity had a significant influence on both gametogenesis and gametophyte growth, with the Photosynthetically Usable Radiation (PUR) correlating strongly with biomass increase. Light quality on the other hand had marginal effects on gametogenesis, while still affecting vegetative growth, resulting in significantly higher growth rates under white and blue light under similar light intensities. Understanding the interactive dynamics between the different lifecycle controls of gametogenesis was shown to be essential in order to quantitatively understand the forces in play, influencing both gametogenesis and the vegetative growth of S. latissima gametophytes. The results may point at novel abiotic/biotic drivers behind gametophyte lifecycle transitions, and can help clarify the limits of kelp gametophyte dispersal, also enabling a better control of in vitro gametophyte cultures.

## ST 03-6

### Effect of hydrodynamics on the horizontal structuring of macroalgal communities

**Thomas Burel**[*1], Gauthier Schaal[1], Jacques Grall[2], Erwan Ar Gall[1]

[1] *Lemar, University of Brest - IUEM, France*
[2] *Observatoire du Domaine Côtier, University of Brest - IUEM, France*

In temperate rocky shores dominated by seaweeds, canopy-forming Phaeophyceae are dominant and form macroalgal communities. These communities are distributed vertically as an adaptation to different emersion durations and horizontally, mainly under the influence of hydrodynamics. The direct effect of hydrodynamics on intertidal organisms is well documented at the species level but the community level has been scarcely investigated yet. In that prospect, in situ wave height was measured at small scale as a proxy of hydrodynamics within macroalgal communities. In parallel, both the specific richness and the cover of the surrounding macroalgae were sampled at three sites of the coast of Brittany. Average wave heights exhibit a large range of variations fluctuating between 5 cm and 150 cm allowing an overview of the micro-topography of the shore. Wave heights had a significant effect on the extent of macroalgal canopies, showing correlations with the cover of canopy forming Phaeophyceae (1) negative in high and middle intertidal communities (Pearson's *r* between -0.62 and -0.39), and (2), on the contrary, positive at the limit between the intertidal and the subtidal zones ($r = 0.39$). Beyond the site effect, small scale variations of hydrodynamics explained most of horizontal structural community variations, up to 19% of the total variance. Some undercover species of Rhodophyta are also positively correlated with wave heights. Besides, correlations were found between hydrodynamics and ecological state indices. These results underline the interest of both the horizontal community approach and the fine scale monitoring of wave heights to assess the impact of hydrodynamics on intertidal rocky shores dominated by seaweeds. Further studies using this method, might help understanding the combined effects of wave heights and elevation on macroalgal dominated rocky shores.

## ST 03-7

### The effects of velocity and canopy deformation on the photosynthesis of a seaweed bed in a recirculating flow chamber

**Yukio Inoue**[*1], Kenjiro Hinode[1], Hoshimi Kamisaki[1], Yuhei Matsuda[2], Masahiro Otake[3], Tatsuki Toda[3], Ryuta Terada[4], Gregory Nishihara[5]

[1] *Graduate School of Fisheries and Environmental Sciences, Nagasaki university, Japan*
[2] *Faculty of Fisheries, Nagasaki university, Japan*
[3] *Graduate School of Engineering, Soka university, Japan*
[4] *United Graduate School of Agricultural Sciences, Kagoshima university, Japan*
[5] *Organization for Marine Science and Technology, Nagasaki university, Japan*

Seaweed beds forms a canopy affecting water flow in and around them, and is an important variable affecting mass transport to and from the canopy. Nutrients are transferred from the bulk seawater to the surface of macroalgae, where it is absorbed through their surface. A change in mass transport caused by the interaction of the canopy with water motion affects mass transport and can lead to variable nutrient uptake and photosynthesis rates. Many previous studies reported that photosynthesis and nutrient uptake rates increases relative water velocity, but none have considered how the canopy and water motion interaction can affect mass transport. To elucidate how this interaction can affect the physiology of macroalgae, we measured the spatial distribution of water velocity around and in the canopy and examined its impact on photosynthesis. Experiments were conducted in a recirculating flow chamber. *Sargassum siliquastrum* was used to create a seaweed bed (LWD: 57 cm x 24 cm x 12 cm). Eight different water velocities (0.5 cm $s^{-1}$ to 40 cm $s^{-1}$) were examined. Dissolved oxygen concentrations were measured in the chamber at each velocity treatment for 2 hours under dark conditions and for 1 hour under light conditions (800 µmol photons $m^{-2}$ $s^{-1}$). Water velocities were also measured in and around the canopy. To estimate the deformation of the canopy due to water flow, the cross-sectional area of the canopy parallel to the flow direction was measured using digital images.We show that the canopy deflected with the flow as velocity increased, with a parallel increase in gross primary photosynthesis rate. However, the gross photosynthesis rates reached a maximum at 9.9 cm $s^{-1}$, then declined as

velocity exceeded 9.9 cm $s^{-1}$. Canopy deformation maybe a factor in the photoinhibition of canopy photosynthesis at high flow velocities.

## ST 03-8

### Recovery of kelp forest: two case studies in Korea

**Kwon Mo Yang**[*1], Byung Hee Jeon[2], Dong Suk Lee[1], Seok Woo Hong[1], Yong Wook Ko[3], Jeong Ha Kim[1]

[1] *Biological Sciences, Sungkyunkwan University, Republic of Korea*
[2] *East Sea Branch, Korean Fisheries Resources Agency, Republic of Korea*
[3] *Korean Polar Research Institute, Republic of Korea*

Two different experimental approaches have been conducting in two coastal areas, the Korean east coast and Jeju coast in Korea, to recover kelp beds from existing urchin barrens. Korean east coast has been suffering marine deforestation last decades, comprising about 60% of all rocky shallow subtidal area, with the average density of urchins 7.8 individuals/㎡ in the completely barren sites. Experimental manipulation of sea urchin density was conducted on the nine natural bed rocks of barren condition, each separated by sandy barriers in between. Three experimental conditions were applied: all urchin removal, "half"-removal, control for no-removal. At all removal sites, macroalgal community was recovered in good shape for three consecutive spring seasons (2015-2017), whereas barren state continued at the no-removal control sites. For the "half"-removal condition, we started with 4.0 individuals/$m^2$, and then switched to 2.5 individuals/$m^2$ to achieve an optimal density level, which may be necessary for the maintenance of kelp forest. A larger scaled approach is on-going this year. In the case of Jeju coast, where sea urchin is not common, barren condition is presumably caused by multiple stress factors. We applied the metapopulation concept to artificial reefs (with different substrate types) to improve the chance of natural recruitment of seaweeds as the function of distance from nearby existing source kelp beds. The experimental design and on-going results will be introduced in the presentation.

## ST 04-1

### Towards an understanding of the biodiversity and taxonomy of the genus *Ulva* (Ulvaceae, Chlorophyta)

**Thi Lan Anh Tran**[*1], Christophe Vieira[2], Frederik Leliaert[2,3], Van Tu Nguyen[1], Olivier De Clerck[2]

[1] *Institute of Tropical Biology, Vietnam Academy of Sciences, Ecology Department, Vietnam*
[2] *Phycology Research Group, Gent university, Belgium*
[3] *Botanic Garden Meise, Botanic Garden Meise, Belgium*

Cryptic species and morphological diversity are challenging the taxonomy of *Ulva* , a genus of green macroalgae that occurs globally in tropical to temperate waters. Since 1753 when the first species of *Ulva*, *U. lactuca*, was described, over 400 names have been described or transferred to the genus, but only a quarter of these names are regarded as accepted in AlgaeBase. Because of the ecological importance of the genus in coastal ecosystems, the potential negative impact of some species (e.g., in forming algal blooms, biofouling, invasive species), and the extensive use of *Ulva* for human needs (e.g., food supply, pharmaceutical use, and bioremediation purposes) there is an urgent need for an accurate taxonomy of the genus. The use of molecular tools (DNA barcoding) has greatly altered our view of Ulva species diversity. The most frequently used markers are the nuclear rDNA ITS, and the chloroplast genes rbcL and tufA. Assigning correct names to DNA sequences, however, remains problematic because of identification errors in public sequence databases, resulting either (1) names of species popping up in several places of the trees and (2) in multiple names assigned to a single species. Based on a comprehensive molecular data set of *Ulva* compiled from publicly available nucleotide sequences, our study aims to (1) provide a state-of-the-art phylogenetic framework for the taxonomy of *Ulva,* (2) assess Ulva species diversity using single locus species delimitation approaches (ABGD, bPTP, and GMYC), (3) identify poorly studied geographic regions for this group, and finally (4) to provide a molecular backbone for species identification of *Ulva* species, and to suggest common practices concerning the description of new species.

## ST 04-2

### SoEM: a novel PCR-free biodiversity assessment method based on small-organelles enriched metagenomics

**Jihoon Jo**[*1], Hyun-Gwan Lee[2,3], Kwang Young Kim[2,3], Chungoo Park[1,3]

[1] *School of Biological Science and Technology, Chonnam National University, Republic of Korea*
[2] *Department of Oceanography, Chonnam National University, Republic of Korea*
[3] *Marine Ecological Disturbing and Harmful Organisms Research Center, Chonnam National University, Republic of Korea*

DNA metabarcoding is currently adopted for large-scale community-level taxonomic identification to understand the composition of ecological communities from complex marine environments. However, before being widely used in this emerging field, this experimental and analytic approach still has several technical challenges to overcome, such as polymerase chain reaction (PCR) bias, unequal efficiency of PCR amplification, and lack of well-established metabarcoding markers, a task which is difficult but not impossible to achieve. In this study, we present an adapted PCR-free small-organelles enriched metagenomics (SoEM) method for marine biodiversity assessment. To avoid PCR bias and random artifacts, we extracted target DNA sequences without PCR amplification mainly from marine environmental samples enriched with small organelles including mitochondria and plastids because their genome sequences provide a valuable source of molecular markers for molecular ecology studies compared with nuclear genomes. To experimentally enrich small-organelles, we performed subcellular fractionation using modified differential centrifugation for marine environmental DNA samples. To validate our proposed approach, we collected two marine environmental samples from the coast of South Korea and tested the taxonomic capturing capacity of the SoEM method. Therefore, regardless of taxonomic levels, at least 3-fold greater numbers of taxa were identified in our SoEM method, compared to those identified by the conventional multi-locus DNA metabarcoding method. The SoEM method is thus effective and accurate for identifying taxonomic diversity and presents a useful alternative approach for evaluating biodiversity in the marine environment. Therefore, we believe that it will be an attractive method for many marine ecologists and conservation biologists.

## ST 04-3

### Diversity and spatial pattern of marine macroalgae in Itu Aba Island (Taiping Island, Taiwan), South China Sea: an updated inventory with comprehensive molecular references

**Pin-Chen Chen**[*1], John J. Perez C.[2], Ching-Wei Wang[1], Carolin Nieder[1], Ming-Shiou Jeng[3], Shao-Lun Liu[1]

[1] Department of Life Science, Tunghai University, Taiwan
[2] Sustainability Science & Engineering Program, International College, Tunghai University, Taiwan
[3] Biodiversity Research Center, Academia Sinica, Taiwan

Itu Aba Island, also known as Taiping Island, located in South China Sea in one of the areas in Asia with the highest biodiversity, is also highly threatened by human activity. The goals of this study were to improve the knowledge of seaweed biodiversity In Taiping Island, and to provide a basic data to allow better conservation and management of marine ecosystems by means of herbarium and molecular references. The benthic marine macroalgae community was surveyed on May 11-14 and September 19-22, 2017 using six sampling directions around the island. We found 20 orders, 41 families, 68 genera and 119 species in Taiping Island, including 61 Rhodophyta, 34 Chlorophyta, 9 Ochrophyta, and 15 cyanobacteria. With the help of molecular data, 87 out of 203 are new records for Taiping Island. As expected, composition by species was significantly different between the reef flat zone and the reef slope zone. The most common species encountered included *Caulerpa* spp., *Dictyota* spp., *Galaxaura* spp. and *Halimeda* spp. in the inner reef zone. In the coral reef zone, the algae coverage was low and most of them were Corallinales and Peyssonneliales. Among them, 10 are new records for South China Sea with 5 undescribed species that are new to science. By applying such a comprehensive DNA barcoding seaweed survey, our state-of-the-art work showed that DNA-assisted benthic survey can expeditiously fill the taxonomic knowledge gap and provide an ecological baseline for species-rich benthic marine biota in the remotely inaccessible island.

## ST 04-4

### Revisions of *Ralfsia* and *Endoplura* (Ralfsiales, Phaeophyceae) from Korea including new candidate species

**Antony Oteng'o**[*1], Boo Yeon Won[1], Tae Oh Cho[1]
[1] Life Sciences, Chosun University, Republic of Korea

*Ralfsia* is a crustose brown algal genus widely distributed in marine environment throughout the world. Four *Ralfsia* species were listed in Korea: *Ralfsia fungiformis* (Gunnerus) Setchell and N.L. Gardner, *Ralfsia verrucosa* (Areschoug) Areschoug, *Ralfsia* confusa Hollenberg and Ralfsia integra Hollenberg. Another crustose brown algal genus, *Endoplura*, is a monotypic genus with *Endoplura* aurea Hollenberg from California. In this study, we collected unidentified samples of Ralfsia and Endoplura from Korean coastal lines. These are recognized as candidates of new species within these genera based on morpho-anatomical and molecular analyses. A new candidate species in *Ralfsia* is characterized by a light brown crustose thallus without rhizoids, erect unbranched vegetative filaments, and one or two plurilocular reproductive filaments with 2-5 clavate-shaped terminal sterile cells. A new candidate species in *Endoplura* is characterized by thalli 153-255 ㎛ thick, curve vegetative filaments forming unilateral symmetry, and short plurilocular reproductive filaments with 2-3 apical sterile cells. Phylogenetic analyses based on *rbcL* reveals that these new candidate species are nested within clades of *Ralfsia* and *Endoplura* respectively, but they were distinct from congeners.

## ST 04-5

### Taxonomic revision of the order Bangiales (Rhodophyta) from Korea based on morphology and molecular analysis

**Young Ho Koh**[*1], Myung Sook Kim[1]
[1] Department of Biology, Jeju National University, Republic of Korea

The order Bangiales is one of the important taxa for food resources in the northwest Pacific region. Identification of the order Bangiales is difficult because of the lack of diagnostic characteristics and morphological plasticity. Recently, molecular analysis had been conducted using nuclear SSU and plastid *rbcL* genes for taxonomic revision of the order Bangiales. In Korea, taxonomic study had performed by morphology only and a few molecular studies for the genus *Pyropia*. Here, we carried out molecular analysis using rbcL and COI-5P, and morphological observations for taxonomic revision of Korean Bangiales. In the molecular analysis, Korean Bangiales are separated into four genera (*'Bangia'1, 'Bangia'2, Neomiuraea, Pyropia*) and sixteen species. Three genera are strongly supported with high bootstrap values except that '*Bangia*'1 is low supported. '*Bangia*'1 contained 'Porphyra' corallicola, which is a new recorded filamentous species in Korea. We also confirmed a new species of *Pyropia*, which had been identified as *Py. dentata* or *Py. haitanensis* from Korea and China, and a new recorded species, *Py. spathulata*. Although, '*Porphyra*' corallicola and *Py. spathulata* have been reported in the northwest Atlantic only, we confirmed the extended distribution of these species to the northwest Pacific in this study. Our study underlined the taxonomic revision of Korean Bangiales using molecular approach and morphological data to apply as a potential bioresources.

## ST 04-6

### Measuring both oxygenic and anoxygenic photosynthetic organisms using pulse amplitude modulation (PAM) fluorometry in wastewater ponds

**Piamsook Chandaravithoon**[*1], Raymond J. ritchie[1], John W. runcie[2]
[1] Technology and Environment, Prince of Songkla University-Phuket, Thailand
[2] Aquation Pty Ltd, Australia

Oxygenic photosynthesis can be measured using O2 or CO2 gas exchange, oxygen electrodes, Winkler titration and 14CO2-fixation and by PAM (Pulse Amplitude Modulation) fluorometry. Anoxygenic photosynthetic bacteria (APB) do not use water as an electron source and are typically photoheterotrophic rather than photoautotrophic and so 14CO2 fixation is a misleading estimate of photosynthetic electron transport in APB photosynthesis. Most use bacteriochlorophyll (BChl) a as their primary photosynthetic pigment. In vivo BChl a has a Soret band similar to Chl a but its QY bands are in the infrared and fluorescence is at > 800 nm rather than in the far red (>700 nm). Blue-diode-based PAM can be used measure the ETR in purple non-sulphur anoxygenic photobacteria and purple sulphur bacteria because their RC-2 type BChl a complexes fluoresce similarly to PSII. Conventional blue-diode PAM cannot readily distinguish oxygenic and RC-2 type anoxygenic photosynthesis in situations such as sewage ponds which contain both types of photosynthetic organisms. We developed two new types of PAM machines: one supposedly would only measure oxygenic photosynthesis and the other supposedly only measure RC-2 type anoxygenic photosynthesis. The oxygenic PAM uses a 695-750 nm bandpass filter to measure Chl a fluorescence from PS-II, the anoxygenic PAM uses a highpass filter (>780 nm) to measure BChl a fluorescence. The fluorescence bands of Chl a and BChl a were too wide to unambiguously distinguish between oxygenic and anoxygenic photosynthesis purely by fluorometry. Treatment with the specific PS-II inhibitor DCMU (Diuron) did enable

discrimination of the two types of photosynthesis in a mixture of oxygenic and anoxygenic organisms. A better choice of fluorescence filters would improve the discrimination between the two types of photosynthesis. Ecologies made up both oxygenic and anoxygenic organisms such as microbial mats and hypereutrophic environments are common. Anoxygenic photosynthesis in such systems is largely unquantified.

## ST 04-7

### Propagating a cellular stress into the environment: revealing hydrogen peroxide as an external stressor in coastal ecosystems

**Isla M Twigg**[*1], Federico Baltar[2], Jack R Hall[1], Christopher D Hepburn[1]
[1] *Marine Science, Otago University, New Zealand*
[2] *Limnology and Bio-Oceanography, University of Vienna, Austria*

Benthic primary producers provide energy and important habitat for many marine organisms, but produce hydrogen peroxide ($H_2O_2$), a driver of oxidative stress during photosynthesis. Through their high biomass, productivity and ability to alter local hydrodynamics, benthic primary producers have the potential to increase $H_2O_2$ concentrations within the biogenic structures they form. This study determined that $H_2O_2$ production by benthic primary producers can act as an external stressor in a coastal ecosystem. This was achieved by measuring $H_2O_2$ concentrations within sea lettuce blooms (*Ulva* spp.), forests of giant kelp (*Macrocystis pyrifera*), and seagrass meadows (*Zostera muelleri*); quantifying $H_2O_2$ production rates of these species; and testing the response of heterotrophic bacterial production to relevant $H_2O_2$ concentrations. $H_2O_2$ production rates and in situ concentrations were variable between species. *Ulva* spp. produced $H_2O_2$ at a rate five-times higher than other species. Additionally, concentrations were higher within *Ulva* spp. blooms than seagrass meadows and kelp forests, where $H_2O_2$ concentrations were not above ambient. At in situ concentrations, $H_2O_2$ reduced heterotrophic bacterial productivity and carbon flow through the microbial loop by 75-99%. This study reveals $H_2O_2$ as an additional stressor from globally important *Ulva* spp. blooms and identifies low rates of $H_2O_2$ production and retention around biogenic structures as positive attributes of the ecosystem engineers *M. pyrifera* and *Z. mulleri*. $H_2O_2$ production by benthic primary producers and differences among key functional groups can affect carbon flow through the microbial loop thus propagating a stress signal up the food web, altering coastal ecosystem functioning.

## ST 04-8

### Chemical defence by allelopathic active metabolites on the surface of cultivated Mexican Rhodophyta *Halymenia floresii* against biofouling

**Shareen A Abdul Malik**[*1], Gilles Bedoux[1], Daniel Robledo[2], Yolanda Freile-Pelegrín[2], Nathalie Bourgougnon[1]
[1] *Laboratory of Marine Biotechnology and Chemistry, University of South Brittany, France*
[2] *Marine Resources Department, CINVESTAV, Mexico*

During the experimental culture of *Halymenia floresii* under IMTA (Integrated MultiTrophic Aquaculture) the surface of the *H. floresii* was observed to be remarkably free from settlement by fouling organisms. Thus we hypothesize that the presence of allelopathic active compounds on the surface of *H. floresii* interfere the settlement and growth of competitors and protect the surface. To study this, *H. floresii* was cultivated under controlled environmental conditions and analyzed for its surface chemical defence metabolites. The surface-associated metabolites were extracted by the DIP method, using different immersion solvents with increasing polarity and immersion periods. Using epifluorescence microscopy, the suitable immersion solvent and time were determined. n-hexane was the solvent that worked best at any of the immersion period tested. The mean surface-area mass of *H. floresii* (n=2) was observed to be 600 ng $cm^{-2}$ which contrasted with the mass of the whole-cell metabolites, 4.5 µg $mg^{-1}$. The chemical profiling of the extracts was performed by liquid chromatography mass spectrometry and the compounds were identified by comparing with mass spectral library. The surface of the healthy and bleached *H. floresii* (n=3) were observed under scanning electron microscopy (SEM) at different angles. The topography of the bleached *H. floresii* was completely disrupted by the deterioration of cortex in comparison with that of the healthy surface. Further studies are in progress to explore quorum sensing inhibiting nature of the extract on the surface-associated bacterial isolates of *H. floresii*.

## ST 05-1

### Can RNA transcriptomes accurately resolve a phylogenetic tree?

**Seongmin Cheon**[*1], Jianzhi Zhang[2], Chungoo Park[1]
[1] *School of Biological Sciences and Technology, Chonnam National University., Republic of Korea*
[2] *Department of Ecology and Evolutionary Biology, University of Michigan, United States of America*

With the advancement of next-generation sequencing technologies, large-scale phylogenetics using genome or transcriptome sequences has become the standard tool for many previously unresolvable lineages. Although the area of phylogenomics, which involves reconstructing the phylogenetic and evolutionary history of a species by analyzing a large number of loci across the genome, is so far active, it is still hampered in cost-effectively obtaining high quality genome assembly and annotation for orthology inference. Recently, a number of studies have taken advantage of transcriptome sequences in efficiently identifying numerous nuclear orthologous protein-coding genes, and have demonstrated the utility of transcriptome data for resolving phylogenetic relationships of diverse lineages of organisms. Despite the recognized limitations stemming from the difficulty of orthology determination in transcriptome data, including incomplete genomic data, it is not clear yet whether phylogenomic and phylotranscriptomic tree topologies are congruent. Here, we compare the phylogenomic and phylotranscriptomic tree topologies from 22 mammalian and 15 plant species with both fully sequenced nuclear genomes and publicly available high-throughput RNA-seq data. We observed that the overall topology of transcriptome-based phylogeny is almost identical to the topology of the genome tree. These congruent and consistent phylogenetic results mostly depend on orthology inference. Regardless of selected tissue samples for transcriptome sequences, these phylotranscriptomic trees were accurately inferred. Our findings suggested that transcriptome sequence data may become the standard for generating large, phylogenetically informative data sets, and will offer fascinating insights into understanding the evolutionary history of organisms and their genomes.

## ST 05-2

### Effect of antioxidant addition during extraction of protein from *Ulva* sp.

**Louise Juul Pedersen**[*1], Annette Bruhn[2], Søren Krogh Jensen[3], Trine Kastrup Dalsgaard[1]

[1] *Department of Food Science, Aarhus University, Denmark*
[2] *Department of Bioscience, Aarhus University, Denmark*
[3] *Department of Animal Science, Aarhus University, Denmark*

The objective was to study the effect of antioxidants during protein extraction from *Ulva* sp. Addition of antioxidants is hypothesized to inhibit indigenous redox enzymes during protein extraction, thereby increasing the nutritional and functional quality and yield of extracted protein. The inhibition of redox enzymes may lower the oxidation of polyphenols to quinones, hereby avoiding enzymatic browning and the generation of insoluble quinone-mediated protein-complexes, which are less bioavailable. Samples of *Ulva* sp. were juiced into MilliQ water (control) or sulphite solution (antioxidant) (first juicing) and pulp was resuspended in the respective solutions and juiced again (second juicing). Analyses were carried out on the juice fraction to study the fraction of non-fiber-bound soluble protein. Color measurements were performed to examine enzymatic browning. Content of polyphenols and redox enzyme activity were determined by Folin Ciocalteu spectrophotometric assay and a kinetic spectrophotometric assay, respectively. Preliminary results showed that addition of sulphite inhibited redox enzyme activity and improved recovery of polyphenols. This led to a decrease in enzymatic browning of the juice. Quantification of the photosynthetic protein ribulose-1,5-biphosphate-carboxylase/oxygenase (rubisco) was performed by size exclusion separation. The amount of native rubisco in the first juicing increased upon high level addition of sulphite. During the second juicing, sulfite increased the amount of higher polymeric protein as well. The total protein yield in *Ulva* sp. juices and the yield of acid precipitated protein will be looked further into, i.a. solubility and protein characterization. In conclusion, addition of sulphite during extraction of protein from *Ulva* sp. inhibits redox enzyme activity, leading to improved recovery of polyphenols and decreased enzymatic browning, and resulting in a higher content of native rubisco protein in the extract.

## ST 05-3

### Toxicity evaluation of 6 antifouling biocides measured based on chlorophyll fluorescence of gametophytes of the brown macroalga *Undaria pinnatifida* (Harvey) Suringar

**Hojun Lee**[*1], Jihae Park[2], Soyeon Choi[1], Geonhee Kim[1], Taejun Han[1,3]

[1] *Marine Sciences, Incheon National University, Republic of Korea*
[2] *Department of Environmental Technology, Food Technology and Molecular Biotechnology, Ghent University Korea, Republic of Korea*
[3] *Ghent University Korea, Republic of Korea*

Antifoulants have been widely used in boat paints for controlling the redundant algae on submerged parts of boat. The introduction of these compounds into marine ecosystem may have serious consequences as they can affect non-target algal species. In present study, we evaluated the acute (48 h) toxic effects of these six antifouling biocides on gametophytes of *Undaria pinnatifida* using a sensitive and inexpensive method for detection of chlorophyll fluorescence. The compounds tested were 4,5-Dichloro-2-octyl-isothiazolone (DCOIT), Diuron, Irgarol, Medetomidine, Tolylfluanid, Zinc pyrithione (ZnPT). Responses were assessed as percent inhibition of relative fluorescence unit (% RFU inhibition) relative to the control. Toxicity had the following order with diuron being most toxic: Diuron (0.0442 mg $l^{-1}$) > Irgarol (0.0587 mg $l^{-1}$) > ZnPT (0.2189 mg $l^{-1}$) > Tolylfluanid (0.3870 mg $l^{-1}$) > DCOIT (0.5608 mg $l^{-1}$) > Medetomidine (4.1045 mg $l^{-1}$). The Undaria method is rapid, simple, practical, and cost- effective for the detection of photosynthesis-inhibiting antifouling biocides, thus making a useful tool for testing the toxicity of antifouling in marine environments.

## ST 05-4

### Deformity of benthic diatom as biomarkers of marine environment

**Soyeon Choi**[*1], Jihae Park[2], Hojun Lee[1], Geonhee Kim[1], Taejun Han[1,3]

[1] *Marine Science, Incheon National University, Republic of Korea*
[2] *Department of Environmental Technology, Food Technology and Molecular Biotechnology, Ghent University Korea, Republic of Korea*
[3] *Ghent University Korea, Republic of Korea*

Marine environments are subjected to contamination by metals derived from various marine activities. Due to the limit of physicochemical analyses for the detection of contaminants, the development and application of bioassay methods for assessing marine environmental risks have become a research priority for providing information on pollutant-induced toxic effects. Diatoms are regularly used for bioassessment and ecotoxicological studies. In particular, deformities in diatoms frustules has been bioassay parameter to environmental pollutions such as metals and organic compounds. However, only few studies have been conducted to investigate the biomonitoring using diatom in marine environment, despite of enough investigate using diatom in fresh water environment. This study aim to investigate the bioassessment and ecotoxicological advancement taken place in diatom research especially in terms of exploring new endpoint, deformity, in a perspective which can greatly enhance the evaluation of fluvial ecosystem quality for biomonitoring practices. The standards of detection and quantification of deformity in a benthic diatom *Cylindrotheca closterium* Ehrenberg as an effective tool for biomonitoring of various heavy metal pollution in marine environments are presented.

## ST 06-1

### Can shifting in cultivation condition improve the growth and carbohydrate content of sugar kelp (*Saccharina latissima*)?

**Saifullah Saifullah**[*1,3], Silje Forbord[1,2], Aleksander Handå[2], Yngvar Olsen[1]

[1] *Department of Biology, Norwegian University of Science and Technology, N-7491 Trondheim, Norway*
[2] *Department of Environment and New Resources, SINTEF Ocean, N-7465 Trondheim, Norway*
[3] *Department of Fisheries, University of Sultan Ageng Tirtayasa, Indonesia*

Seaweed growth in an aquaculture environment affected by light and nutrient conditions. A study designed at the coast off Central-Norway to investigate whether shifting of cultivation depths affected the carbohydrate contents of the sugar kelp (*Saccharina latissima*). The sporophytes were growing in rope cultures at two depths, i.e. 1-2 m and 8-9 m below the surface. Some rope cultures then moved from 1-2 m depth to 8-9 m depth and vice versa after six weeks cultivation at sea. Some other rope cultures maintained as the control treatment at the same depth along the study (1-2 m depth and 8-9 m depth). The seaweed biomass collected from April to August 2017, then stored in a freezer until the analysis. Glucose content measured using the phenol-sulphuric acid method. Normality test, descriptive analysis, and student t-test conducted to analyse the result by using IBM SPSS Statistics 25. The results demonstrated that (1) the samples distributed normally; (2) the carbohydrate content of the alga increased after shifting. For instance, there was a different value of glucose on week

22 (two weeks after the kelp shift from one depth to another) between the samples. Glucose from the control of 1-2 m depth is 1.4 g kg-1, while from the kelp shift to 8-9 m depth is 1.7 g kg-1. It also applied to the kelp from the control of 8-9 m depth. It contains lower glucose compare to the seaweed shift to 1-2 m depth (1.3 g kg-1 and 1.4 g kg-1 respectively). The study also shows that (3) there was no carbohydrate difference before and after the alga move from one depth to another. Although the student t-test results show no statistically significant (P>0.05) differences, the carbohydrate content of the seaweed might be increase through shifting the cultivation depths.

## ST 06-2

### Emersion effect on growth, pigments and biochemical responses in *Pyropia yezoensis*

**Sojin Jang**[*1], Sookkyung Shin[1], Samanta Palas[1], Jang K. Kim[1]

[1] *Department of Marine Science, Incheon National University, Republic of Korea*

*Pyropia yezoensis* is one of the most important aquaculture species in Korea. In some seaweed farms, *Pyropia* is exposed to air occasionally, experiencing emersion stresses. Therefore, emersion stresses could alter growth, pigment contents, oxidative stress responses and antioxidant defense responses in *Pyropia*. Accordingly, this study is designed to determine how emersion stress affects the growth, pigment contents and oxidative responses in *Pyropia*. *Pyropia* is cultivated at constant temperature (10 °C) and exposed daily to air for 0 (control), 30 min (40±10% water loss) and 2 h (90±5% water loss) over a period of 16 days. Sampling is made before and after emersion at each sampling day (day 1, 2, 4, 8 and 16). Growth rate, pigment contents and reactive oxygen species (ROS), and antioxidant enzyme activities such as superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and glutathione S-transferase (GST) are measured to check the quality of *Pyropia* under emersion stresses. The findings from this study will provide critical information regarding *Pyropia* quality under emersion stresses.

## ST 06-3

### Physiological responses and growth of the seaweed *Ulva* sp. under changing cultivation conditions in pilot land-based ponds

**Stephanie Revilla-Lovano**[*1], Jose M. Sandoval-Gil[1], Laura K. Rangel-Mendoza[1], José A. Zertuche-González[1]

[1] *Marine Botany Research Group, Instituto de Investigaciones Oceanológicas, University of Baja California, Mexico*

Land base intensive cultivation systems are becoming an option for the commercial production of seaweeds. There are multiple options in terms of seeding density, nutrient type and dose, and volume of water exchange in order to optimize the production of seaweed. The purpose of this study was to determine the optimal production of *Ulva* sp. evaluating its physiological responses and growth during its cultivation in a land-based 40 $m^3$ ponds. Through an entire cultivation cycle (four weeks), photosynthesis, respiration, pigments and nutrient content were measured. Light, temperature, pH, and dissolved inorganic nitrogen (DIN) were simultaneously monitored. Additionally, laboratory experiments were performed to assess the effects of increasing temperature and pH on the seaweed physiology (photosynthesis, nitrogen uptake). DIN (ammonium, nitrate) uptake kinetics were also determined to evaluate *Ulva* sp. capacity to incorporate the fertilizer used during cultivation. Results showed a gradual decrease in photosynthetic capacities and nutrient content (reserve carbohydrates, nitrogen) during cultivation; this was likely associated to the low availability of light and inorganic carbon for photosynthesis as biomass increased within the ponds (from 1 to ~7 kg FW $m^{-3}$); seaweed specific growth was also reduced, resulting in a reduction in biomass productivity per unit area. Short-term (hours) increments in pH and temperature, which can occur in ponds on daily-basis, caused severe inhibition of photosynthesis and nitrogen uptake, as obtained from laboratory experiments. Also, uptake kinetics demonstrated that *Ulva* sp. incorporates ammonium more efficiently than nitrate, and DIN analysis in the seawater of the ponds indicated that the presence of ammonium inhibits the acquisition of nitrate by the seaweed. Generally, our results can be directly applied to optimize culture conditions of *Ulva* sp. Based on these results, biomass production could be optimized by harvesting between the first and second week of cultivation.

## ST 06-4

### Protoplast isolation from four brown algal species using a simple mixture of commercial enzymes

**Jose Avila Peltroche**[*1], Boo Yeon Won[1], Tae Oh Cho[1]

[1] *Natural Science, Chosun University, Republic of Korea*

Protoplasts are naked living plant cells useful for genetic modification strategies, tissue culture and physiological studies. Compared with green and red seaweeds, protoplast isolation protocols in brown algae have been hampered by the use of non-commercial enzymes or crude extracts. We have previously reported the protoplast isolation and regeneration from brown algal *Hecatonema terminale* using commercially available cellulase and alginate lyase. In this work, we expanded our protoplast isolation protocol adding driselase and osmolarity tests to *Sphacelaria fusca* (Sphacelariales), *Undaria pinnatifida*, *Ecklonia* sp. (Laminariales) and *Petalonia fascia* (Ectocarpales). Inclusion of driselase did not increase protoplast yield in the species tested. Increasing osmolarity of enzymatic solution showed positive effect in and *S. fusca* and *P. fascia* but negative one in *U. pinnatifida* and *Ecklonia* sp. Further experiments in *U. pinnatifida* and *P. fascia* showed that chelation pre-treatment only improved the protoplast production in the latter one and an incubation time of 4 h was optimal for both species. Our protoplast yields were superior to the values obtained using previous protocols for brown algae. Maximum protoplast yields for *S. fusca*, *U. pinnatifida*, *Ecklonia* sp. and *P. fascia* were 0.15, 47, 10 and 122 x $10^6$protoplasts/g fresh weight, respectively. Our results show that high amount of protoplasts from brown seaweeds can be isolated using a simple mix of commercial enzymes.

## ST 06-5

### Hatchery strategies for long term storage of *Saccharina latissima* seed string in Alaska

**Annie Thomson**[*1], Tamsen Peeples[2], Margaret Sherman[3], Rachel Hennegan[3], Michael Stekoll[3]

[1] *Fisheries, University of Alaska Fairbanks, United States of America*
[2] *Alaska Mariculture, Blue Evolution, United States of America*
[3] *Biology, University of Alaska Southeast, United States of America*

Kelp farming has the potential to economically diversify coastal communities of Alaska while offering potential ecosystem services including carbon sequestration and mitigating the effects of eutrophication. Our research

is focused on identifying methods to control life stages of *Saccharina latissima* to optimize kelp mariculture output. Our aim is to 1) understand natural fertility patterns of sporophytes and 2) investigate how growth and development of gametophytes and juvenile sporophytes on seed string can be controlled and stored long term by varying environmental conditions. We have evaluated removing iron from the gametophyte culture medium and filtering out blue light while gametophytes are in culture, changing light intensity and temperature in which gametophytes are grown as potential methods to delay or halt gametogenesis. Our preliminary results suggest removing iron from the gametophytes nutrient medium is a reliable method of halting gametogenesis. However long-term storage without iron may negatively affect the viability of the kelp seed as the life cycle progresses. Ongoing experiments are examining how gametophyte and juvenile sporophyte growth can be slowed by varying temperature and light intensity in culture. Preliminary results suggest gametophytes grown under low temperatures (4°C) grow slower and produce less eggs and sporophytes then gametophytes grown at optimal temperatures (12°C). Results from current and upcoming experiments will help inform the growing kelp mariculture sector as it looks to optimize supply and growth practices and provide insight to the ecological life cycle strategy of *S. latissima*.

## ST 06-6

### Effects of stocking density on productivity and nutrient removal of *Gracilaria vermiculophylla* in *Paralichthys olivaceus* biofloc effluent

**Sookkyung Shin**[*1], Su-Kyoung Kim[2], Jun-Hwan Kim[2], Taejun Han[1], Charles Yarish[3], Jang K. Kim[1]

[1] *Marine science, Incheon National University, Republic of Korea*
[2] *Department of Aquaculture, National Fisheries Research & Development Institute, Republic of Korea*
[3] *Department of Ecology and Evolutionary Biology, University of Connecticut, United States of America*

To evaluate nutrient bioextraction capacity of *Gracilaria vermiculophylla*, this alga was cultured at 0.2, 2, 4 and 8 g $L^{-1}$ (FW) of stocking density, 160 ± 10 µmol $m^{-2}$ $s^{-1}$ of light emitting diode (LED) and 12:12 L:D photoperiod for 20 days. *G. vermiculophylla* was cultured at 20°C in two different media, 1) effluent from a juvenile *Paralichthys* biofloc culture system and 2) von Stosch enriched (VSE) medium. The total nitrogen and phosphorus concentration of VSE medium was adjusted to 1000 µmol $L^{-1}$ and 33 µmol $L^{-1}$, respectively. The total nitrogen and phosphorus concentration of biofloc medium was 3000-3800 µmol $L^{-1}$ and 100-200 µmol $L^{-1}$, respectively. Specific growth rate was significantly higher at 0.2 than 8 g $L^{-1}$ at both media. However, the productivity was significantly higher at 8 than 0.2 g $L^{-1}$ at both media. Tissue nitrogen contents were significantly higher at VSE medium than at biofloc medium at 8 g $L^{-1}$ (3.7% in VSE and 3.4% in biofloc). The nitrogen removal rate was highest at the highest stocking density, 1.50 mg $L^{-1}$ $d^{-1}$ (VSE) and 1.31 mg $L^{-1}$ $d^{-1}$ (biofloc), respectively. The nutrient removal was not significantly influenced by medium at 8 g $L^{-1}$. These results show that *G. vermiculophylla* can grow and have the potentiality to efficiently remove nutrients in the biofloc medium at high nitrogen concentration.

## ST 07-1

### Construction of a genetic linkage map in *Pyropia yezoensis* (Bangiales, Rhodophyta) and QTL analysis of several economic traits of blades

**Lin-bin Huang**[*1], Xing-hong Yan[1]

[1] *College of Fisheries and Life Science, Shanghai Ocean University, China*

*Pyropia yezoensis* is an important economic seaweed, to construct a genetic linkage map and analyze the quantitative trait loci (QTLs) of blades, a doubled haploid (DH) population containing 148 DH strains established from the intraspecific hybridization between two strains with different colors was used in the present study and genotyped using 79 pairs of polymorphic sequence-related amplified polymorphism (SRAP) markers labeled with 5'-HEX and capillary electrophoresis. A chi-square test for significance of deviations from the expected ratio (1:1) on the loci which were polymorphic between parents and segregated in mapping population identified 301 loci with normal segregation ($P \geq 0.01$) and 96 loci (24.18%) with low-level skewed segregation ($0.001 \leq P < 0.01$). The map was constructed using JoinMap software after a total of 92 loci were assembled into three linkage groups. The map spanned 557.36 cM covering 93.71% of the estimated genome, with a mean interlocus space of 6.23 cM. Kolmogorov-Smirnov test (α=5%) of the marker positions along each LG showed a uniform distribution. After that, 10 QTLs associated with five economic traits of blades were detected, among which one QTL was for length, one for width, two for fresh weight, two for specific growth rate of length and four for specific growth rate of fresh weight. These QTLs could explain 2.29-7.87% of the trait variations, indicating that their effects were all minor. The results will serve as a framework for future marker-assisted breeding in *P. yezoensis*.

## ST 07-2

### Population and landscape genomics in the sugar kelp *Saccharina latissima*

**Alexander Thomson**[*1], Wouter Visch[2], Michele S. Stanley[1]

[1] *Molecular Ecology, Scottish Association for Marine Science, United Kingdom*
[2] *Department of Marine Sciences - Tjarno, University of Gothenburg, Sweden*

Interest in the cultivation and harvesting of macroalgae is increasing worldwide. In Europe, the production of the sugar kelp, *Saccharina latissima,* is expected to increase substantially in the coming decade. At the same time, wild kelp populations are facing increased environmental and ecological pressures in the form of warming sea temperatures, ocean acidification, and more direct human disturbance, leading to shifting range distributions and large-scale ecosystem shifts. These changes, and their impacts on wild kelp populations, underpin the need for greater understanding of their population diversity, dynamics and adaptive capabilities. Here we describe how the population sequencing of wild *S. latissima* populations from Scotland and Sweden offers a genetic baseline for mapping, monitoring and managing wild diversity, as well as offering insights into potential drivers of selection and adaptation in sugar kelp. We have used a reduced-representation sequencing approach (dd-RADseq) to sequence over 400 individuals from 20 stations across Sweden and Scotland. This approach can offer 1000's to 10,000's of SNP-based markers, offering high-resolution genotyping for diversity, differentiation, and connectivity analysis, as well as allowing the putative identification of genes under selection within the population.Our study also aims to test the relationship between allele frequencies and environmental constraints through genetic-environment association tests. By sampling along strong temperature and salinity gradients, and by applying a paired sampling approach at extremes of those gradients, we aim to explore potential genetic drivers of adaptation and selection in sugar kelp. The population data will go towards the informed management and conservation of wild and cultivated kelp resources. The information gained will also shed light on how *Saccharina*

*sp*. adapt to temperature and salinity through the identification of putative genes under selection and adaptation, and will lay the foundations for future investigation into functional genes of interest in kelp.

## ST 07-3

### Gametophyte transcriptome reveals sex-biased gene expression in the kelp *Saccharina latissima*

**Catia Monteiro**[*1], Sandra Heinrich[2], Inka Bartsch[3], Klaus Valentin[4], Erwan Corre[5], Jonas Collen[6], Lars Harms[7], Gernot Glöckner[8], Kai Bischof[1]

[1] *Marine Botany, University of Bremen, Germany*
[2] *Institute for Plant Science and Microbiology, University of Hamburg, Germany*
[3] *Functional Ecology, Alfred-Wegener-Institute, Helmholtz Centre for Marine and Polar Research, Germany*
[4] *Polar Biological Oceanography, Alfred-Wegener-Institute, Helmholtz Centre for Marine and Polar Research, Germany*
[5] *Station Biologique de Roscoff, plateforme ABiMS, CNRS: FR2424, Sorbonne Université, France*
[6] *Integrative Biology of Marine Models (LBI2M), Station Biologique de Roscoff, Sorbonne Université, CNRS, France*
[7] *Computing – Bioinformatics, Alfred-Wegener-Institute, Helmholtz Centre for Marine and Polar Research, Germany*
[8] *Institute for Biochemistry I, Medical Faculty, University of Cologne, Germany*

In kelps, the sex of individuals is expressed during the haploid life stage when the microscopic gametophytes exhibit varying degree of sexual dimorphism. *Saccharina latissima* is an ecologically important kelp on some temperate rocky shores and of emerging commercial interest as an aquaculture species. However, genomic information concerning kelp gametophytes is still lacking. We studied to what extent sexual dimorphism and associated performance in *S. latissima* gametophytes are related to sex-biased gene expression and discuss implications on species ecology. RNA was extracted from male and female clonal gametophytes. A de *novo* transcriptome was assembled with the Trinity software based on sequencing reads obtained from an Illumina HiSeq platform. Functional annotation was performed using the Trinotate pipeline. Differential expression was estimated using DESeq2 at Trinity's gene level with an adjusted p-value of 0.001 and a log2 fold change of at least 2 indicating significance. The number of reads per library ranged from 28.7 to 38.3 million and were assembled into 256,118 transcripts, corresponding to 211,947 Trinity genes. Ninety percent of total expression was present in 58,741 transcripts with a N50 of 1,895 bp. 36,379 transcripts were functionally annotated using the UniProt Swiss-Prot database. Principal Component analysis indicated that 34% of the variability is explained by sex. The analysis revealed 23,698 differentially expressed genes between males and females, most apparent with respect to genes related to protein and cytoskeleton synthesis, that may be related to the sexual dimorphism of kelp gametophytes. Our study, thus, lays the foundation for further studies on the morphogenesis, reproductive biology and evolutionary processes in *S. latissima*.

## ST 07-4

### Evolutionary dynamics of mitogenomes in Cyanidiophyceae (Rhodophyta)

**Chung Hyun Cho**[*1], Seung In Park[1], Claudia Ciniglia[2], Hwan Su Yoon[1]

[1] *Biological Departments, Sungkyunkwan Univerisity, Republic of Korea*
[2] *Department of Environmental, Biological and Pharmaceutical Science and Technologies, University of Campania "L. Vanvitelli", Italy*

Most species are generally fatal to harsh conditions, but some species can thrive in the extreme environments including high temperature, acidic, and heavy-metal rich conditions. Compare to many prokaryotic extremophiles, only few eukaryotic species are reported from extreme environment. The Cyanidiophyceae (Rhodophyta) are the best eukaryotic example, that thrive in acidic (pH 0-2), and high-temperature habitats (35-50°C). Study on this interesting organism, however, is poorly conducted. To fill the gap of our understanding on the cyanidiophycean biology, we have completely sequenced and annotated five new mitogenomes from the representative clades of Cyanidiophyceae. In this presentation, it will be discussed in i) resolving the phylogenetic relationship and ii) the classification of mitochondria type in Cyanidiophyceae. To this end, we compared trees based on concatenated gene set and sub-sampled datasets. We will also distinguish two mitochondrial types, *Cyanidium-type* and *Galdieria-type*, based on their genomic characteristics, mitochondrial gene and amino acids compositions. Based on comprehensive genomic analyses, we will suggest a possible evolutionary scenario of the Cyanidiophyceae.

## ST 07-5

### Genome sequencing and population genomic analyses provide insights into domestication and adaptation to new environments in the kelp *Undaria pinnatifida*

**Louis Graf**[*1], Youn Hee Shin[1], Ji Hyun Yang[1], Frédérique Viard[2], Wendy A. Nelson[3], Hwan Su Yoon[1]

[1] *Biological Sciences, Sungkyunkwan University, Republic of Korea*
[2] *Adaptation et Diversité en Milieu Marin, Station Biologique de Roscoff, France*
[3] *Nationl Institute of Water & Atmospheric Research, University of Auckland, New Zealand*

*Undaria pinnatifida* (Laminariales, Phaeophyceae) is a famous multicellular kelp species playing important ecological roles in its natural habitat in Eastern Asia. It is extensively cultivated in Korea (~500.000 tons/year) for food consumption, abalone farming or for its extracts. *U. pinnatifida* is also well known worldwide for being an invasive species. Indeed it was introduced to Europe in the 1970s initially to the Mediterranean coast and later to Brittany. In the late 1980s the species was also recorded in New Zealand. Introductions most likely occurred from cultivated individuals from the native range. Therefore *U. pinnatifida* represents an interesting model to investigate both the domestication (i.e. artificial selection) and the return to natural selection in new environments. To investigate these questions at the whole-genome level first we produced a high quality draft genome of *U. pinnatifida* from a cultivated individual from Korea. Secondly we re-sequenced the genomes of 10 individuals from Korean natural populations and 10 individuals from Korean cultivated populations to investigate domestication. Finally we re-sequenced 21 individuals from introduced populations in France and in New Zealand. We describe the genome of *U. pinnatifida* and briefly compare it to previously sequenced brown algae genomes. We then discuss genome-wide variations between the different populations considered and identified putative selective sweeps at multiple loci. We notably discuss the importance of domestication on the capability of *U. pinnatifida* to invade new environmentsoutside of its native range.

## ST 07-6

### Large-scale gene duplication events in the dinoflagellate lineage

**Sung-Gwon Lee**[*1], Chungoo Park[1]
[1] *School of Biological Science and Technology, Chonnam National University, Republic of Korea*

Dinoflagellates are one of the ecologically important algal groups in the ocean, contributing to marine primary production and coral reef building. They showed many unique biological and physiological features such as the absence of nucleosomes, endosymbiosis, complex life cycle and bioluminescence. Among these characteristics, they have the most striking genomic feature which is immense and widely varied nuclear genomes size, extending 1 to 270 giga bp (Gb). In general, large cellular DNA content is mainly known as a result of accumulation of transposable elements (TE), whole genome duplication (WGD), and retention of duplicate genes. Paleopolyploidy is the result of WGD or massive gene duplication occurred at least several million years ago, also is well-known for plant and some animal genome evolution [1, 2], but little is known in the dinoflagellate phylum. Until recently, genome capable of detecting paleopolyploidy in dinoflagellate lineage have rarely been published. However, previous studies showed that ancient WGDs can detect through age distributions of duplicated genes analyzed using transcriptome data in plants and insects [3, 4]. Here, we used recently published genome/transcriptomes and newly sequenced transcriptomes data from forty dinoflagellates and two outgroups to investigate the ancient gene duplication event of dinoflagellates. We performed comparative genomic and phylogenetic analyses to detect ancient gene duplication and to reconstruct their relationships, respectively. Using age distributions of duplicate genes and a phylogenetic tree, we found evidences for at least one round dinoflagellate-wide massive gene duplications (polyploidy or aneuploidy). Interestingly, these bursts of gene duplication were more frequently observed at the Gonayulacales, Prorocentrales, and Gymnodiniales, including species previously reported to have large genomes (~ 55 to 165 Gb). Our finding provides evidences that ancient massive gene duplications could contribute to genome size complexity during dinoflagellate evolution.

*Undaria pinnatifida*

*Ecklonia cava*

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## PP 01

### Lipid formation by arctic microalga *Chlamydomonas* sp. KNF0008 at low temperatures

**Eun Jae Kim**[*1], Woongsic Jung[1,2], Suyoun Lim[1,3], Sanghee Kim[1], Han-Gu Choi[1], Se Jong Han[1,4]

[1] *Division of Polar Life Sciences, KOPRI, Republic of Korea*
[2] *Research and Development, GDE, Republic of Korea*
[3] *Functional Genomics R&D Team, Syntekabio, Republic of Korea*
[4] *Polar Sciences, University of Science and Technology, Republic of Korea*

In the present study, we introduce a new lipid-producing microalga, *Chlamydomonas* sp. KNF0008, collected from the Arctic. This strain was capable of growing at temperatures ranging from 4 °C to 20 °C, and the highest cell density was measured at 15 °C and 100 µmol photons $m^{-2}$ $s^{-1}$ light intensity under continuous shaking and external aeration. KNF0008 showed the elevated accumulation of lipid bodies under nitrogen-deficient conditions, rather than under nitrogen-sufficient conditions. Fatty acid production of KNF0008 was 4.2-fold (104 mg $L^{-1}$) higher than that of *C. reinhardtii* CC-125 at 15 °C in Bold's Basal Medium. The dominant fatty acids were C16:0, C16:4, C18:1, and C18:3, and unsaturated fatty acids (65.69%) were higher than saturated fatty acids (13.65%) at 15°C. These results suggested that Arctic *Chlamydomonas* sp. KNF0008 could possibly be utilized for production of biodiesel during periods of cold weather because of its psychrophilic characteristics.

## PP 02

### Biofuel production using arctic psychrophilic microalga *Chlamydomonas* sp. KNM0029C

**Eun Jae Kim**[*1], Sanghee Kim[1], Han-Gu Choi[1], Se Jong Han[1]

[1] *Polar life sciences, KOPRI, Republic of Korea*

In this study, 184 strains owned by KOPRI were used to find a candidate used as a feedstock for biofuels. After culturing at 8 °C for 2 weeks in media (TAP, BBM, F/2), 19 strains showing the highest cell concentration were selected and the lipid content of each strain was measured. The strain showing the highest lipid content was KNM0029C. According to molecular and morphological analysis, KNM0029C was identified as genus *Chlamydomonas*. KNM0029C showed the highest cell concentration at 4 °C under 80 µmol photon m-2s-1 of light intensity in TAP medium. For the cultivation of KNM0029C, the composition of the TAP medium was optimized, which increased the cell concentration by 30 % and increased the lipid content by 9.5 %. In order to efficiently produce biodiesel from biomass of KNM0029C, the production yield of FAME usable as biodiesel was compared between existing extraction methods and a modified A extraction method. The modified A method yielded 0.16 g of FAME per g of biomass, which was 5.4 % lower than the conventional Lewis's method, but it reduced the process of removing moisture. After the biodiesel process, bioethanol was produced using the remaining residues. Bioethanol production using yeast fermentation was compared through a combination of physical, chemical, and biochemical (enzymatic) pretreatment methods. The highest yield of bioethanol was obtained by pretreatment with enzymatic treatment after ultrasonication and showed 0.22 g of bioethanol production per g of residual biomass. It was 38 % higher than the bioethanol production, which showed the highest yield in previous reports, using residual microalgae after de-oiled process. In this study, using polar microalgae KNM0029C could be secured biomass in low temperature environment and converted to biofuels. These results can be used as a source for the production of renewable energy using polar microalgae.

## PP 03

### Component analysis and development of functional food from Japanese *Sargassum horneri*

**Akiko Yamada Taniguchi**[*1], Yuko Sato[2], Machiko Kazami[1], Haruko Noguchi[1], Kinuko Niihara[3], Masafumi Yoshida[3]

[1] *Department of Innovation for Sustainability, Faculty of Agriculture, Tokyo university of Agriculture, Japan*
[2] *Division of Medical Nutrition, Faculty of Healthcare, Tokyo Healthcare University, Japan*
[3] *Department of Natural Sciences, Faculty of Knowledge Engineering, Tokyo City University, Japan*

*Sargassum horneri* (or "*Akamoku* " in Japanese) is a seaweed that grows approximately 10 m in length and is widely distributed across Asia. It has gained extreme popularity as food in Japan in the recent years. Akamoku changes to bright green color when boiled and has a sticky texture. This stickiness and slippery components are believed to possess functionalities. Experimental samples of Akamoku were obtained from three different production areas in Japan: Kamakura, Sendai, and Sado. We measured the moisture, protein, fat, ash, and carbohydrate contents as general ingredients, followed by dietary fiber, mineral and polyphenol contents, antioxidant activity, and color tone analysis. We also examined the difference between the components of male and female strains. The potential of functional food preparation from the samples was also investigated. The general ingredients of Japanese Akamoku were approximately 2% protein, 0.1% lipid, 6.5% carbohydrate, and 5% dietary fiber. As compared to regular seaweed, it contained several dietary fibers. The mineral contents of Japanese redcurrant were potassium, calcium, magnesium, iron, zinc, and copper. Akamoku had a high polyphenol content of 95–120 mg/100 g of sample, and it was expected to have functions, such as antioxidant activity. The amounts of water-soluble sugar, water-soluble protein, and polyphenol in the samples were more eluted in the female strains than in the male strains. Akamoku could be developed into tofu and functional foods such as bread. Akamoku was long considered to be an industrial waste, and its research as food has not yet been conducted. We investigated the ingredients of Akamoku at the main production areas and determined the characteristics of male and female strains. Our findings indicate the potential of Akamoku as a functional food.

## PP 04

### Effect of substratum types on the growth of erect and stolon fronds of edible *Caulerpa okamurae*

**SongHyun Lee**[*1], Ji Ha Shin[1], Seo Kyoung Park[1], Han gil Choi[1]

[1] *Faculty of Biological Science, Wonkwang University, Republic of Korea*

To examine the effect of substratum types on the growth of *C. okamurae*, erect fronds (3-5cm) were cultured in the three different substratum treatments (fine sand, coarse sand, no substratum) for 15 days. The other culture conditions were the same with 25°C, 30 µmol photons $m^{-2}$ $s^{-1}$, 16:8 h L:D (Light: Dark). After 15 days, number of rhizoid clusters and new erect fronds were counted and separated erect and stolon weights of *C. okamurae* were measured. Relative growth rates (RGR) were then calculated for erect and stolon weight. *C. okamurae* produced rhizoids and erect fronds, between 0.93~1.40 clusters and 1.40~3.00 individuals,

respectively. The RGRs of *C. okamurae* were from 0.43 to 1.95% $day^{-1}$ for total weight, and the RGR of erect and stolon were 0.62~2.08% $day^{-1}$ and 0.00~1.15% $day^{-1}$ . At the fine sand treatment, RGRs for total thalli, stolon and erect fronds were maximal and new erect frond production was greater than the other ones. On the other hands, stolon grew slowly in coarse sand treatments, but rhizoid production was similar in the two sediment treatments. In conclusion, *C. okamurae* grew well as substrate are present and better growth observed in fine sand treatments. Present results imply that stolons and rhizoids of *C. okamurae* make them stable with a firm attachment to the substrate, which stimulate the growth of stolon and erect fronds.

## PP 05

### A review of top value-added products from seaweed biomass and prospects of cascading biorefinery: preliminary results

**Xueqian Zhang**[*1], Thomsen Marianne[1]
[1] *Environmental Science, Aarhus University, Denmark*

Seaweed was a previously untapped resource and is currently gaining increasing attention for its potential as biorefinery feedstock. In this emerging field of seaweed biorefinery, scientific production started in 2009 and has been rising at a fast pace with an annual growth rate of 17.49%, as shown by our bibliometric analysis[1]. The results of the keyword co-occurrence analysis based on the same bibliographic collection reveal a continued research interest in the fermentation process and a growing interest in extracting biomolecules with unique functional properties. The former is presumably due to the variety of the products derived from the fermentable sugars in seaweed biomass (e.g., biofuels, bioplastics, etc.) and the versatility of the products (e.g., succinic acid as a platform chemical), which can improve the economic viability of biorefinery businesses. The latter is likely to be driven by favorable market conditions, e.g., growing demand and prospects for market entry. Besides, there is a tendency of expanding existing phase I biorefinery systems to the multiple-line production system. Side (waste)-stream valorization through improved biomass utilization may result in increased environmental performance and economic value creation. This presentation provides an overview of progress in this research field by demonstrating a catalog of top value-added seaweed biorefinery products and cascading biorefinery designs.

## PP 06

### Metabolic induction, a powerful tool to enhance the chemodiversity of macroalgae cell culture

**Erwan Le Gélébart**[*1], François Vauchelles[1], Maëva Menguy[1], Lucas Best[1], Coralie Hamon[1], Rémi Laville[1]
[1] *Innovation Direction, BiotechMarine-SEPPIC, France*

Today, only few macroalgae are of an economic interest whereas it exists about 800 species on Brittany's coast. These macroalgae are relatively poorly studied and valorized. One of the reasons is the low accessibility of the biomass as some species are not so abundant and it's not always possible to cultivate them. Cosmetics active market is a very competitive world, ingredients must be both innovative and efficient. To answer this demand we decided to valorize rare and poorly known species by developing a technique to culture macroalgae cells. This requires to isolate macroalgae cells from natural samples, to keep these macroalgae at cell state during the entire process, to perform the scale-up to reach industrial scale. By using our macroalgae cell culture technique we produce biomass in a sustainable way allowing extraction of interesting compounds for cosmetic actives development. In order to increase the chemodiversity and/or the amount of active compounds available from the obtained biomass, macroalgae cells are grown under stressing conditions. Growth kinetics are monitored in order to select physical or chemical stressors which allow us to produce differentiating phytochemical compounds while maintaining biomass production. Metabolomics is the scientific field concerned with the study of naturally occurring, low molecular weight organic metabolites within a cell, considered to provide a direct "functional readout of the physiological state" of an organism. Differences between control and stressed conditions were observed using high-throughput analyzers such as GC-MS and LC-MS. Data are analyzed to highlight the expression of particular metabolic pathways. Overproduction of compounds helps us to choose the best conditions to produce macroalgae cells biomass with interesting cosmetic active potential. This technology gives us access to an entire segment of biodiversity which remains unexplored today to give birth to very innovative and sustainable cosmetic active ingredients.

## PP 08

### Neuroprotective activities of Malaysian agarophyte: *Gracilaria manilaensis* Yamamoto & Trono with cholinesterase and nitric oxide inhibitory activities

**Yoon Yen Yow**[*1], Jun Rui Pang[1], Sher Wei How[1], Siew Moi Phang[1], Kah Hui Wong[1]
[1] *Department of Biological Sciences, Sunway University, Malaysia*
[2] *Institute of Ocean and Earth Sciences, University of Malaya, Malaysia*
[3] *Institute of Biological Sciences, University of Malaya, Malaysia*
[4] *Department of Anatomy, University of Malaya, Malaysia*

*Gracilaria* spp. are the well known agar and carrageenan producers for the food industry. *Gracilaria manilaensis* Yamamoto & Trono is one of the commonly cultivated red algae in Malaysia which has gradually received attention. Yet, its potential to the human neuronal health was not known. In this study, the hot aqueous, methanol and ethanol extracts of *G. manileansis* were prepared through tincture. The neuroprotective potential in terms of cholinesterase inhibitory activities was investigated through Ellman assay, whereas the nitric oxide inhibitory activity of lipopolysaccharide-stimulated RAW264.7 macrophage cell line was assessed through Griess assay, respectively. All the extracts showed significant positive inhibitory activity against acetylcholinesterase but not butyrylcholinesterase. Methanol extract showed the highest anti-acetylcholinesterase activity with average EC50 of 2.6 ± 0.16 mg/mL and mixed-inhibition pattern. Simultaneously, methanol and ethanol extracts showed potent nitric oxide inhibitory activity, while hot aqueous extract promoted the nitric oxide production of RAW264.7 cell instead. Our results suggested that *G. manilaensis* may serve as a potential source of functional food and nutraceutical for neuronal health.

## PP 09

### Bioactivity of different polarities of *Sargassum crystaefolium* extracts on human mammary carcinoma cell line MCF7

**Yunianta Yunianta**[*1], Yenny Risjani[2]
[1] *Agricultural Product Technology, University of Brawijaya, Indonesia*
[2] *Aquatic Ressources Management, University of Brawijaya, Indonesia*

The bioactivity of different polarities of *Sargassum crystaefolium* extract was investigated using breast cancer cell line MCF7. The IC50 was investigated by a colorimetric 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (MTT) assay and showed that the IC50 value of n-hexane; ethyl acetate, n-butanol and methanol extract fraction were 15,4 ppm, 17,91 ppm, 10,55 ppm, 14.28 ppm respectively. Analysis using confocal laser scanning microscope showed that there was a significant impact on the induction of caspase 3 activity related to the apoptosis and on the Ki67 activity related to the proliferation process of MCF7 cell line. Flowcytometry analysis showed that different polarities extract fraction of S. crystaefolium could inhibited the proliferation of MCF7 cell and increased caspase 3 activity that finally induced the apoptosis of MCF7 cell significantly. The addition of 15,4 ppm of n-hexane fraction; 17,91 ppm of ethyl acetate fraction; 10,55 ppm of n-butanol fraction and 14.28 ppm of methanol fraction could caused apoptosis of MCF7 cell up to 7,84%; 23,99%; 31,38% and 19,66% respectively.

## PP 10

### The variation of floridoside and isofloridoside of *Pyropia haitanensis* response to stress by high performance liquid chromatography-mass spectrometry

**Juanjuan Chen**[*1], Jiali Zhao[1], Haimin Chen[1], Rui Yang[1], Qijun Luo[1], Xiaojun Yan[1]
[1] *School of marine sciences, Ningbo University, China*

*Pyropia* is exposed to a variety of environmental stresses including high and low temperatures, desiccation, light, and osmotic stress. Floridosides has a variety of functions and participates in the regulation of intracellular osmotic pressure. Hence, it was worthy to understand the relationship between the variantion of floridosides of *Pyropia haitanensis* and stresses. The results showed that: (1) Comparing to the control group (cultured temperature set at 20 ℃), the contents of floridoside and isofloridoside increased at 25 ℃ about 3.01 and 1.34 times; while as the temperature continued increase to 28 and 35℃, the contents begun to reduce, about 1.20 and 0.64 times for floridoside and 0.97 and 0.83 times for isofloridoside. (2) As stimulated by different salinity (the salinity 25 used as control), the contents of floridoside and isofloridoside were all decreased lower than those of control about 0.05 mg/g and 0.38 mg/g, respectively. While as the salinity increased to 80, the contents of them both increased and reached the maximum 0.03 and 0.09 mg/g at salinity 50. And then the contents gradually reduced to minimum 0.006 and 0.02 mg/g at salinity 80, respectively. After stimulated by salinity, the recovery procedure was proceeding for 3 h. The contents of floridoside and isofloridoside were dramatically increased. Especially at salinity 50, the contents of flrodisode and isofloridosde were increased about 1.96 and 1.59 times higher than those in control. (3) In the desiccation experiment, the content of floridoside decreased with the dry time at 1 h, and then gradually increased higher than control at 6 h; while the contents of isofloridoside were all lower than that in control. In all, it could be suggested that floridosides could response to environmental stress rapidly, and the variation of floridoside was more sensitive than that of isofloridoside.

## PP 11

### Preparation and identification of antioxidant peptides from protein hydrolysate of marine alga *Gracilariopsis lemaneiformis*

**Xiaoqian Zhang**[*1], Dequn Cao[1], Xue Sun[1], Xinping Chen[2], Nianjun Xu[1]
[1] *Department of Marine Sciences, Ningbo University, China*
[2] *Medical Center, Vanderbilt University, United States of America*

*Gracilariopsis lemaneiformis* is protein-enriched, which makes it a potential source of antioxidant peptides. However, there is still no report about the antioxidant activity of the peptides obtained from *G. lemaneiformis*. In this experiment, marine alga *G. lemaneiformis* proteins were hydrolysed by α-chymotrypsin to prepare antioxidant peptides. Comparing with other hydrolysates, α-chymotrypsin hydrolysates displayed the highest antioxidant activity. The hydrolysis conditions of α-chymotrypsin were further optimized using response surface methodology (RSM), and the optimal conditions were as follows: substrate concentration 10 mg/mL, reaction time 2.0 h, enzyme/protein ratio (E/S) 1.9%, temperature 46.4 ℃ and pH 9.2. After fractionated and separated by ultrafiltration, gel exclusion chromatography and reversed-phase high performance liquid chromatography, an antioxidant peptide was purified and identified as Glu-Leu-Trp-Lys-Thr-Phe by UPLC-MS/MS. The results also confirmed that Glu-Leu-Trp-Lys-Thr-Phe could significantly scavenge the DPPH free radicals with an EC50 value of 1.514 mg/mL. It seemed that the smaller molecular size and hydrophobic and/or aromatic amino acids in its sequence contributed to its antioxidant activity. Thus, *G. lemaneiformis* protein hydrolysate may be a good source of natural antioxidants.

## PP 12

### Antioxidant activities of *Hizikia fusiforme* by extraction methods

**Youn-Ji Lee**[*1], Won-Suk Kim[2], You-Jin Jeon[3], Yong-Tae Kim[1]
[1] *Food Science and Biotechnology, Kunsan National University, Republic of Korea*
[2] *Pharmaceutical Engineering, Division of Bioindustry, Silla University, Republic of Korea*
[3] *Marine Life Sciences, Jeju National University, Republic of Korea*

*Hizikia fusiforme* is a kind of seaweed and richly contains protein, carbohydrates, vitamins, and minerals. It cleans the blood, interferes with the generation of active oxygen, and prevents constipation with rich dietary fiber in it. Also, it helps prevent adult diseases such as hypertension and arteriosclerosis and different kinds of cancer like intestinal cancer. In this study, antioxidant and physiological activities of extracts from *Hizikia fusiforme* with two different extraction methods (70% ethanol extraction and high pressure extraction) were investigated. The yield of *Hizikia fusiforme* extract by the method of high pressure extraction showed higher value, 45.62% (w/v). The amounts of substances related to polyphenol content was higher in 70% ethanol extract (13.04 mg/g), whereas flavonoid content was higher in high pressure extract (9.3 mg/g). The ABTS and DPPH radical scavenging activities of the 70% ethanol extract were 97.4% and 30.9% at 5 mg/mL, respectively, which were higher than those of the high pressure extract. The reducing power of 70% ethanol extract was higher than that of high pressure extract. The 70% ethanol extract had relatively high antioxidant activity. These results suggest that extracts of Hizikia fusiforme have a potential to act as functional materials, and 70% ethanol extractions are superior to high pressure extraction for enhancement of the antioxidant activity. We are currently investigating further the antioxidant and physiological activities of those extract, and also attempting to identify the substances that have antioxidant and physiological activities.

## PP 13

### Protective effect of phloroglucinol on oxidative stress-induced dna damage and apoptosis through activation of the Nrf2/HO-1 signaling pathway in HaCaT human keratinocytes

**Yung Hyun Choi**[*1], Cheol Park[2], Hee-Jae Cha[3], Suhkmann Kim[4], Heui-Soo Kim[5], Gi-Young Kim[6], You-Jin Jeon[6]

[1] *Department of Biochemistry, Dongeui University College of Korean Medicine, Republic of Korea*
[2] *Department of Molecular Biology, Dong-eui University, Republic of Korea*
[3] *Department of Parasitology and Genetics, College of Medicine, Kosin University, Republic of Korea*
[4] *Department of Chemistry, College of Natural Sciences, Pusan National University, Republic of Korea*
[5] *Department of Biological Sciences, College of Natural Sciences, Pusan National University, Republic of Korea*
[6] *Department of Marine Life Sciences, School of Marine Biomedical Sciences, Jeju National University, Republic of Korea*

Phloroglucinol (PG) is a component of phlorotannins, which are abundant in marine brown alga species such Ecklonia cava. Recent studies have shown that PG has beneficial effects in protecting cells against oxidative stress by eliminating oxygen radicals. In this study, we evaluated the protective efficacies of PG in oxidative stress (hydrogen peroxide, H2O2)-stimulated HaCaT human skin keratinocytes. Treatment of HaCaT cells with PG before H2O2 treatment significantly inhibited the H2O2-induced reduction of cell viability in a dose-dependent manner. Excessive ROS production, DNA damage and apoptosis induced by H2O2 were also remarkably reversed by PG in HaCaT cells. In addition, H2O2-induced mitochondrial dysfunction was related to a decrease in ATP levels, and these changes were also significantly attenuated in the presence of PG. Furthermore, PG-mediated cytoprotective properties were associated with increased expression of nuclear factor erythroid 2-related factor-2 (Nrf2) and heme oxygenase-1 (HO-1); however, the inhibition of HO-1 function using an HO-1 specific inhibitor significantly weakened the cytoprotective effects of PG. Collectively, the results demonstrate that PG is able to defend HaCaT keratinocytes against oxidative stress-induced DNA damage and apoptosis through activating the Nrf2/HO-1 signaling pathway.

## PP 14

### On suppression of postprandial blood glucose level in mekabu (Sporophylls of *Undaria pinnatifida*) in young women

**Shori Takano**[*1], Kazuma Yoshizumi[2], Hitomi Kobayashi[1], Naoki Iwamoto[3], Takehiko Kaneko[1], Masaki Taga[1]

[1] *Human Ecology, Wayo Women's University graduate school, Japan*
[2] *Product Planning, KANERYO Sea Vegetable CORP., Japan*
[3] *Food and Nutrition, Tokyo Kasei Gakuin University, Japan*

Postprandial blood glucose level is assumed to be controllable for patients with hyperglycemia and even those with severe diabetes. Many reports on postprandial blood glucose suppression effect in seaweed extract have been reported. However, it has been found that there is little effect of postprandial blood glucose suppression by eating raw mekabu (*Sporophyll of Undaria Pinnatifida*). Therefore, we aimed to examine the effects of postprandial blood glucose level suppression and the secretion of blood glucose control related hormone by meal supplementation in healthy subjects. Seven young Japanese females aged 20 years or older (21.4 ± 0.9 years old) who were not identified as impaired by glucose tolerance were selected. Three trials were conducted every two weeks. The group was divided into three groups: white rice group, white rice + mekabu group and white rice + cabbage group. Subjects ingested mekabu or cabbage 5 minutes before ingested white rice. Five blood samples were taken from the brachial vein at the time of fasting (0 min) and after ingesting the test meal (30, 60, 90, 120 min). Glucose levels, insulin, GLP-1, TG and pancreatic amylase were measured. In the blood glucose incremental areas under the curves (AUC), the mekabu group was significantly lower than that of white rice group. When GLP-1 was evaluated by AUC, GLP-1 AUC tended to be higher in the mekabu group than in the white rice group. The results suggest that ingesting mekabu before white rice suppresses the postprandial blood glucose level and improves postprandial glycemic control. We think that these effects are caused by fucoidan and alginic acid contained in the mekabu. The increase in secretion of GLP-1 is thought to be due to water-soluble dietary fiber contained in mekabu.

## PP 15

### Development of fermentation foods from seaweeds

**Motoharu Uchida**[*1], Nobuo Hideshima[2], Toshiyoshi Araki[3]

[1] *National Research Institute of Fisheries and Environment of Inland Sea, Fisheries Research and Education Agency, Japan*
[2] *General Counsel, Maruhide Shoyu Co., Ltd., Japan*
[3] *Community-University Research Cooperation Center, Mie University, Japan*

Fermentation has over 7,000-years history. However, few studies are conducted for obtaining foods from seaweeds. This paper introduces four topics of seaweed fermentation studies using lactic acid bacteria (for developing seaweed sauce), yeast (seagrass beer), mold (koji) and bacilli (nasso). 1) Seaweed sauce: Origin of fermented sauce is high-salt content gravy products, which has over 3000-years history. Fermented sauce products are usually produced from soy and fish, but that from seaweed have not been developed. Recently, the authors have developed a high-salt content seaweed sauce from nori, *Pyropia yezoensis* using enzymatic degradation and fermentation processes. The nori sauce does not contain any allergens originated from cereals. 2) Seagrass beer: Study to produce bio-ethanol from seaweeds is a recent topic. However, polysaccharides contained in seaweeds are not suitable for preparing bio-ethanol and only limited quantity of ethanol (usually, ca. 1% v/v) can be produced. The authors produced 16.5% concentration of ethanol from seagrass seeds. The ethanol products are more expected to be utilized as alcohol beverages (beer) rather than biofuel. 3) Seaweed koji: Koji is a traditional fermentation culture product which is commonly used in the manufacture process of Japanese fermented products and promote enzymatic degradation. Koji is usually prepared by culturing a mold on cereals such as soybean or rice. The authors prepared the koji by culturing a mold *Aspergillus oryzae* on seaweed nori, and applied to nori sauce manufacture. 4) Nasso: Natto is a common food in Japan prepared with soybean by fermentation with *Bacillus subtilis*. A study is going on to develop similar products (nasso) from nori by fermentation with bacilli.
Development of novel foods are going on from seaweed fermentation. It will open new marine fermentation industries and contribute to a wise utilization of seaweed resources. This work was supported by the BRAIN.

## PP 16

### Prevention of diet-induced obesity by red edible seaweed *Eucheuma denticulatum* In Vivo

**Vimala Balasubramaniam**[*1], Nurul Aznyda Norizan[1], Ezarul Faradianna Lokman[1], Hussin Muhammad[2], Aswir Abdul Rashed[1], Mohd Fairulnizal Mohd Noh[1]

[1] *Cardiovascular, Diabetes & Nutrition Research Centre, Institute For Medical Research, Malaysia*
[2] *Herbal Medicine Research Centre, Institute for Medical Research, Malaysia*

*Eucheuma denticulatum* is a red edible seaweed found in the east coast of Malaysia. It is one of the primary sources of iota carrageenan that has commercial value and usually exploited for food and cosmetic products. This seaweed has shown to promote potential health benefits. The present work aimed to assess the anti-obesity effect of *E. denticulatum* freeze dried powder supplemented with high-fat diet (HFD) on in vivo model. Male Sprague Dawley rats aged 6-7 weeks (weighing 220-250g) were divided into six groups (n=6 per group) according to the following diet; normal diet group (ND), high fat diet group (HFD), HFD with orlistat (50 mg/kg) (HFD+OR), HFD with 10% seaweed (HFD-1), HFD with 15% seaweed (HFD-2) and HFD with 20% seaweed (HFD-3). Each group was fed for 8 weeks ad libitum and food intake was measured. At the end of the nutritional period, the rats were sacrificed. Blood was collected for determination of lipids and glucose, as well as amino transaminase, insulin, plasma ghrelin and leptin levels. Adipose and liver tissues were subjected to histological analysis. *E. denticulatum* fed rats significantly ($p<0.05$) reduced weight gain, adipose tissue mass, triglyceride, low-density lipoprotein, liver enzymes and leptin while improving ghrelin level relative to the HFD fed rat. Food intake did not differ between the HFD only and HFD-seaweed supplemented groups. Histological examination showed that the sizes of the adipocytes were significantly smaller in the HFD-seaweed fed groups as well as decreased lipid droplets in the liver compared with the HFD group. *E. denticulatum* effectively attenuates weight gain independent of food intake and improving its related biomarkers, highlighting the potential of *E. denticulatum* in obesity prevention.

## PP 18

### Antioxidant and prebiotic properties of polysaccharide fractions from *Ulva pertusa* by microwave-assisted aqueous two-phase extraction

**Sangmi Sun**[*1], Bao Le[1], Seung Hwan Yang[1]

[1] *Department of Biotechnology, Chonnam National University, Republic of Korea*

*Ulva pertusa* is one of main "green tide" forming seaweeds which naturally rich source of active polysaccharides. In this study, different fractions of polysaccharide from *U. pertusa* were prepared and evaluated its effect. Microwave-assisted aqueous two-phase extraction technology was employed to improve polysaccharides extraction yield and properties. The impacts of four independent variables, including the extraction time, power and pH were selected and investigated through an experimental response surface methodology (RSM) design. The chemical structure of polysaccharides was investigated via FT-IR assay. The results showed that the extraction time of 44 min, 600 W, pH 6.5 has the highest antioxidant activities. The relationship between the molecular weight of polysaccharides and its effect was investigated. Furthermore, there was a significant correlation between the prebiotic properties and molecular weight of polysaccharides. Therefore, the optimal process of this study provides the new strategy effectively to produce the antioxidant and prebiotic compounds from *Ulva pertusa*.

## PP 19

### Polyelectrolyte complexes of red algal galactans and chitosan

**Rando Tuvikene**[*1], Marju Robal[1]

[1] *School of Natural Sciences and Health, Tallinn University, Estonia*

Many gel-forming or viscous marine polysaccharides are used extensively in industry as thickeners and gelling agents. Besides their texturizing properties such polysaccharides often exhibit diverse biological activities, such as anticoagulant, antiviral, antitumor activity and are thus important in various medical applications. Carrageenans are sulphated polysaccharides from red algae and represent a group of structurally versatile anionic galactans. Chitosan is one of a few natural polysaccharides with a cationic nature and can be obtained by alkaline deacetylation of chitin. Both of these hydrocolloids show various functional properties and can be thus employed in many applications, e.g. in food and cosmetic industry. Obtaining water soluble galactan-chitosan polyelectrolyte complexes may further expand their application due to the combination of the beneficial properties of these polysaccharides. In this study the water-soluble polyelectrolyte complexes between chitosan preparations with different acetylation degrees and various algal galactans (kappa, iota, lambda carrageenan, furcellaran, funoran) were obtained by carefully choosing the experiment conditions. The polysaccharides were characterized by NMR, FTIR, FT-Raman spectroscopy and size exclusion chromatography methods. Viscoelastic properties of the complexes were measured in the presence of various counter-ions. Antioxidant activities of the galactan-chitosan polyelectrolyte complexes were characterized by DPPH, ABTS, hydroxyl radical scavenging and FRAP assays; immunomodulating properties were evaluated by the peritoneal macrophage activation. Anticoagulant activities were tested by prolongation of APTT and TT. Antibacterial activities were estimated by the growth inhibition of bacterial strains from the Staphylococcus, *Escherichia* and *Pseudomonas* genera. To prepare water soluble sulphated galactan-chitosan complexes, the molecular weight of one component must be lowered to prevent the formation of precipitation. For galactan-chitosan complexes the gelling capacity and biological activities were found to be synergistically enhanced compared to the respective characteristics observed for pure forms of these polysaccharides.

## PP 20

### Tuberatolide B protects LPS-stimulated inflammatory response in RAW264.7 cells and zebrafish model through inhibiting MAPKs and NF-kB signalings

**Eun-A Kim**[*1], Junseong Kim[1], Nalae Kang[1], Soo-Jin Heo[1]

[1] *Jeju Marine Research Section, Korea Institute of Ocean Science & Technology, Republic of Korea*

Brown algae are known to contain rich anti-inflammatory compounds. The objective of this study was to identify anti-inflammatory compound in the Sargassum macrocarpum and anti-inflammatory effect of tuberatolide B (TTB) was investigated. RAW 264.7 cells were seeded on the well plates. After 16 h, cells were treated with TTB incubated and subsequently treated with LPS. After 24 h, we measured cell viability and NO production using MTT or griess regents, and inflammatory cytokines using ELISA kit as well as signaling pathways by western blotting in in vitro cell experiment. Zebrafish embryos were transferred to the well plate. At 7-9 hpf, TTB and LPS were added to the well. We are confirmed NO production and cell death using DAF-FM-DA or acridine orange solution in in vivo zebrafish experiment. TTB significantly suppressed the production of NO and pro-inflammatory cytokines such as interleukin (IL)-6 and IL-1β.

In addition, the mechanism involved in the inhibition of the inflammatory effect of LPS by TTB was investigated. The results showed that TTB aforementioned this effect through NF-κB and MAPKs phosphorylation pathways. We also assessed the anti-inflammatory activity of TTB using in vivo zebrafish model. In LPS-stimulated zebrafish, TTB enhanced survival and significantly inhibited the NO production and mRNA expression of inducible NO synthase. Anti-inflammatory activity of TTB against LPS in RAW264.7 cells and the zebrafish model was determined. These finding suggest that TTB may be used as functional anti-inflammatory foods and nutraceuticals.

## PP 21

### *Stichopus japonicus* suppresses inflammatory and cancer progression by promoting ROS-mediated inhibition of MAPK signaling

**Junseong Kim**[*1], Eun-A Kim[1], Narae Kang[1], Do-Hyung Kang[1], Soo-Jin Heo[1]
[1] *Jeju Marine Reseaecher section, Korea Institute of Ocean Science & Technology, Republic of Korea*

Sea cucmbers are used in formulation of traditional medicine in east asia and it was known that it exhibits different activities depending on the habitat. Therefore, in this study, we confirmed the anti-inflammatory and anti-cancer effect of red sea cucumber (*Stichopus japonicus*) from Jeju Island. We obtained a vacuum dried *S. japonicas* extracts (VDSEs) by treatment with MeOH or MeOH/DCM (2:1) and a vacuum-dried *S. japonicus* extracts by treatment with 70% methanol (VD-M). VDSEs and VD-M used experiment to ROS generation and protein expression. Both extractions showed inhibition of NO production without toxicity. And VDSEs significantly inhibited PGE2, protein level of iNOS and COX-2 as well as pro-inflammatory cytokines such as IL-6, IL-1β, and TNF-α at 20 and 50 μg/ml. VDSEs suppressed the phosphorylation of mitogen-activated protein kinase (MAPK) pathway molecules such as ERK, JNK, and p38 also reduced ROS generation. Our results demonstrated that *S. japonicas* extracts using different extraction methods presented anti-inflammatory activity by inhibiting MAPKs and ROS generation. VD-M showed inhibition of tumor cell growth and induced increased ROS generation which is associated with the induction of apoptosis though mitogen-activated protein kinase (MAPK) pathway in murine colon carcinoma cells (CT-26). The combination of VD-M and N-acetylcysteine (NAC), a ROS scavenger, increased ROS production and apoptosis compare with non-treated group via regulation MAPKs pathway on ERK and JNK. Thus, VD-M promotes ROS mediated suppression of ERK and JNK signaling and inhibits cancer progression. Therefore, VDSEs can be used and applied as a useful anti-inflammatory agent, and VD-M could be a beneficial and useful for treating colon carcinoma.

## PP 22

### Saringosterol acetae inhibits liver cancer progression Via PI3K/Akt/mTOR signaling in a zerafish xenograft model

**Eun-A Kim**[*1], Junseong Kim[1], Nalae Kang[1], You-Jin Jeon[2], Soo-Jin Heo[1]
[1] *Jeju Marine Research Section, Korea Institute of Ocean Science & Technology, Republic of Korea*
[2] *Marine Life Sciences, Jeju National University, Republic of Korea*

*Hizikia fusiforme* has been found to possess a number of potential biological functionalities but just a few reports have revealed for the relationship between activities and compounds. The zebrafish model system is one of the most widely used animal models. That is attaining popularity as becomes an attractive model for molecular genetics, developmental biology, drug discovery and screening of human disease. In this study, we established that inhibition of liver cancer progression effects was occurred in human cancer cell xenograft zebrafish model. The zebrafish were injected with saringosterol acetate (SSA) isolated from Hizikia fusiforme (2 μg/g or 5 μg/g) once every three days. After a week, the abdominal cavity of zebrafish was inoculated with Hep3B cells during ten times a month. Angiogenic factors (VEGF, TGFβ, MMP2, MMP9, IL6, and TNF-α), and α-fetoprotien (AFP) production were significantly increased in HepB cells-injected group compared with normal group. However, SSA considerably inhibited angiogenic factors and AFP production. Further mechanistic studies showed that SSA-injected group suppressed TGFβ pathways and phosphorylation of PI3k/Akt/mTOR pathways in the liver tissues treated with SSA at 5 μg/g concentration. This model can be used as an in vivo experiment to confirm the inhibition of liver cancer progression. SSA can be used and applied as a useful anti-cancer agent of nutraceutical or pharmaceutical.

## PP 23

### 5-bromoprotocatechualdehyde suppresses lung cancer growth through regulation of ROS and the AKT/MAPKs signaling pathway in human lung cancer cells

**Junseong Kim**[*1], Eun-A Kim[1], Nalae Kang[1], Do-Hyung Kang[1], Soo-Jin Heo[1]
[1] *Jeju Marine Reseaecher section, Korea Institute of Ocean Science & Technology, Republic of Korea*

Early asymptomatic lung cancer has the highest mortality rate in cancer. Therefore, we investigated anti-cancer activity of 5-bromoprotocatechualdehyde (BPCA) from polysiphonia morrowii Harvey (P. morrowii) in lung cancer H460 lung cancer cells. Dried P. morrowii powder was extracted thrice with 80% aqueous methanol at room temperature. The extract was separated using HPLC and the chemical structure was confirmed 1H and 13C NMR date. BPCA identified the anti-cancer activity by cell viability, apoptotic assay, ROSgeneratiom and protein expression. BPCA showed inhibition of tumor cell growth and induced decreased ROS generation which is associated with the induction of apoptosis though mitogen-activated protein kinase (MAPK) pathway and AKT signaling in lung cancer cells. The combination of BPCA and hydrogen peroxide (H2O2), increased ROS production and apoptosis compare with non-treated group via regulation of AKT signaling and JNK MAPKs pathway. The result of the present study demonstrated that BPCA induced lung cancer cell death through ROS-mediated phosphorylation of AKT/MAPK signaling. Therefore, BPCA could be a beneficial and useful for treating lung cancer.

## PP 24

### Beneficial effects of Ishophloroglucin a from *Ishige okamurae* on obesity in leptin deficient obese mice

**Nalae Kang**[*1], Eun-A Kim[1], Junseong Kim[1], You-Jin Jeon[2], Soo-Jin Heo[1]
[1] *Jeju Marine Research Section, Korea Institute of Ocean Science & Technology, Republic of Korea*
[2] *Department of Marine Life Sciences, Jeju National University, Republic of Korea*

Leptin resistance commonly defined by the failure of leptin signal on

central nervous system is considered as the primary risk factor for the pathogenesis of overweight and obesity. This study investigated the anti-obesity effects of Ishophloroglucin A (IPA) from *Ishige okamurae* as a new leptin substitute. IPA (2.5 mg/kg) was orally injected to C57BL/6J-ob/ob mice, a leptin deficiency model, for 6 weeks, and leptin (0.85 mg/kg) was intraperitoneal (IP) injected to the mice as positive control. In results, IPA treatment reduced the body weight and fat mass as well as food intake. Also, it reduced the total cholesterol and triglyceride level. Moreover, IPA treatment stimulated the leptin signaling pathway by acting as leptin substitute in hypothalamus of brain, and activated the insulin signaling pathway inhibited by leptin deficiency in peripheral organs including liver and muscle. Finally, IPA treatment reduced the size of visceral (VIS), subcutaneous (SQ), and periaortic (Peri) adipose tissue. In conclusion, these results present that IPA from I. okamurae is of value as a new leptin substitute regulating leptin/insulin signaling pathway in obese status.

## PP 25

### Ishophloroglucin a from *Ishige okamurae* alleviates the high fat diet-induced obesity through leptin signaling pathway on peripheral metabolism

**Nalae Kang**[*1], Eun-A Kim[1], Junseong Kim[1], You-Jin Jeon[2], Soo-Jin Heo[1]

[1] *Jeju Marine Research Section, Korea Institute of Ocean Science & Technology, Republic of Korea*
[2] *Department of Marine Life Sciences, Jeju National University, Republic of Korea*

Leptin, well known as an appetite hormone, plays a role in fat metabolism on peripheral tissues including adipose, liver, and muscle tissues. In here, we investigated the anti-obesity effects of Ishophloroglucin A (IPA) from *Ishige okamurae* through leptin signaling pathway on peripheral metabolism of a high fat diet obese mice model. C57BL/6J obese mice model were organized by feeding high fat diet for 6 weeks and IPA (2.5 mg/kg) was orally treated for 4 weeks. After finishing the experiment, the several serum biochemical parameters were measured using ELISA or test kit, and the white adipose, liver, and muscle tissues were observed using immunohistochemistry methods. As a result, IPA treatment reduced the body weight, the circulating leptin level, total cholesterol, triglyceride, GOT, and GPT levels increased by high fat diet. Also, IPA treatment activated various leptin signaling pathways including Janus kinase 2 (JAK2)-signal transducer and activator of transcription (STAT), mechanistic target of rapamycin (mTOR)-ribosomal S6 kinase (S6K), and SH2-containing protein tyrosine phosphatase 2 (SHP2)-extracellular signal-regulated kinases (ERK) in the peripheral tissues. Moreover, IPA treatment reduced the adipose tissue size, and alleviated the steatosis in liver and muscle tissues. In conclusion, these results indicate that IPA, the specific phlorotannins from *I. okamurae*, regulates obesity through the leptin signaling pathway on peripheral metabolism of obese mice fed with a high fat diet.

## PP 26

### The effect of fucoidan from brown algae reduces migration on human head and neck squamous cell carcinoma cells

**Yu-Chen Chen**[*1], Shye-Jye Tang[1]

[1] *Department of Bioscience and Biotechnology, National Taiwan Ocean University, Taiwan*

Fucoidan is a complex of polysaccharides containing substantial percentages of L-fucose and sulfate ester groups, mainly derived from brown algae. Fucoidan is demonstrated to inhibit proliferation and metastasis in breast cancer, colorectal cancer, prostate cancer, and lung cancer, showing that the polysaccharide may increase the prognosis survival in cancers. Head and neck squamous cell carcinoma (HNSCC) is one of the world top ten most common cancers with its highest occurrence, highly malignant and metastasis. The epithelia to mesenchymal transition is involved in wound healing, organ fibrosis and the initiation of metastasis in cancer progression. This study aimed to evaluate the efficacy of fucoidan as a chemo-target agents to suppress metastasis in HNSCC cells. Fucoidan was prepared from *Sargassum hemiphyllum* as well as *Laminaria japonica* and characterized by HPLC and FTIR. Contents of sulfate and polysaccharide from two brown algae by hot water extraction was observed different ratio, and trypsin might improve the efficient of extraction.. Fucoidan was not found cytotoxic activity in SAS and FaDu cells, whereas viability of OECM1 cells were decreased after 48 h treatment of fucoidan. Cell migration of HNSCC cells was suppressed after fucoidan treatment. The expression of Zeb1 and vimentin was increased by fucoidan, showing that unusual effects were elicited by fucoidan in EMT pathway. After HNSCC cells treated with fucoidan for 0, 3, 6, 12 and 24 hours, phosphorylation of Akt(Ser473)and GSK3β were reduced leading to decrease of β-catenin. Our findings demonstrate that fucoidan may reduce the activation of AKT to promote the activity of GSK3αβ leading to inhibiting cell migration of HNSCC.

## PP 27

### Korean marine microalgae with biotechnological potential: a review

**Ji Won Hong**[*1], Nam Seon Kang[1], Hyeong Seok Jang[1], Hyung June Kim[1], Yong Rock An[2], Hyung Seop Kim[3]

[1] *Department of Taxonomy and Systematics, Marine Biodiversity Institute of Korea, Republic of Korea*
[2] *Department of Exhibition and Education, Marine Biodiversity Institute of Korea, Republic of Korea*
[3] *Department of Marine Biotechnology, Kunsan National University, Republic of Korea*

Marine microalgae have long been used as food additives and feeds for juvenile fish and invertebrates as their nutritional values are desirable for humans and marine aquaculture species. Recently, they have also been recognized as a promising source for cosmeceutical, nutraceutical, and pharmaceutical products as well as biofuels. Marine microalgae of various species are rich in multiple anti-oxidant phytochemicals and their bioactive components have been employed in cosmetics and dietary supplements. Oil contents in certain groups of marine microalgae are extraordinarily compelling and therefore have been commercialized as omega-3 and omega-6 fatty-acid supplements and mass production of microalgae-based biodiesels has been demonstrated by diverse research groups. Numerous natural products from marine microalgae with significant activity are reported yearly and this is attributed to their unique adaptive abilities to the great diversity of marine habitats and harsh conditions of marine environments. Previously unknown toxin compounds from red tide-forming dinoflagellates have also been identified which opens up potential applications in the blue biotechnology sector. This poster presentation provides a brief overview of the biotechnological potentials of Korean marine microalgae. We hope that this review poster will provide guidance for future marine biotechnology R&D strategies and the various marine microalgae-based industries in Korea.

## PP 28

### Microanalysis of uronic acid monomers and oligomers by high performance liquid chromatography with fluorimetric detection

**Hirotaka Kakita**[*1], Shouhei Seki[2,3], Shougo Hiraga[3], Haruyoshi Ishijima[3], Naoki Yanaoka[1]

[1] *Graduate School of Integrated Basic Sciences, Nihon University, Japan*
[2] *Graduate School of Environmental Sciences, Hokkaido University, Japan*
[3] *College of Humanities and Sciences, Nihon University, Japan*

Algal alginates are important resources for a lots of industrial materials. Alginates consist of two uronic acids (i.e. D-mannuronate and L-guluronate). In addition to uronic acid composition, the percentage and configuration of each uronic acid oligomer in polysaccharide molecules are very important determinants of polysaccharide properties. The exact content of uronic acid monomers and oligomers is often an important feature in the study of their functional or biological properties. Uronic acid monomer composition also influences the physical properties of polysaccharide preparations and gels in industry. Alginates rich in L-guluronate form strong but brittle gels, whereas those rich in D-mannuronate are weaker but more flexible. The ratio of D-mannuronate to L-guluronate (M/G ratio) is indicative of the nature of the gel that forms in the presence of divalent cations. Furthermore, the influences of the percentage and configuration of each uronic acid oligomer on biological and physiochemical properties of polysaccharides have also been reported. Effects of each uronic acid ologomer percentage and configuration on polysaccharide physicochemical properties have also been reported. Therefore, a highly sensitive analytical technique for uronic acid monomers and oligomers would be useful for both biological studies and manufacturers' quality control. The aim of this present work was to develop a method for microanalysis of uronic acid monomers and ologomers in normal-phase partition chromatography (NPPC), with postcolumn fluorescence derivatization. Fluorescence measurement was performed at 288 nm for excitation and 470 nm for emission. A linear gradient elution system was found to be a suitable method for the simultaneous microanalysis of uronic acid monomers and oligomers. The proposed method was successfully applied to uronic acid analysis and should prove useful for automated simultaneous microanalysis of uronic acid monomers and oligomers in the hydrolysates of algal alginates.

## PP 29

### Anticoagulant and antioxidant activity of native and alkali treated lambda-carrageenans of different molecular weights

**Kadri Saluri**[*1], Rando Tuvikene[1]

[1] *School of Natural Sciences and Health, Tallinn University, Estonia*

Currently the world has very high demand for alternative bioactive compounds and increasingly the focus is drifting towards marine products. Macroscopic algae are considered a potential source for both pharmacological products and functional foods. Carrageenans are polysaccharides obtained from a variety of red seaweeds, consisting of sulfated galactopyranose units. Current work involved samples extracted from tetrasporophyte of marine seaweed Gigartina skottsbergii. Extracted lambda-carrageenan was alkali treated to obtain theta-carrageenan. Both carrageenans were autohydrolyzed for up to 72 h. The structure was confirmed with vibrational and nuclear magnetic resonance spectroscopy and the molecular weight was determined with size-exclusion chromatography. For each sample a variety of anticoagulant and antioxidant tests were performed. Lambda- and theta-carrageenans of various molecular weights demonstrate bioactivities in both anticoagulant measurements of thrombin time and activated partial thromboplastin time as well as antioxidant activities of various assays. Current work illustrates the potential of lambda-carrageenan for future research in pharmacology and natural product design.

## PP 30

### Biochemical composition and antiviral activity against *Herpes simplex* virus type-1 of enzymatic hydrolysates from *Solieria filiformis* (Gigartinales, Rhodophyta)

**Yolanda Freile-Pelegrín**[*1], Ana Peñuela[1], Nathalie Bourgougnon[2], Gilles Bedoux[2], Daniel Robledo[1]

[1] *Marine Resources, CINVESTAV, Mexico*
[2] *Biotechnologie et Chimie Marine, Université de Bretagne Sud, France*

Seaweeds are an important source of bioactive compounds. In particular, Sulfated polysaccharides from seaweeds have been shown antiviral activity against several known viruses. The complexity of the cell wall in Rhodophyta is a major problem when extracting metabolites. Enzyme-Assisted Extraction (EAE) is an environmentally friendly technique used to improve biological activities of certain metabolites. It is well known that enzymes have high specificity on cell wall maceration during enzymatic hydrolysis treatments. A promising antiviral activity (IC50 <93µg/mL) against *Herpes simplex* virus type-1 of water-soluble extract of *Solieria filiformis* currently produced under IMTA in the Yucatan coast, was recently reported by our group using a protease enzyme. In order to improve previously reported activity, in the present study we used EAE with a combination of different proportions of protease and carbohydrase (1:0 ; 0:1; 1:1; 2:1 and 1:2). The biochemical characterization of the hydrolysates obtained was carried out, together with proteins and sulfate content. Moreover, total sugar was also determined by high-performance anion-exchange chromatography (HPAEC). Antiviral activity was tested on Vero cell lines infected with HSV-1 (MOI= 0.001), incubated for 72 h at 37°C under 5% CO2, after incubation, antiviral activity was evaluated by the neutral red dye method. The highest yield (46.1±1.7%) was obtained using 2:1 protease and carbohydrase proportion. A strong and improved antiviral activity (IC50 <20µg/mL) without cytotoxicity was observed using this proportion. The galactose was the main sugar present and, together the high sulfate content (18%), may explain the increase in the antiviral activity, probably related with a higher carrageenan content. Financial support CONACYT 2015-01-118.

## PP 31

### Valorization of *Chaetomorpha* spp. (Cladophoraceae, Chlorophyta) filamentous seaweed discarded from an IMTA system using a biorefinary concept

**Yolanda Freile-Pelegrín**[*1], Cresencia Chávez-Quintal[1], Tomás Madera-Santana[2], Daniel Robledo[1]

[1] *Marine Resources, CINVESTAV, Mexico*
[2] *Alimentación y Desarrollo, Centro de Investigación en Alimentación y Desarrollo, Mexico*

Carrageenan and agar, important phycocolloids from Rhodophyta, and fucoidan from brown seaweeds, are drawing much attention for their biological activities, as well as novel biomaterials. However,

polysaccharides from Chlorophyta remain largely unexploited. *Chaetomorpha* is a green filamentous seaweed that grows in a wide range of salinities and temperatures. Because of its proliferation it is often reported as nuisance in other seaweed cultures and ordinarily discarded. However, *Chaetomorpha* can represent a promising feedstock for different purposes due to its polysaccharides content. In addition to its sulfated polysaccharide content, Chaetomorpha also contains other interesting structural polymers that should be considered important from an industrial point of view. In the present study, the potential important polysaccharides content from *Chaetomorpha* biomass discarded from an integrated multi-trophic aquaculture (IMTA) system was evaluated using a sequential extraction process with a biorefinery approach. Initial proximal composition of *Chaetomorpha* was determined. A preextraction of dried biomass with dichloromethane/methanol (1:1; v/v) for 24 h removed lipids (1.6±0.1%). From deffated samples, a sulfated polysaccharide with gelling capacity was extracted with water (21.1±1.3%) under specific microwave-assisted extraction (MAE) conditions of heating in closed vessels. The insoluble residue (60.5±0.4%) was then used as raw material to obtain cellulose (44.6±0.5%). The content of sulfates (25.7±1.5%), uronic acids (33.3±2.4%), and the α/β cellulose ratio were determined. Structural characterization of this polysaccharide was also performed using FTIR, NMR, XRay and TGA analyses. From our results, discarded *Chaetomorpha* appears to be potential source of different important polysaccharides.
Financial support CONACYT 2015-01-118.

## PP 32

### Anticancer and immunomodulatory activities of the brown seaweeds *Cystoseira* spp.

**Ahmad Mansur**[*1], Murray Brown[1], Richard Billington[1]
[1] *School of Biological and Marine Sciences, University of Plymouth, United Kingdom*

Brown seaweeds contain numerous bioactive compounds, of which some could be utilised for the treatment of cancers. In this study, we investigated the anticancer and immunomodulation activities of bioactive compounds from three Cystoseira species: *C. tamariscifolia, C. compressa* and *C. crinita* collected from the United Kingdom and Libya.
The biochemicals were extracted from freeze-dried seaweed samples using solvents namely chloroform, methanol and water and then measured using colourimetric techniques. Human leukaemia HL60 and THP-1 cell lines and human prostate cancer PC3 cells, as well as activated M1-like and M2-like macrophages, were exposed *in vitro* to extracts. The cell viability was measured utilising the (3-(4, 5-dimethylthiazolyl-2)-2, 5-diphenyltetrazolium bromide) (MTT) assay. The study of immunomodulatory activity was performed on human macrophage-like cells in the presence of various concentrations of the crude extracts (25 – 250 µg $ml^{-1}$ ). ELISA was used to measure the cytokine TNF-α production by M1-like and M2-like macrophages. *C. crinita* extracts had the highest total polyphenol concentrations of approximately 153.03 ± 15.1 mg $g^{-1}$ DW. *C. compressa* and *C. tamariscifolia* were found to contain 74.71 ± 6.12 mg $g^{-1}$ DW and 102.23 ±1.85 mg $g^{-1}$ DW respectively. Significant anticancer activity of the *C. tamariscifolia* extracts was found with $IC_{50}$ = 2.32 ± 0.21, 24.8057± 3.69 and 23.031 ± 5.04 µg $ml^{-1}$ on HL60, THP-1 and PC3 cell lines respectively. The extracts also exhibited cytotoxicity against M2 activated macrophages with $IC_{50}$ = 87.968 ± 10.87 µg $ml^{-1}$, and *C. crinita* showed an inhibition effect on the cytokine Tumor Necrosis Factor-alpha (TNF-α) production by M1 macrophages. The results reveal that *C. tamariscifolia, C. crinita* and *C. compressa* extracts might be a promising strategy for anticancer therapy and immunomodulation.

## PP 33

### Inhibition of alpha-amylase and alpha-glucosidase activities by *Himanthalia elongata* and the mode of inhibition of alpha-glucosidase

**Suraiami Mustar**[*1], Peter Ian Chater[2], Chris Ward[2], Jeffrey Pearson[2]
[1] *Nutrition Unit, Cardiovascular, Diabetes and Nutrition Research Centre, Institute for Medical Research, Malaysia*
[2] *Faculty of Medical Sciences, The Medical School, Newcastle University, United Kingdom*

Diabetes mellitus is due to a deficiency in insulin secretion by the pancreas or when the body cannot utilise the insulin it produces, causing elevated blood glucose level (hyperglycaemia) in the body. According to the World Health Organisation, the number of people with diabetes has risen to 422 million (8.5%) in 2014 compared to only 108 million (4.7%) in 1980. One of the possible approaches to decreasing postprandial hyperglycaemia is by suppressing the absorption of glucose via the inhibition of α-amylase and α-glucosidase. Pancreatic α-amylase hydrolyses complex starches to maltose and glucose in the lumen of the small intestine while intestinal α-glucosidase converts the maltose and/or sucrose to glucose which can lead to hyperglycaemia. Therefore, the objectives of this study were to determine the inhibition of α-amylase and α-glucosidase by *Himanthalia elongata* whole seaweed powder (homogenate) and extracts containing polyphenols and its mode of inhibition of α-glucosidase. The total polyphenol content (TPC) of the samples was determined using Folin-Ciocalteu's reagent. The inhibition of α-amylase and α-glucosidase was measured using colourimetric methods with 3, 5-dinitrosalicylic acid and 4-nitrophenyl-α-D-glucopyranoside respectively. The mode of inhibition of α-glucosidase was evaluated using the Michaelis-Menten equation and the Lineweaver-Burk plot. Results indicated that *H. elongata* 75% and 50% aqueous acetone extracts contained the highest TPC and the homogenate the least. The homogenate and deionised water extract did not inhibit α-amylase, but the organic solvent extracts inhibited the enzyme effectively (IC50 = 0.53–2.58 mg/ml). However, for α-glucosidase, all the extracts and homogenate inhibited the enzyme, exhibiting mixed-type inhibition for the organic solvent extracts. We conclude that *H. elongata* homogenate/extracts can inhibit carbohydrate-hydrolysing enzymes and therefore show potential as anti-diabetic agents.

## PP 34

### Cultivation of *Spirulina (Arthrospira) maxima* for quality standardization and sustainable biomass production in Jeju Island, Korea

**Taeho Kim**[*1], Won-Kyu Lee[1,2], Yong-Kyun Ryu[1,2], Areumi Park[1], Younsik Jeong[1], Yeonji Lee[1], Soo-Jin Heo[1,2], Chulhong Oh[1,2], Do-Hyung Kang[1,2]
[1] *Jeju Marine Research Institute, Korea Institute of Ocean Science & Technology (KIOST), Republic of Korea*
[2] *KIOST compus, Korea University of Science and Technology(UST), Republic of Korea*

*Spirulina (Arthrospira)* are 3.6B year old cyanobacterium and inhabits in alkaline aquatic ecosystem from freshwater to seawater. As a sustainable primary producers, and have been studied on various aspects centered by bio-industry and environmental bioremediation. *Spirulina* are representative a functional source as a bio-industrial biomass that can be consumed by humans in the world. *Spirulina* are used as dietary supplements not only in the form of a whole food but also in the form of tablet, flake and powder. In this study, *S. maxima* were cultured in the medium with four open raceway ponds (5 ton pond-1) established at Jeju Research Institute in KIOST to identify the stability and safety of chemical

cell components according to the standard rules of Korean Ministry of Food and Drug Safety (MFDS) under serial batch conditions. From March to October 2018 (Lot#1-#3), three culture samples were harvested and analyzed using a tubular separator and AOAC methods.
Biomass production was averaged 0.95±0.25 g/L for the cultivation period. Total chlorophyll contents (MFDS >5.0 mg/g) were 9.29±0.33 mg/g and total pheophorbide contents (MFDS <1,000 mg/kg) were 54.88 mg/kg. Heavy metals in the cultured cells were recorded zero or detected below in the MFDS standard guide. Protein (53.0-53.9%), carbohydrate (28.9-30.9%), lipid (3.1-3.6%) and ash (10.48-10.89%) were stably contained in the cells. Harmful microorganisms and residual pesticides of the powder were not detected. These results were strongly indicated that the quality of *S. maxima* biomass for application on various industry was suitable and affordable under the rules of Korea MFDS.

## PP 35

### Carrageenan as shaping agent to produce the modified starch capsule

**Yi Yuan**[*1], Xiancui Li[1]
[1] *Experimental Marine Biological Laboratory, CAS, Institute of Oceanology, Chinese Academy of Sciences, China*

The traditional hard capsules were produced from gelatin, which is always produced from the skin or bone from different types of animals. The modified starch, carrageenan and other non-animal derived ingredients were mixed and dissolved in water at 85 ℃ to produce the hard capsule in this study. 12 optimized formulations from lab experiments were studied in the gelatin hard capsule production line. The results showed that the carrageenan was one perfect shaping agent to produce the starch hard capsule. The gelatin hard capsule production line was modified to accommodate the production of starch capsule. About 5,000,000 starch hard capsules caps and bodies were produced separately. The caps and bodies were cut and buckled in the machine. Then the capsules were sealed in PVC bags and stored in room temperature and humidity. Capsules could keep stable for 20 months for some formulations. The percent of pass were more than 90% in the crushing experiment for some formulations. The time was less than 5 minutes in the disintegration experiments for all formulations.

## PP 36

### Antihypertensive effect of peptides derived from *Chlorella ellipsoidea*

**Jin Hwang**[*1], Hyo Geun Lee[1], Hyun-Soo Kim[1], Hye-Won Yang[1], Seo-Young Kim[1], Ji-Min Hyun[1], Jun-Geon Je[1], You-Jin Jeon[1]
[1] *Marine Life Science, Jeju National University, Republic of Korea*

*Chlorella* species belong to green algae and show important bioactivities including antioxidant, antidiabetes, anti-inflammatory and immunomodulatory effects. In the present study the peptides extracted from *Chlorella ellipsoidea* was studied for its Antihypertensive Effect. *Chlorella ellipsoidea* was hydrolyzed using several proteinases including Protamex, Kojizyme, Neutrase, Flavourzyme, Alcalase, trypsin, α-chymotrypsin, pepsin and papain Among them, Alcalase-proteolytic hydrolysate was selected for further fractionation into three ranges of molecular weight (below 5 kDa, 5~10 kDa and above 10 kDa) and ACE inhibitory activity was evaluated. The below 5 kDa fraction was further purified using consecutive chromatographic methods and the effect of isolated peptide was tested in spontaneously hypertensive rats (SHRs) by oral administration. Alcalase-proteolytic hydrolysate and its fraction which was below 5kDa showed the highest ACE inhibitory. The peptide purified from the below 5 kDa fraction was composed of 4 amino acids, Val-Glu-Gly-Tyr (MW: 467.2 Da). The peptide showed ACE inhibitory activity with an IC50 value of 128.4 μM. The oral administration of purified peptide in SHRs revealed its antihypertensive effect by decreasing the systolic blood pressure significantly. These data suggest that antihypertensive peptides from *Chlorella ellipsoidea* would be an attractive crude material in development of antihypertensive.

## PP 37

### Investigation of extraction of fucoidan from Taiwan local *Sargassum* spp. in different coast and analyze its composition

**Zhi Yuan Wu**[*1], Hsiu Mei Lin[1], Jung Huang Chen[1]
[1] *Department of Bioscience and Biotechnology, National Taiwan Ocean University, Taiwan*

Phaeophyta and the *Sargassum* spp. are widely distributed throughout Taiwan coast waters. In this study we will extract bioactive substances (fucoidan) from this algae and do its component identification. The main component of fucoidan is fucose and sulfate group. The fucoidan extracted from brown algae in different regions will own different compositions depend on their growing environment, which affects different biological activities. The aim is the establishment of a database component in Taiwan local algae. Taiwan local *Sargassum fusiforme*, *Sargassum ilicifolium*, and *Sargassum horneri* were selected for this study. In the study, the yield of fucoidan and sodium alginate, monosaccharide composition, sulfate content, total sugar content and chemical composition analysis of algae species was confirmed. We first extract and separat fucoidan by acid-base extraction. The fucoidan is acid hydrolyzed and pre-column derivatization with 1-phenyl-3-methyl-5-pyrazolone (PMP). In addition, high performance liquid chromatography (HPLC) with UV-Vis detector was use to analysis monosaccharide composition, such as mannose, glucose, galactose, xylose, and fucose. Next, the total sugar percentage and sulfate content were identified by phenol sulfuric acid method and turbidimetric method, respectively. The functional group composition was confirmed by Fourier transform infrared spectroscopy (FTIR). Finally, we successfully established a database and hope to confirm its biological activity in the future.

## PP 38

### Investigation of extraction of polysaccharides from southern Taiwan local *Sargassum ilicifoium* and analyze its composition

**Min-Hsuan Tsou**[*1], Hsiu-Mei Lin[1]
[1] *Bioscience and Biotechnology, National Taiwan Ocean University, Taiwan*

Fucoidan and alginate are the main polysaccharides in brown algae. Among them, fucoidan is a physiologically active polysaccharide consisting mainly of fucose and sulfate groups. In recent years, it has been explored in the biomedical field to cause cancer cell apoptosis, inhibit cancer cell metastasis, inhibit cancer cell angiogenesis, inhibit inflammatory gene NF-kB, antiviral, immune regulation and antioxidant equivalent. The bioactivities of fucoidan are associated with its structures,

monosaccharide compositions, the contents and the locations of sulfate groups. In this study, the aim is establishment of a database component in Taiwan local algae. We selected the *Sargassum ilicifoium* from southern Taiwan, and extracted its fucoidan by hot water extraction to identify the yield, monosaccharide composition, sulfate, total sugar and so on. Finally, we successfully established a database and hope to explore its biological activity.

## PP 39

### A study on the improvement and effective extraction of UVAPs in marine microalgae *Spirulina* (*Arthrospira platensis*)

**Eon-mi Kwon**[*1], Hye-min Kim[1], Mi-seong Kim[1], Jung-Suk Lee[1], Young-Seok Han[1]

[1] *Environment, Energy & Biotechnology, Neoenbiz Co. Ltd., Republic of Korea*

*Spirulina* has ultraviolet absorbing pigments (UVAPs) or mycosporine-like amino acids (MAAs), a functional substance that protects spirulina from UV radiation. Thus, spirulina has been spotlighted as a good natural source to extract the functional materials. In addition to obtain the functional material, this study aimed to induce the enhancement of UVAPs by exposure various light conditions, and to establish the optimized extraction method to extract UVAPs. Also, this study explored the production conditions to secure the powder from the extracted functional materials under various drying methods such as natural drying, hot-air drying, and freeze drying. UVAPs enhancement study was performed under visible light (PAR), UV-B and PAR + UV-B conditions. To establish the optimal extraction methods, spirulina was extracted with various temperature ranges (10, 25, 40, and 60°C) and solvents (DW, 25, 50, and 75% EtOH). As a result, the UVAPs productivity of spirulina was the highest under UV-B conditions and the yield was the highest at 25 °C in DW. This study could contribute to provide fundamental data to develop the time and cost-effective technology for manufacturing of UV protection products.

## PP 40

### Research of functional materials from the brown alga *Sargassum horneri* (Turner) C. Agardh

**Sol Jang**[*1], Mi-seong Kim[1], Eun-mi Kown[1], Tae Seob Choi[1], Jung-Suk Lee[1], Young-Seok Han[1]

[1] *Environment, Energy & Biotechnology, NeoEnBiz Co., Republic of Korea*

The brown algae *Sargassum* genus plants contain a variety of physiologically active substances such as anticoagulants, antiviral agents, antioxidants and anticancer agents. It is used in various industries such as food, nutritional supplements and cosmetic supplements. However, *Sargassum* has been considered as invasive species due to their life cycle causing obstacles in economic and social aspects. Thus, many coastal states including Korea have been tried to remove them which are flowed and piled up the shores. The aim of this study is to recycle the inflowed *Sargassum* sp., specifically *Sargassum horneri*, as development a high value-added materials by extracting functional materials such as fucoidan and nutrients (C and N). To obtain the functional materials, *S. horneri* was naturally dried out and divided into morphological characteristics such as leaf, stripe and air bladder, and each part was extracted. The results revealed that the N content was high in leaf > air bladder > stripe in order, and the C content was high in stripe > air bladder > leaf in order. The amount of fucoidan was 1.81 g/100g as calculating fucoidan standard curve equation. As results, this study confirmed the inflowed the *S. horneri* has valuable amount of functional materials, and can be recycled to have a wide application. Currently, we are performing to find the best formula to make food additives for aquiculture organisms.

## PP 41

### Suitable unialgal strains for algal hemagglutinin production

**Hirotaka Kakita**[*1], Naoki Yanaoka[1], Hideki Obika[2]

[1] *Graduate School of Integrated Basic Sciences, Nihon University, Japan*
[2] *Health Research Institute, National Institute of Advanced Industrial Science and Technology, Japan*

Macroalgae have been utilized as food, fertilizer and medicine from early times. However relatively few raw materials for industry are obtained from macroalgae when compared with those from terrestrial plants. On the other hand, several researchers have reported that some macroalgae contain biologically active substances (e.g. *Porphyra* polysaccharides and *Grateoloupia* pyrogallols). Also, some macroalgae can produce unique components which land organisms cannot. Therefore the discovery of new macroalgal components and the establishment of effective technologies for producing them will help to expand the seaweed industry. We surveyed the Inland Sea macroalgae for hemagglutinins, because hemagglutinins are at the focus of research aimed at developing new industrial tools utilizing their ability to bind to specific carbohydrates. We reported that two red algae, *Gracilaria vermiculophylla* and *Gracilariopsis chorda* contained hemagglutinins with strong activity against rabbit erythrocytes. In this study, three kinds of naturally occurring *G. vermiculophylla* and the three kinds of naturally occurring *G. chorda* were surveyed for hemagglutinins. Rabbit erythrocytes were used for hemagglutination assay. The two red algae, *G. vermiculophylla* and *G. chorda* were examines monthly for maturation of naturally occurring macroalgae appearing at each of three different habitats around Shikoku Island, in southwest Japan, over 3 years. Among the unialgal strains tested, the unialgal strain, which was derived from tetraspores released by fertile tetrasporophytes of *G. chorda* growing in the Katsuura River, Tokushima Prefecture, Japan, did not mature even after a period of 3 years from the initiation of the culture. The growth rate of this strain was the highest among the *G. chorda* strains tested. Thus, the sterile unialgal strain of *G. chorda* seems to be useful for producing algal hemagglutinins.

## PP 42

### *Ecklonia cava* ameliorates the gluten-caused inflammation and oxidative damages in a human keratinocytes

**Min Ju Kim**[*1], Eun-Ji Shin[1], Eui Jeong Han[2], Disanayaka Mudiyanselage Dinesh Madusanka[2], Mawalle Kankanamge Hasitha Madhawa Dias[2], Ginnae Ahn[2,3]

[1] *Department of R&D, Nantapizza 5000, Republic of Korea*
[2] *Department of Food Technology and Nutrition, Chonnam National University, Republic of Korea*
[3] *Department of Marine Bio-Food Sciences, Chonnam National University, Republic of Korea*

In this study, we investigated the beneficial capacity of Ecklonia cava (E. cava) against gluten-induced inflammation and oxdiative stress in HaCaT,

a human keratinocyte. First of all, we prepared the hot water extract of E. cava (ECH) and used it for this study. ECH did not show cytotoxicities at the used all concentrations and improved the reduced cell viability as well as the increased intracellular reactive oxygen species (ROS) generation, the apoptotic body formation and the sub-G1 DNA population under the gluten stimulation. Also, ECH reduced the expression levels of inflammatory cytokines such as interleukin (IL)-1β, IL-4, IL-5, IL-6, IL-8, IL-13 and TNF-α as well as inflammatory mediators such as inducible nitric oxide synthase (iNOS) and cyclooxygenase (COX)-2, compared to the only gluten-stimulated cells. Moreover, ECH suppressed the activation of nuclear factor (NF)-κB p65/ERK/P38 signaling in the gluten-stimulated cells. From these results, we indicate that ECH ameliorates the inflammation and oxidative stress caused by the exposure to gluten in HaCaT cells and might be a natural material for the treatment of gluten-caused various diseases. This work (Grants No. M01201720150306) was supported by Korea Institute of Marine Science & Technology Promotion (KIMST).

## PP 43

### Effect of organic acid catalysts on the subcritical water hydrolysis in *Sargassum horneri*

**Byung Soo Chun**[*1], Yeon Jin Cho[1], Yu Rin Jeong[1], Saravana Periaswamy Sivagnanam[2], Hee Chul Woo[3]

[1] *Department of food science and technology, Pukyong national university, Republic of Korea*
[2] *Department of food chemistry and technology, Teagasc food research centre, Ireland*
[3] *Department of chemical engineering, Pukyong national university, Republic of Korea*

Macroalgae (seaweeds) are good potential sources of high biotechnological and high value interest due to production of a great diversity of their biological activities. *Sargassum horneri* belongs to the brown algae family phaeophyta which has abundance bioactive compounds. Furthermore, it has lot of unexplored bioactive compounds which have high value on economical aspect and on human live. In this study, *S. horneri* was treated with subcritical water hydrolysis (SWH) at temperature range of 180-260°C, while pressure vary between 15-220 bar for the desired temperature studied with/without organic acid catalysts. Subcritical water refers to water above its normal boiling temperature (100°C), but below its critical temperature. In this area, as temperature and pressure increase, the dissociation and self-diffusion coefficients increase, and density, dynamic viscosity, and surface tension decrease. The obtained hydrolysate of *S. horneri* were investigated for their hydrolysis yield, total sugar, reducing sugar, total phenolic compounds, total flavonoid compounds, amino acids, and total organic carbon contents, and biological activities. When using formic acid, the overall results including hydrolysis yield were found to be improved. In particular, the effects of organic catalysts on phenol compounds, flavonoid content, and antioxidant activity have been found to be significant. Sugar, reducing sugar, and antihypertensive activity have been shown to increase in content when the temperature is low and the others at higher temperatures.

## PP 44

### The Norwegian seaweed biorefinery platform (SBP-N)

**Céline Rebours**[*1], Jon Halfdanarson[2], Svein Jarle Horn[3], Svein H. Knutsen[4], Tom Ståle Nordtvedt[5], Håvard Sletta[6], Finn L. Aachmann[7]

[1] *Møreforsking Ålesund AS, Norway*
[2] *Møreforsking Molde, Norway*
[3] *Norwegian University of Life Sciences, Norway*
[4] *Fisheries and Aquaculture Research, Norwegian Institute of Food, Norway*
[5] *SINTEF Ocean , Norway*
[6] *SINTEF Industry, Norway*
[7] *Norwegian University of Science and Technology, Norway*

Norway is the leading European producer of wild harvested seaweed biomass. Over the last ten years, research and development efforts in biology and biotechnology have contributed to the emergence of a seaweed farming industry, which is expected to increase globally to US$22 billion by 20242. The number of Norwegian cultivation licenses has increased drastically since 2014. As of January 2019, about 670 ha have been allocated for the cultivation of seaweed for food or feed applications, which potentially correspond to over 100,000 tons of fresh biomass mainly from Saccharina latissima and Alaria esculenta. Products with a relatively high market value such as food and feed ingredients are predicted to play an important role in creating value from Norwegian cultivated seaweeds. Norway has a long coastline with a well-established aquaculture sector, broad experience in developing sea-based industries (oil, aquaculture, fisheries), and a strong research community focusing on Marine Innovation. In the recent years, Norwegian research institutions have developed processing tools for seaweed, and analyses to characterise products like biopolymers, chemicals, fibres, feed, food and bioactives. To make better use of these advantages and knowledge, a national consortium has been established to coordinate efforts from research institutions and industry in developing technologies aiming at the creation of economically and environmentally sustainable biorefinery processes, and corresponding high-value and bulk product pipelines. This national research-driven knowledge-based platform includes the main research facilities on seaweed in Norway and the goal of the platform is to serve as a hub for research, knowledge, methodology and stakeholder networking. Furthermore, the platform will aid in the regulation of seaweed cultivation and harvesting industries, and in the safety and quality characterisation of seaweeds and their derived products. This 5-year project will be launched in May 2019 and funded by the Research Council of Norway.

## PP 45

### Development of microalgae *Phaeodactylum tricornutum* transformants which produce hFGF1, hFGF2 and hIGF1

**Byeo-Ri Kwon**[*1], Erdenedolgor Erdene-Ochir[2], Cheol-Ho Pan[2], Seul-Ki Kim[1], Bok-Kyu Shin[1]

[1] *Algaeprona Inc., Republic of Korea*
[2] *Natural Product Informatics Research Center, KIST Gangneung Institute of Natural Products, Republic of Korea*

Microalgae Phaeodactylum tricornutum (PT) is a model species with a known genome sequence and developed molecular biology technology. The purpose of this study was to develop microalgae strains producing growth factors (hFGF1; human-fibroblast growth factor type 1, hFGF2; human-fibroblast growth factor type 2, hIGF1; human-insulin-like growth factor type 1) which are used as cosmetic ingredients as anti-winkle agents. Transformants were obtained by inserting each growth factor gene into PT using the novel vector of the over-expression promoter. Transformation was performed using the bombardment method, and gene insertion was confirmed by genomic DNA-PCR. The expression of each growth factor was confirmed by enzyme-linked immunosorbent assay (ELISA). After the transformation, 96, 48 and 80 colonies of hFGF1, hFGF2 and hIGF1 were obtained, respectively. Among them, 32, 23, and

41 colonies were completely inserted of the whole protein genes to the PT genome. The PT transformants with high target protein expression were selected by ELISA. Microalgae is attracting attention as a bio-factory to produce functional proteins. This study is meaningful for confirming the possibility of producing functional proteins that are industrially utilized in microalgae. Subsequently, large-scale cultivation and purification techniques will be applied to confirm the production of industrial-scale functional proteins from actual microalgae.

## PP 46

### Evaluation of anti-adipogenic effect of seaweed extracts in Korea

**Suk Jin Kim**[*1], So Hyeon You[1], Yun Min Hong[1], Ga Yeong Won[1], Soo-Im Choi[1], Gun-Hee Kim[2]

[1] *Health Functional materials, Duksung Women's University, Republic of Korea*
[2] *Food and Nutrition, Duksung Women's University, Republic of Korea*

Obesity caused by westernization of diet and lifestyle is increasing the incidence of metabolic diseases such as insulin resistance, type 2 diabetes, dyslipidemia and nonalcoholic fatty liver disease. Seaweeds contain a variety of bioactive compounds such as phlorotannins and polysaccharides. There have been many studies on the potential therapeutic benefits of seaweed in the management of body weight. This study was carried out to investigate the effects of ethanolic extracts from 31 seaweeds on the differentiation and lipid accumulation in 3T3-L1 preadipocytes. The level of lipid accumulation in 3T3-L1 cells were measured by Oil Red O staining assay. 19 species of seaweeds were significantly attenuated lipid accumulation during adipocyte differentiation in 3T3-L1 cells. Especially, Sargassum pinnatifidum Harvey (SPH, 42%), Sargassum muticum (Yendo) Fensholt (SMF, 39%) and Myagropsis myagroides Fensholt (MMF, 36%) at the concentration of 100 ug/ml was showed excellent inhibitory effect of lipid accumulation in 3T3-L1 cells. From these results, SPH, SMF and MMF were found to be used as a safe and efficient natural substance to manage obesity. In order to use these species as new health functional foods, it is necessary to study the identification of bioactive components contained in seaweed.

## PP 47

### Cloning of allophycocyanin gene from *Gracilariopsis lemaneiformis* and studying on its optical activity in recombinant expression in heterologous host

**Xiaonan Zang**[*1], Yalin Guo[1], Deguang Sun[1], Feng Zhang[1], Xuexue Cao[1], Di Xu[1], Xuecheng Zhang[1]

[1] *College of Marine Life Sciences, Ocean University of China, China*

Allophycocyanin (APC) belongs to phycobiliprotein, which is a pigment-protein with optical activity. As report, APC has the highest activity in the stimulation of cell proliferation and human immunity, and also it plays a positive role against tumor. In addition, APC can be used as natural harmless fluorescent probe in medical field. Hence, it has broad application prospects to carry out the recombinant expression of APC with optical activity. Before that, the assembly mechanism of optical active allophycocyanin should be elucidated. In this study, apcA and apcB were first cloned from Gracilariopsis lemaneiformis and expressed in Escherichia coli BL21 to obtain the optical active allophycocyanin. The apcA gene contains 486 base pairs, which encodes 161 amino acids. G/C content of apcA gene is 55.3%, ATG is the starting codon and TAG is the stop codon. The apcB gene contains 486 base pairs, which encodes 161 amino acids. G/C content of apcB gene is 55.2%, ATG is the starting codon and TGA is the stop codon. Then recombinant expression vectors- pET-hol-pcyA (hol gene encodes heme oxygenase-pcyA gene encodes ferredoxin reductase) were transformed into E. coli BL21 with five recombinant strains pACYCDuet-apcAB- pACYCDuet-apcAB- cpcU-pACYCDuet-apcAB-cpcS-pACYCDuet-apcAB-cpcT-pACYCDuet-apcAB-cpcUST (apcAB genes encode α and β subunit of apo-allophycocyanin. cpcU, cpcS and cpcT genes encode chromophore lyases-CpcU, CpcS and CpcT). SDS-PAGE and western blotting results verified that allophycocyanin was expressed in all the recombinant strains. The fluorescence emission spectra showed that characteristic fluorescence peak (656nm) of allophycocyanin was detected in the recombinant strains when the λex was 635nm, which indicated that all these recombinant strains could synthesize allophycocyanin with optical activity. The allophycocyanin catalyzed by chromophore lyases(CpcU, CpcS and CpcT) has the closest spectra with the natural allophycocyanin, indicating that the co-exist of chromophore lyases will catalyze the combination of phycocyanobilin and allophycocyanin more effectively.

## PP 48

### Antioxidant potential of common seaweeds from the Azores Archipelago, Portugal

**Juliane Bernardi**[*1], Edson Vasconcelos[1], Adilma Cocentino[1], Ana Isabel Neto[2], Mutue Fujii[3], Fungyi Chow[4]

[1] *Oceanography, Universidade Federal de Pernambuco, Brazil*
[2] *Biology, Universidade dos Açores, Portugal*
[3] *Núcleo de Pesquisa em Ficologia, Instituto de Botânica, Brazil*
[4] *Instituto de Biociências, Universidade de São Paulo, Brazil*

Oxidative stress has been associated with several diseases, such as cancer, hypertension, diabetes, atherosclerosis and aging processes. Antioxidants can act preventing oxidative burst. Recently, several seaweed species have been studied as promising sources of healthy and bioactive compounds, as an alternative to synthetic antioxidants. So, we aimed to analyze the antioxidant potential of the *Rhodophyta Laurenciella marilzae, Laurencia pyramidalis, Osmundea pinnatifida* and *Gelidium microdon* and the *Phaeophyceae Cystoseira abies*-marina and *Fucus spiralis* from São Miguel island, on the Azores Archipelago, Portugal, collected during summer of 2015. Seaweeds were air dried and extracted with dichloromethane and methanol (2:1), and antioxidant potential was measured through five UV-Vis microplate spectrophotometric methods: DPPH (2,2-diphenyl-1-picryhydrazyl) and ABTS (2,2–azinobis (3-ethylbenzthiazoline-6-sulfonic acid)) free radical scavenging, metal chelating capacity, ferric reducing antioxidant power (FRAP) and quantification of total phenolic compounds using reducing power by Folin-Ciocalteu. All species showed antioxidant potential. The brown seaweed *C. abies-marina* was the most prominent one, with the lowest EC50 value (0.26 mg ml-1), followed by the red seaweed *O. pinnatifida* (0.32 mg ml-1) at DPPH assay. At this same assay, *C. abies-marina* showed the highest activity (6.09 ± 0.03 mg GAE g-1). This species also had better performance at FRAP (17.54 ± 1.57 mg GAE g-1) and ABTS (4.88 ± 0.13 mg GAE g-1) assays. At metal chelating assay, *L. marilzae* and *L. pyramidalis* had higher activity (23.08 ± 0.02 and 22.77 ± 0.10 mg GAE g-1, respectively). *Fucus spiralis* showed higher phenolic content (7.59 ± 0.56 mg GAE g-1). Except the *Laurenciella* and *Laurencia* species, the other seaweeds are traditionally consumed as food by the Azorean people, and besides it´s great nutritional value, the antioxidant potential of those species could increase it´s functional and commercial value.

## PP 49

### Fucoxanthin contained oil extraction from *Sargassum horneri* by supercritical carbon dioxide

**Byung-Soo Chun**[*1], Yu-Rin Jeong[1], Yeon-Jin Cho[1], Saravana Periaswamy Sivagnanam[2], Hee-Chul Woo[3]

[1] *Department of Food Science and Technology, Pukyong National University, Republic of Korea*
[2] *Department of Food chemistry and technology, Teagasc food research centre, Ireland*
[3] *Department of Chemical Engineering, Pukyong National University, Republic of Korea*

Macroalgae (seaweeds) are good potential sources of high biotechnological and high value interest due to production of a great diversity of their biological activities. Fucoxanthin (FX) is a major carotenoid present in the chloroplasts of brown seaweeds. FX has got great interest due to its health benefits, such as antioxidant, anti-inflammation, anti-cancer and anti-obesity activities. There are several conventional procedures for the FX extraction from a natural raw material such as soxhlet, ultrasound, and oil extraction techniques. There are a lot of drawbacks associated with these methods. Supercritical carbon dioxide (SC-CO2) extraction is an alternative to conventional techniques. It has numerous advantages over conventional techniques. Structurally, FX molecule contains an unusual allenic bond and some oxygenic functional groups such as epoxy, hydroxyl and carbonyl moieties. In this work, SC-CO2 extraction was performed at 45°C, 200 bar for 2 hours, and organic solvent extraction was done to compare. Ethanol was used as a co-solvent during the SC-CO2 extraction. The compounds which is non-polar extracted from supercritical carbon dioxide include carotenoids as well as other non-tragic substances. These substances are highly viscous and reduce their efficiency in the recovery process. Therefore, the use of ethanol as co-solvent enhanced the extraction rate of polar substances and efficiency in the recovery process. FX, polyunsaturated fatty acid, and antihypertensive activity of SC-CO2+Ethanol extract showed 0.779±0.07 mg/g, 27.86±0.04%, and 81.75±12%, respectively.

## PP 50

### The effects of marine algal natural product on inflammatory myopathy in *in vitro* and *in vivo* zebrafish model

**Seo-Young Kim**[*1], You-Jin Jeon[1]

[1] *Department of Marine Life Sciences, Jeju National University, Republic of Korea*

Inflammation affects various organs of the body, and also is associated with disruption of anabolic signals initiating muscle growth. Therefore, inflammation is an important contributor to the pathology diseases implicated in skeletal muscle dysfunction. In the present study, we attempted to investigate the protective effect of a natural biologically active substance isolated from marine brown alga, *Ishige okamurae* (IO) by examining its inhibitory effects on pro-inflammatory mediators, and myopathy genes expression in TNF-α or H2O2-stimulated C2C12 myocytes and zebrafish in vivo model. Diphlorethohydroxycarmalol (DPHC), a IO-derived bioactive compound, suppressed the NO production and the mRNA expression levels of pro-inflammatory cytokines in C2C12 differentiated cells. In addition, DPHC down-regulated MuRF-1 and MAFbx/Atrogin-1, which are the key proteins of myopathy via NF-κB and MAPKs signaling pathways in in vitro and zebrafish muscle tissue. Furthermore, DPHC enhanced the endurance of zebrafish reduced by in TNF-α or H2O2 without any training. These results indicate that DPHC, a marine algal-derived bioactive compound, has a potential to regulate inflammatory myopathy and is expected to be used as possible nutraceuticals or functional food to reduce inflammation in skeletal muscle tissue.

## PP 51

### The effects of marine algal polyphenols on muscle growth in C2C12 muscle cells through myogenesis pathways

**Seo-Young Kim**[*1], You-Jin Jeon[1]

[1] *Department of Marine Life Sciences, Jeju National University, Republic of Korea*

Skeletal muscle is an important tissue in energy metabolism and athletic performance. The use of effective synthetic supplements and drugs to promote muscle growth is limited by various side effects. Moreover, their use is prohibited by anti-doping agencies; hence, natural alternatives are needed. Therefore, we evaluated the muscle growth effect of substances that can act like synthetic supplements from edible seaweed. First, we isolated six marine algal polyphenols belonging to the phlorotannin class, namely dieckol (DK), 6,6′-bieckol (6,6-BK), 2,7″- phloroglucinol-6,6′-bieckol (PHB), phlorofucofuroeckol A (PFFA), phloroglucinol-6,6′-bieckol (PBK), and phloroglucinol (PG) from an edible brown alga, Ecklonia cava and evaluated their effects on C2C12 myoblasts proliferation and differentiation. Of the six phlorotannin isolates evaluated, DK and PHB induced the highest degree of C2C12 myoblast proliferation. In addition, DK and PHB regulates myogenesis through down-regulating the Smad signaling, a negative regulator, and up-regulating the insulin-like growth factor-1 (IGF-1) signaling, a positive regulator. Interestingly, DK and PHB bind strongly to myostatin, which is an inhibitor of myoblast proliferation, while also binding to IGF-1 receptors. Moreover, they bind to IGF-1 receptor. These results suggest that DK and PHB are potential natural muscle building supplements and could be a safer alternative to synthetic drugs.

## PP 52

### Inhibition of inflammatory responses elicited by urban fine dust particles in keratinocytes and macrophages by diphlorethohydroxycarmalol isolated from a brown alga *Ishige okamurae*

**Won Woo Lee**[*1], Min Jeong Seo[1], Sang-Cheol Kim[1]

[1] *Bioresources Industrialization Support, Nakdonggang National Institute of Biological Resources, Korea*

Fine dust (FD) particles have become a major contributor to air pollution causing detrimental effects on the respiratory system and skin. Although some studies have investigated the effects of FD on the respiratory system, their possible effects on the skin remain under-explored. We investigated the FD mediated inflammatory responses in keratinocytes, present in the outer layers of skin tissues and the transfer of inflammatory potential to macrophages. We further evaluated the anti-inflammatory effects of the polyphenolic derivative, diphlorethohydroxycarmalol (DPHC) isolated from *Ishige okamurae* against FD-induced inflammation. Size distribution of FD particles was analyzed by scanning electron microscopy. FD particles induced the production of cyclooxygenase-2, prostaglandin E2 ($PGE_2$), interleukin(IL)-1β, and IL-6 in HaCaT keratinocytes and the expression of nitric oxide(NO), inducible nitric oxide synthases(iNOS),

$PGE_2$, tumor necrosis factor - α expression in RAW 264.7 macrophages. Further, we evaluated the inflammatory potential of the culture medium of inflammation-induced HaCaT cells in RAW264.7 macrophages and observed a marked increase in the expression of NO, iNOS, $PGE_2$, and proinflammatory cytokines. DPHC treatment markedly attenuated the inflammatory responses, indicatingits effectiveness in suppressing a broad range of inflammatory responses. It also showed anti-inflammatory potential in in-vivo experiments using FD-stimulated zebrafish embryos by decreasing NO and reactive oxygen species production, while eventing cell death caused by inflammation.

## PP 53

### A polysaccharide isolated from *Lactobacillus brevis*-fermented *Ecklonia cava* protects splenocytes against oxidative stress caused by gamma ray irradiation.

**Min Jeong Seo**[*1], Won Woo Lee[1], Sang-Cheol Kim[1]

[1] *Bioresources Industrialization Support, Nakdonggang National Institute of Biological Resources, Korea*

In the present study, we identified that the three aqueous extracts of the fermented *Ecklonia cava* (*Lactobacillus brevis* (ALFE), *Saccharomyces cerevisiae* (ASFE), and *Candida utilis* (ACFE)) increased the proliferation of murine splenocytes compared to the untreated cells and ALFE especially showed the highest proliferation effect among them. In addition, Viscozyme extract of LFE (VLFE) prepared by enzyme-assisted extraction using Viscozyme showed a markedly increased cell proliferation, compared with the other enzyme extracts. The further study indicated that the polysaccharide isolated from > 30 kDa fraction of VLFE (VLFEP) significantly enhanced survival and proliferate effects in 2 Gy-irradiated cells, comparing to only-irradiated cells. VLFEP markedly reduced DNA damage as reducing the production of reactive oxygen species and the increment of sub-G1 DNA contents caused by 2 Gy-irradiation. Moreover, VLFEP modulated the expression levels of P53, Bax, and Bcl-2 via inhibiting degradation and phosphorylation of IkBa as well as NFkB p65 translocation into nuclei. Taken together, these results demonstrate that VLFEP has a radio-protective effect as a modulator of apoptosis via inhibiting the activation of NFkB signal pathway.

## PP 54

### Applications of seaweed fertilizers in agriculture

**Peili Shen**[*1], Lin Zhang[1], Yimin Qin[1]

[1] *State Key Laboratory of Bioactive Seaweed Substances, Ministry of Agriculture Key Laboratory of Seaweed Fertilizers, QingDao Bright Moon Seaweed Group Co.,LTD, China*

Seaweeds and their extracts are widely used in the development of organic fertilizers and agricultural products. Compared with chemical fertilizers, seaweed fertilizers have the advantages of being safe, non-toxic, comprehensive and efficient, and environmentally friendly. As the main functional components of seaweed fertilizers, alginic acid is a natural polysaccharide polymer widely found in brown seaweed. Alginate oligosaccharide is a small molecular fragment obtained by degradation of alginic acid. It introduces the application effect of alginic acid and its derivatives on promoting plant growth, increasing yield, improving soil, and inducing crop disease resistance etc. The interaction mechanism among seaweed fertilizers, crops and soil are described in the field of research and development as a fertilizer builder. The application of seaweed and its residue on compound fertilizers are introduced, which can provide ideas for the development of seaweed fertilizer products. Seaweed fertilizer plays an important role in the sustainable development of agriculture.

## PP 55

### Characterization of 17 elements in ten edible seaweed species from Greenland

**Susan Løvstad Holdt**[*2], Jens Jørgen Sloth[2], Birgitte Koch Herbst[2], Lisbeth Truelstrup Hansen[2], Pernille Erland Jensen[1], Katharina Kreissig[2]

[1] *Department of Civil Engineering, Technical University of Denmark, Denmark*
[2] *National Food Institute, Technical University of Denmark, Denmark*

Even though the consumption of locally produced and harvested seaweed is growing across Northern Europe, there are few studies of their content of essential, trace and toxic elements. This study is the first to report the concentration of 17 elements (As, Ca, Cd, Cr, Cu, Fe, Hg, I, K, Mg, Mn, Na, Ni, P, Pb, Se and Zn) in ten different seaweed species (*Agarum clathratum, Alaria esculenta, Ascophyllum nodosum, Fucus distichus, Fucus vesiculosus, Laminaria solidungula, Palmaria palmata, Saccharina latissima, Saccharina longicruris, Saccharina nigripes*) harvested in Greenland. Samples harvested in the wild were frozen, freeze dried, pulverized and quantified by inductively coupled plasma mass spectrometry (ICP-MS). The quality of the analytical method was assured by simultaneous analysis of certified reference materials and adherence to European standard methods (EN 13805, EN 15763 and EN 15111). To detect statistically significant differences in element concentrations between seaweed species, analysis of variance (ANOVA) and Tukey multiple comparisons of means tests were carried out. All elements differed significantly among species ($p < 0.001$, except for Cr $p = 0.03$, Fe $p = 0.001$ and Pb $p = 0.004$). With regard to maximum levels (ML) of toxic elements in food supplements set by the European Commission (Commission Regulation (EC) No 1881/2006), only *S. latissima* exceeded the ML for Cd of 3.0 mg/kg. None of the samples exceeded the ML for Hg of 0.1 mg/kg. The ML for Pb of 3.0 mg/kg was exceeded by some samples of *A. esculenta* and *S. nigripes*. Iodine levels were especially high in *L. solidungula, S. latissima* and *S. nigripes* (3479 mg/kg to 4692 mg/kg). Based on the results obtained in this study, the dietary exposure to especially Cd, Pb and I through consumption of Greenland seaweeds should be taken into account when choosing seaweed species, serving size and frequency.

## PP 56

### Approach application of an edible film from Gracillaroid, *Gracillaria fisheri*

**Kangsadan Boonprab**[*1], Goson Sumit[1], Sunit Sawasruksa[1]

[1] *Fishery Products Department, Fisheries Faculty, Kasetsart University, Thailand*

This work was focused on food application of an edible polysaccharide film from Gracillaroid, *Gracillaria fisheri* through the investigation on its characters regarding to optimum molding temperature and the proposing of the best technique for food application according to a proper character. Among molding temperature (25, 60, 70 and 100 °C), the best temperature were 70 and 100 °C. Temperatures did not show the difference significantly ($p \leq 0.05$) in all characters, except elongation at break. Theirs characters [mean(unit) ± SD; n=3] at 70 and 100 ° C of color character, tensile strength [(MPa), elongation at break (%), water

vapor permeability (ng m/m$^2$ s Pa), oxygen transmission (cm$^3$ /m$^2$ /day), thickness (μm) and water activity were L*: 23.25 ± 1.22, a*: 0.53 ± 0.06, b*: 1.15±0.61 and L*: 23.73 ± 1.15, a*: 0.65 ± 0.08, b*: 1.39±0.55; 7.95 ± 0.23 and 7.36 ± 0.42; 12.28 ± 1.86 and 24.78 ± 1.23; 0.2035 ± 0.30 and 0.2128 ± 0.29; 5.90 ± 0.01 and 5.29 ± 0.05; 87.10 ± 0.01 and 86.60 ± 0.01 and 0.5801 ± 0.01 and 0.5772 ± 0.02, respectively. The best to the worst of film stability in a variety of solvent by showing total carbohydrate releasing from the film to the solvent was oil (33.85 ± 0.03 μg/mL; n=3), distilled water [(pH 7, at room temperature): 79.75 ± 0.02 μg/mL; n=3] and ethanol 100% (129.86 ± 0.77 μg/mL; n=3) in order. Its stability in ethanol (0-70%), distilled water (30-100 °C) pH 3-6 and pH 8-10 in distilled water showed inverse variation to concentration or a variety condition with the difference significantly ($p \leq 0.05$). Since wrapping ingredient for instant noodle soup of the bio-film instead of aluminum foil showed the same solubility. The best technique of practical food application through unstable in boil water character was indicated.

## PP 57

### Effect of pollutants in the free fatty acid profile and their oxidized derivatives in two brown algae

**Nicolás Latorre Padilla**[*1], Francisco Castañeda[1,2], Alejandra Núñez[1,2], Andrés Meynard[1,2], Javier Zapata[1,2], Camila Espinoza[1,2,3], Philippe Potin[4,5], Catherine Leblanc[4,5], Loretto Contreras-Porcia[1,2,3]

[1] *Departamento de Ecología y Biodiversidad, Universidad Andres Bello, Chile*
[2] *Centro de Investigación Marina Quintay (CIMARQ), Universidad Andrés Bello, Chile*
[3] *Center of Applied Ecology and Sustainability, (CAPES), Chile*
[4] *The Marine Plants and Biomolecules Laboratory, Station Biologique de Roscoff, France*
[5] *Laboratoire International Associé Dispersal and Adaptation in Marine Species, Station Biologique de Roscoff, France*

Sea pollution it's a worldwide issue and Chilean´s coasts are not excluded. The main source of pollutants in the marine environment comes from land activities such as industrial and domestic wastes, mining activity and air pollution. Other sources such as port activity, and oil transport makes a great impact in the marine environment. In Chile there are marine zones highly contaminated by heavy metals and PAHs given the costal industrial activity. Pollutants negatively affect both animals and photosynthetic organisms that live in polluted areas. The aim of this work was to observe the effects of the exposure to heavy metals (Cu and Cd) and PAHs, and their combination, in the Free Fatty Acids (FFA) profiles in two species of brown algae, *Macrocystis pyrifera* and *Lessonia spicata*. For that, we exposed for 1 week juveniles sporophytes of both species to Cu, Cd, PAHs, and their combinatory including a control treatment. FFA extraction was done with ethyl acetate, partitioned with water and reconstituted in methanol. The extracts were analyzed with LC/MS and GC/MS. For LC/MS the samples were diluted, and for GC/MS they were derivatized with Trimethylsilyldiazomethane and Sylon. The results show differences in the FFA profile between treatments and the control in both species. We found that both hexadecanoic and octodecanonic acids were more relatively abundant in the polluted treatments than the control which was more evident in the Cu treatment. We aim, in the short term, to characterize other compounds, that could show us about the state of stress of these species and therefore their sensibility or tolerance to these pollutants that are presented in combination in the environment.

## PP 58

### Light-regulated cytoplasmic streaming in coenocytic green alga *Bryopsis plumosa*

**Chan Young Hong**[*1], Ji Woong Lee[1], Gwang Hoon Kim[1]

[1] *Biological Sciences, Kongju National University, Republic of Korea*

Cytoplasmic streaming is essential for the large cells to speed up transport of molecules and organelles around the cell. In *Bryopsis plumosa*, cytoplasmic streaming is involved in the formation of a new growing tips and branching. It has also been shown that actin filaments and microtubules arranged longitudinally in the peripheral cytoplasm of the cylindrical part of the cell participate in cytoplasmic streaming in the longitudinal direction in *Bryopsis*. Our results showed that the initiation and the pattern of cytoplasmic streaming are determined by the light. The cytoplasmic streaming was not observed in dark. The cytoplasmic streaming started when the light was given (> 0.03 μmol photons m$^{-2}$ s$^{-1}$). The velocity of cytoplasmic streaming increased in proportion to light intensity. The maximum velocity of chloroplast movement was observed to be 13 μm/min in 50 μmol photons m$^{-2}$ s$^{-1}$. The pattern of cytoplasmic streaming was affected by different light. When blue light was given at the apical portion or midsection of *B. plumosa* thallus the cytoplasmic streaming in the illuminated region slowed down and eventually stopped resulting in densely accumulated cell organelles in the region. When red light was given to the same thallus the accumulated cell organelles quickly dispersed to the other region of the cell. The treatment of microtubule inhibitor, oryzalin, immediately stopped cytoplasmic streaming and wash out of the inhibitor recovered the movement again. The actin filament inhibitor, cytochalasin D, did not stop the movement, but inhibited chloroplast accumulation in blue light. Our results indicate that photoreceptors are involved in determining the pattern of cytoplasmic streaming, and microtubule plays an important role as a mechanical effector of the movement in *B. plumosa*.

## PP 59

### Characterization of CrELIP involved in the cold stress resistance of a green alga, *Chlamydomonas reinhardtii*

**Ji Woong Lee**[*1], Gwang Hoon Kim[1]

[1] *Department of Biological Sciences, Kongju National University, Republic of Korea*

Early light inducible proteins (ELIPs) located in thylakoid membranes are known to protect photosynthetic machinery from various stresses in higher plants. An *ELIP* homologue was isolated from *Chlamydomonas reinhardtii* (CC125) and named as *CrELIP*. The domain structure of CrELIP was similar to ELIPs of higher plants, containing three transmembrane domains and a chlorophyll a/b-binding domain. The expression of CrELIP responded more sensitively to cold stress than high light stress, especially when cold stress (4 ℃) occurs in combination with high light. It is known that cold stress decreases the synthesis of ribulose-1,5-bisphosphate (RuBP) and thus photosynthetic $CO_2$ fixation is limited. This leads to excess excitation energy in the photosystems and electrons could be transferred to oxygen, such processes generate reactive oxygen species (ROS). To investigate whether CrELIP expression is influenced by oxidative stress, algal culture was treated with $H_2O_2$ and carotenoid biosynthesis inhibitor (norflurazon). The expression of CrELIP was increased with $H_2O_2$ or norflurazon treatment and reduced when ROS quencher (TEMPOL) was treated. The influx of 5% $CO_2$ to the algal culture medium suppressed the expression of CrELIP. These results suggest that CrELIP is involved in protective role of photosystem against ROS in cold stress conditions.

## PP 60

### CRISPR/Cas9-mediated heterologous gene silencing in *Chlamydomonas reinhardtii*

**Hancheol Jeon**[*1], Hyun Dae Hong[1], Jin-Woo Han[1], Hyun-Ju Hwang[1], Jong Won Han[1]

[1] *Genetic Resources research, Marine Biodiversity Institute of Korea, Republic of Korea*

General transformation method, which is using plasmid vector system, induces the expression of not only the target gene but also other genes such as reporter and antibiotics resistance genes. In addition, the other genes are composed with a strong promoter to express proteins. In some cases, the other genes cause side effects such as metabolizable energy waste, and are toxic in severe cases. Therefore, in this study, we aimed to knockout the reporter gene from transgenic line of *Chlamydomonas reinhardtii* by using CRISPR-Cas9 system. First, linearized vector(pOpt_Clover_Hyg), which have reporter gene(GFP) and selective marker gene(Hyg resistance gene), was introduced in *C. reinhardtii* CC277 by glass bead method to obtain transformant. The transgenic lines were screened by hygromycin resistance, and validated gene insertion by PCR of Hyg gene. Then, the activity of reporter protein was investigated by using fluorescence microscope. Among the transgenic lines, stable transgenic line for more than 6 months was used for knockout of reporter gene. Three sgRNA binding sites in reporter gene were predicted by in silico analysis, and used for manufacturing of sgRNA. After binding sgRNA with Cas9 protein, we introduced sgRNA-Cas9 protein complex to cells of *C. reinhardtii* by electroporation method. First screening of knockout transfomant was carried out by using fluorescence microscope. The knockout lines, which are lost fluorescent of GFP, were confirmed gene deletion by sequencing of GFP gene. The sequencing results of knockout lines showed 1 and 10 base pair deletion in reporter gene. Therefore, the present study shows that the CRISPR-Cas9 system can be effectively used to remove unnecessary genes or over-express genes in transformants. In addition, this study can provide basic knowledge in metabolic engineering research.

## PP 61

### Induction of recombinant mannose binding lectin expression by an artificially constructed tandem repeat structure

**Jin-Woo Han**[*1], Hyun-Ju Hwang[1], Hyun Dae Hong[1], Hancheol Jeon[1], Jong Won Han[1]

[1] *Genetic Resources research, Marine Biodiversity Institute of Korea, Republic of Korea*

Lectin is an important protein in medical and pharmacological applications. Impurities in lectin derived from natural sources and the generation of inactive proteins by recombinant technology are major obstacles for the use of lectins. Expressing recombinant lectin with a tandem repeat structure can potentially overcome these problems, but few studies have systematically examined this possibility. This was investigated in the present study using three distinct forms of recombinant mannose-binding lectin from *Bryopsis plumosa* (BPL2)—i.e., the monomer (rD1BPL2), as well as the dimer (rD2BPL2), and tetramer (rD4BPL2) arranged as tandem repeats. The concentration of the inducer molecule isopropyl _-D-1-thiogalactopyranoside and the induction time had no effect on the efficiency of the expression of each construct. Of the tested constructs, only rD4BPL2 showed hemagglutination activity towards horse erythrocytes; the activity of towards the former was 64 times higher than that of native BPL2. Recombinant and native BPL2 showed differences in carbohydrate specificity; the activity of rD4BPL2 was inhibited by the glycoprotein fetuin, whereas that of native BPL2 was also inhibited by D-mannose. Our results indicate that expression as tandem repeat sequences can increase the efficiency of lectin production on a large scale using a bacterial expression system.

## PP 62

### *Ulva clathrata* silver nanoparticles, a potential approach to manage bacterial diseases in shrimp: toxicity, bioaccumulation and depuration

Maribel Maldonado-Muñiz [1], Carlos Luna [2], Raquel Mendoza-Resendez [2], E. D. Barriga-Castro [3], Sonia Soto-Rodriguez [4], **Denis Ricque-Marie**[*1], Lucia Elizabeth Cruz-Suarez [1]

[1] *Universidad Autonoma de Nuevo Leon, Facultad de Ciencias Biológicas, México.*
[2] *Universidad Autonoma de Nuevo Leon, Facultad de Ciencias Físico Matemáticas, México*
[3] *Centro de Investigación en Química Aplicada, México.*
[4] *Centro de Investigación Alimentación y Desarrollo, México.*

Silver and silver chloride nanoparticles (Ag/AgCl NPs) made by reduction of $AgNO_3$ with an *Ulva clathrata* aqueous extract (AEU) have shown in preliminary studies to be able to inhibit in vitro the growth of *Vibrio parahaemolyticus* strains isolated from shrimp affected by the acute hepatopancreatic necrosis disease. Here we report the characterization of Ag/AgCl NPs by several analytical techniques including UV-vis, XRD, TEM, SAED, EDX, FTIR and Raman spectroscopies, and their toxicity, bioaccumulation and depuration in shrimp. These Ag/AgCl NPs had an average particle size of 9.5 nm with spherical to irregular form mainly coated by proteins, polysaccharides and polyphenols from the AEU. The dietary exposure of *L. vannamei* to Ag/AgCl NPs for 7 days at low doses (10 and 100 ppm Ag in diet) did not affect behaviour, nor survival, nor the hepatosomatic index (HPI), but had a tendency to improve shrimp growth. The consumption of feeds supplemented with 1000 and 10000 ppm Ag for 7 days did not affect survival, growth nor feed conversion ratio, but decreased the HPI significantly. The short-term consumption of Ag/AgCl NPs produced a dose-dependant bioaccumulation of Ag, mainly in the hepatopancreas, followed by cephalothorax cuticle while no significant bioaccumulations was observed in the muscle. The depuration study showed that 88.2% of the NPs accumulated in hepatopancreas had been eliminated in 14 days. (Conacyt project 238458).

## PP 63

### *In vitro* gastrointestinal digestion and colonic fermentation of a *S. compressa* hydroethanolic extract and its polysaccharide fraction, and their effect on human fecal microbiota

Benjamín Vázquez-Rodríguez[1], Erick Heredia-Olea[2], Laura Acevedo[2], Janet A. Gutiérrez-Uribe[2], **Lucia Elizabeth Cruz-Suárez**[*1]

[1] *Universidad Autónoma de Nuevo León, Facultad de Ciencias Biológicas, México.*
[2] *Escuela de Ingeniería y Ciencias, Centro de Biotecnología-FEMSA, Tecnológico de Monterrey, México.*

Phlorotannins (PT) and polysaccharides (PS) represent two families of bioactive chemical compounds present in several varieties of brown algae. Both the PT and PS of the brown algae have presented diverse bioactivities that range from antimicrobial to inhibitors of enzymes related to affections of the metabolic syndrome. The *in vitro* colonic digestion and fermentation of an hydroethanolic extract (containing PT

and PS) and of an isolated polysaccharides fraction were carried out using bacterial microbiota consortia extracted from human feces. The prebiotic effect of the extract was evaluated by performing an enzymatic digestion simulating the passage of the sample through the gastrointestinal tract to then perform a colonic fermentation *in vitro* for 48 h. Changes in microbiota (*Bifidobacterium* and *Lactobacillus*) were monitored using real time PCR, short chain fatty acid quantification using GC-FID, sugars and phlorotannin quantification using HPLC. Both the extract and the precipitated fraction of PS showed an increase in short chain fatty acids production compared to the fermentations of the negative control (feces only). The highest concentration of acetic acid, propionic acid, and isobutyric acid occurred at 48 h. The extract showed a significant increase in bifidobacterial populations from 5.91 $\log_{10}$ at 0 h to 6.77 $\log_{10}$ at 48 h ($p < 0.05$). The PS fraction showed a significant increase in lactobacillus populations from 4.00 $\log_{10} \pm 0.12$ at 0 h to 4.51 $\log_{10} \pm 0.09$ at 8 h ($p < 0.05$). Enzymatic digestion and fermentation of the extract resulted in the diminution of all PT compounds and specially the Eckstolonol; among sugars, mannitol was the first, while fucose was the last consumed. In conclusion, the hydroethanolic extract of *S. compressa* algae has a probable prebiotic effect since it promotes the short chain fatty acid synthesis and probiotic strains growth. (Conacyt project 238458).

## PP 64

### Development of cell-penetrating peptides-mediated molecule delivery system in red alga *Pyropia tenera*

**Hancheol Jeon**[*1], Hyun Dae Hong[1], Jin-Woo Han[1], Hyun-Ju Hwang[1], Jong Won Han[1]

[1] *Genetic Resources research, Marine Biodiversity Institute of Korea, Republic of Korea*

Cell-penetrating peptides (CPPs) are effective molecular tools that can deliver various molecular materials into different types of cells. However, there is no study about molecular material delivery system by using CPPs into cells of red algae, especially Pyropia. In this study, we attempted to develop a delivery system of molecular materials into cells of *Pyropia tenera* by using CPPs. Well-known CPPs which were previously reported in other organisms were selected for introducing molecules into cells, and were classified by their physical-chemical properties like hydrophobicity, charge etc. Then, their cell penetration activities were calculated by in silico method. CPPs were conjugated with fluorescein isothiocyanate (FITC) for convenient screening of CPPs. We treated FITC-labeled CPPs into PES medium with P. tenera, and selected CPPs which have high cell-penetrating activity by using fluorescence microscope. The cell-penetration patterns of selected CPPs were observed by using confocal microscope. These results may provide basic knowledge of molecule delivery tool for algal research.

## PP 65

### Differential expression of proteins involved in photosynthesis in the life cycle of marine red alga, *Pyropia tenera*

**Hyun-Ju Hwang**[*1], Hyun Dae Hong[1], Jin-Woo Han[1], Hancheol Jeon[1], Jong Won Han[1]

[1] *Genetic Resources research, Marine Biodiversity Institute of Korea, Republic of Korea*

The understanding life cycle of valuable marine crop, Pyropia sp, is associated with productivity, control of seedling, cultivation of Pyropia sp. Their life stage is determined by environmental factors such as temperature, light intensity and light periods. A few studies for genetic and proteomic approaches have been available until now. In order to understand proteomic differences between sporophyte and gametophytes, comprehensive analysis of proteome was performed using 2-dimensional gel electrophoresis (2-DE) combined with mass spectrometry for protein identification. Totally, 400 proteins were displayed on the 2-DE gel. Among them, about 100 proteins which were differentially expressed in each stage were selected to identify the proteins. The expression pattern was showed quite different between sporophyte and gametophyte. A lot of high molecular weight proteins (over 40 kDa) were disappeared in a sporophyte sample otherwise expressed in a gametophyte sample. Interestingly, most of identified proteins were related to photosynthesis. Proteins produced in sporophytes were involved in light capture in photosynthetic machinery otherwise gametophytes specific proteins were related to Calvin-Benson cycle which involved in energy metabolism. Allophycocyanin(AP), Phycocyanin(PC) and Phycoerythrin(PE) proteins were showed maximum 4.68 log2 fold changes which more than 25 times higher expressed in sporophyte. The expression level of Calvin Cycle related proteins were more than 2-fold higher in gametophytes. The transcription level of photosynthesis involved genes was confirmed by using RT-qPCR. These results support the theory that the life stage was controlled by photosynthetic efficiency via retrograde signaling pathway.

## PP 66

### Purification and characterization of antiviral lectin from red alga, *Glateoupia chiangii*

**Jong Su Yoo**[*1], Jin-Woo Han[1], Hyun-Ju Hwang[1], Hyun Dae Hong[1], Hancheol Jeon[1], Jong Won Han[1]

[1] *Genetic Resources research, Marine Biotechnology Research Division, Republic of Korea*

Lectin has an ability carbohydrates binding ability. Owing to the properties of lectin, it has believed having a potential in application to medical and pharmacological agents. Unique structure and usefulness of red algal lectin has been reported, but it is limited to few marine algal groups. In this study, novel lectin from *Grateloupia chiangii* was purified and characterized. Isolated lectin was named as GCL (*Grateloupia chiangii lectin*). GCL was purified with >90% purity using an affinity chromatography. Molecular weight of GCL was determined to 25 kDa. Horse and rabbit erythrocyte was agglutinated by mixing with GCL, but human and sheep erythrocyte was not agglutinated. Hemagglutination activity of GCL was inhibited by 250 mM of D-mannose and 390 μg of fetuin. The protein was showed heat stability. The activity (~25%) remained even after heating at 90 °C for 30 minutes. In order to understand carbohydrates specificity, glycan microarray was performed using a glycan-300 array kit which immobilized 300 different carbohydrates. GCL showed weak binding signal to monosaccharide, β-Glc-sp, β-Gal-sp and α-Man-sp. GCL was strongly bound to Maltohexaose-β-Sp1 and Maltoheptaose-β-Sp1. GCL preferred high-mannan structures also, i.e. Man-α-1,6-(Man-α-1,3-)Man-α-1,6-(GlcNAc-β-1,2-Man-α-1,3-)Man-β-1,4-GlcNAc-β-1,4-GlcNAc-Sp5. N-terminal sequence and peptide sequence was determined using Edman degradation method and LC-ms/ms. Based on the amino acid sequence, cDNA sequence was obtained. GCL was consisted with 231 amino acids and calculated molecular weight was 24.9 kDa. N-terminus methionine was removed after translation. GCL had a tandem repeat structure with 6 domains that similar to the other red algal lectins. Antiviral test showed that GCL has high antiviral activities to influenza virus and herpes virus at low concentration.

## PP 67

### Anionic macromolecules extracted from *Codium fragile* enhance the immune-associated cells of cyclophosphamide-treated mice

**Chaiwat Monmai**[*1], Weerawan Rod-in, A-yeong Jang, Juhyeon Nam, Yoon Ra Nam, Gyoung Soo Choi, Woo Jung Park

[1] *Department of Marine Food Science and Technology, Gangneung-Wonju National University, Korea*

Cancer is one of the leading causes of death worldwide. The numbers of the cancer case are expected to grow worldwide due to the adaptation of lifestyle behaviors. Most of the anti-cancer drugs currently used in chemotherapy have cytotoxic side effects to normal cells. For decreasing the side effects of immunosuppressant drugs, anionic macromolecules extracted from *Codium fragile* (CFAM) were examined the immune-enhancing biological activities in immunosuppressed mice. The cyclophosphamide (CY)-induced immunosuppression mice were orally administrated with the different concentrations of CFAM. The results showed that administration of CFAM significantly raised spleen index, splenic lymphocyte proliferation, and NK cell activity. The expression of immune-associated genes (IL-2, IL-4, IL-10, TNF-α, IFN-γ, and TLR4) was highly upregulated in splenic lymphocytes, and gene expression was differently regulated according to mitogens such as T-cell (Con A) and B-cell (LPS) mitogens. Additionally, CFAM boosted the proliferation, NO production, and phagocytosis of peritoneal macrophages. These suggested CFAM can be used as a potent immunomodulatory material under immune-suppressive condition. Furthermore, CFAM may also be used as a bio-functional and pharmaceutical material for improving human health and immunity.

## PP 68

### Reproduction and cultivation of *Palmaria palmata* (Palmariales, Rhodophyta) in the gulf of St Lawrence, Canada

**Éric Tamigneaux**[*1], Mathilde Lemoine[2]

[1] *Aquaculture, Merinov-Cégep de la Gaspésie et des Îles, Canada*
[2] *Aquaculture, Merinov, Canada*

*Palmaria palmata* is an edible red seaweed of the North Atlantic. In eastern Canada it is mainly harvested around Grand Manan Island and cultivation can be seen as a desirable alternative to relieve the pressure on wild stocks. Its commercial cultivation, however, is neither mastered nor practiced in Canada. The objectives of this project were a) to test a method to artificially induce sporogenesis on fronds, b) to compare different culture parameters and substrates seeded with tetraspores, c) to optimize the growth of fronds cultivated in tanks. Wild fronds were harvested locally and non-fertile fronds were cultivated at 5 and 10 °C under either a constant long or short photoperiod. Braided nylon ropes, stranded kuralon rope, plastic nets and non-woven artificial textiles were seeded with spores, cultivated in tanks and the distribution and number of thalus were measured. Young fronds were cultivated in tanks with various combinations of stocking density, temperature, light intensity and nitrogen concentrations. Fresh biomass was measured weekly and the productivity per unit surface of tank was calculated. The preliminary results showed that, when non-fertile fronds are artificially conditioned, mature spores are mainly produced at 10 °C under a constant short photoperiod after 2 months. There was a higher density (1,2 ± 0,5 thallus per cm) of plants on kuralon ropes and on the At-Sea textile (2,9 ± 1,7 thallus per cm2) but some individuals were loosely attached on these substrates. In the culture tanks, the highest productivity was obtained with young fronds, grown at 2.5 kg m-2 with nutrient enrichment. The next steps will be to transfer the seeded substrates on a marine farm, to perform organoleptic tests on the cultivated fronds and to scale up the culture technology in a private marine hatchery.

## PP 69

### Cultivation performance and genetic characteristics of Korean (Sugwawon No. 301) and Chinese strains (Huangguan no. 1) of *Saccharina japonica* (Phaeophyceae)

**Eun Kyoung Hwang**[*1], Dong Soo Ha[1], Hwan Su Yoon[2], Chan Sun Park[3]

[1] *Seaweed Research Center, National Institute of Fisheries Science, Republic of Korea*
[2] *Department of Biological science, Sungkyunkwan University, Republic of Korea*
[3] *Department of Marine and Fisheries Resources, Mokpo National University, Republic of Korea*

We compared the difference of cultivation performance and genetic characteristics between Korean (Sugwawon No. 301) and Chinese strains (Huangguan No. 1) of *Saccharina japonica* in an aquaculture farm in Korea. We found that the Sugwawon No. 301 performed as well as the Huangguan No. 1 in Korean waters possibly due to increased flexibility as a result of the different cell arrangements of the two strains. Overall, the use of the Sugwawon No. 301 strain rather than the Huangguan No. 1 strain of *S. japonica* appears the best alternative to help to ensure a stable year round algal feed supply for the Korean abalone industry. From January to June 2018, the number of cortical layered cells and the area of the cortical cells were measured for each length groups (5, 15, 30, 50, 100, 150 cm) of the two strains in a culture farm of Korea. The differences in cell arrangement began to appear from the group of 50 cm. Number of cortical layered cells was more than Sugwawon No. 301 in Huangguan No. 1. And the area of cells of Hangguan No. 1 was larger than that in Sugwawon No. 301. The two strains of *S. japonica* can be typically distinguishable by 12 SSR (Sequence Simple Repeats) genetic markers. Therefore, differences in the cell arrangement between strains of *S. japonica* affects differences in the intracellular contents as well as physical properties of the kelp originated from their genetic differences.

## PP 71

### Possibility of polyploidy breeding using cryptic species in the marine crop *Pyropia yezoensis* (Bangiales, Rhodophyta)

**Kyosuke Niwa**[*1,2], Tomoko Abe[2], Atsushi Kobiyama[3]

[1] *Department of Marine Biosciences, Tokyo University of Marine Science and Technology, Japan*
[2] *Nishina Center for Accelerator-Based Science, RIKEN, Japan*
[3] *School of Marine Biosciences, Kitasato University, Japan*

In the marine crop *Pyropia yezoensis*, a cross-fertilization experiment between a cultivated strain and cryptic species was carried out to investigate the possibility of polyploidy breeding using cryptic species. To perform the cross-fertilization, we isolated a green mutant strain (IBYC-G1) of the cryptic species by heavy-ion beam irradiation. The green mutant was crossed with a wildtype strain (HG-4) of *P. yezoensis f. narawaensis*. The F1 heterozygous conchocelis developed normally and released numerous conchospores. However, almost all the conchospore germlings did not survive past the four-cell stage or thereabout, and

a few germlings developed into gametophytic blades. These results indicated that reproductive isolation occurred during meiosis and that *P. yezoensis* and the cryptic species were different species according to the biological species concept. Almost all the archeospores that were released from the surviving F1 blades developed into normal gametophytic blades. The nuclear DNA marker analysis revealed that the F1 blades that developed from both conchospores and archeospores were allodiploids in the haploid gametophytic phase. Although the F1 blades were extremely slender, their blade color was deeper reddish brown as compared with that of *P. yezoensis f. narawaensis*, and the rate of blade length increase was remarkably higher in the blades of F1 than in those of the cryptic species. These results suggested that polyploidy breeding in the marine crop will attract more attention as a breeding method for further development of new cultivars.

## PP 72

### Bioremediation potential of five seaweed species applied to fish-seaweed integrated aquaculture system

**Sang Rul Park**[*1], Yun Hee Kang[2], Ik Kyo Chung[3]

[1] *Department of Marine Life Sciences, Jejun National University, Republic of Korea*
[2] *Department of Earth and Marine Sciences, Jeju National University, Republic of Korea*
[3] *Department of Oceanography, Pusan National University, Republic of Korea*

The purpose of this study was to investigate bioremediation capacity and growth of five local seaweed species (*Codium fragile, Ulva pertusa, Ecklonia stolonifera, Saccharina japonica, Gracilariopsis chorda*) in fish-seaweed integrated aquaculture system as biofilters for the effluents from black rockfish (*Sebastes schlegeli*). The survival rate and weight gain of fish were more than 90% and 70% fish$^{-1}$ day$^{-1}$ in all systems. *Codium fragile* showed significantly higher specific growth rate (SGR) compared to other seaweed species. The biomass yield of green algae (*C. fragile* and *U. pertusa*) reached maximum values, while the brown algae (*E. stolonifera* and *S. japonica*) showed minimum values. The net yield in *C. fragile* was 1.3–2.5 times higher than that in other seaweed species. Ulva pertusa and *C. fragile* showed highest total ammonia nitrogen uptake efficiency (>80%) while highest total oxidized nitrogen uptake efficiency were measured for *E. stolonifera* and *S. japonica*. Phosphate (P) uptake efficiency varied significantly with seaweed species, ranging from 45% for *U. pertusa* and *E. stolonifera* to 30% for *G. chorda*. While TAN uptake rates were highest in *U. pertusa*, two brown seaweed species (*E. stolonifera* and *S. japonica*) showed highest in ToxN uptake rates. Nitrogen yield was highest in *U. pertusa* and *G. chorda*, and lowest in *E. stolonifera*. Phosphate uptake rate was highest in *E. stolonifera* and lowest in *G. chorda*. Phosphate yield was highest in *E. stolonifera* and lowest in *S. japonica*. This suggests that all species efficiently removed enriched nitrogen and phosphorus from the fish tank effluents. Our results showed that the co-culture of two seaweed species that showed nitrogen source-specific biofiltration as a biofilter can be a reasonable solution for reducing nutrient from the effluents.

## PP 73

### Impact of climate change on seaweed rarming and the role of the GlobalSeaweedSTAR project in Tanzania

**Flower Msuya**[*1], Msafiri Ndawala[1], Sadock Rusekwa[1], Ivy Matoju[1], Gloria Yona[1], Claire Gachon[2], Elizabeth Cottier-Cook[2], Amelia Buriyo[1]

[1] *Botany Department, University of Dar es Salaam, United Republic of Tanzania*
[2] *Scottish Marine Institute, The Scottish Association of Marine Science, United Kingdom*

The seaweed farming in Tanzania, has been practiced for 26 years producing the carrageenophyte seaweeds of *Kappaphycus striatus*, *K. alvarezii*, and *Eucheuma denticulatum* with a production of 11000 t annually. However, in recent years *Kappaphycus*, the preferred species in the world market, is failing to grow when cultivated using the off-bottom method in the shallow intertidal areas. Concomitantly, in recent years problems associated with climate change (e.g. rise in surface seawater temperatures, fouling, ice-ice disease signs, and epiphytism) have led to massive die-offs of the environmentally sensitive *Kappaphycus*. Additionally, algal blooms have been observed including a toxic blue green alga (*Lyngbya*) that cause skin and eye problems to the farmers and a macroalga (identified as *Gracilaria*) that covers seaweed farms, both of which are killing the environmentally hardier *E. denticulatum*. Research works to look for methods of cultivating *Kappaphycus* have been carried out including floating lines systems and bamboo rafts, but both these methods have not realised the goal of producing enough *Kappaphycus* because of rough sea that breaks the seaweed. This paper uses meteorology data (air temperature, rainfall and wind speed) to give some evidence of climate change impact on seaweed farming and presents a novel method of farming the higher valued *Kappaphycus*. Aspects of seaweed diseases, epiphytes, using native species for cultivation, biosecurity issues, and value chain are now being looked at under the GlobalSeaweedSTAR Project to compliment the farming technologies for community livelihood development.

## PP 74

### Effect of single and different ratio of LED light combination on growth rate, pigment content, antioxidant activities and phytoene desaturase gene expression in the green alga *Caulerpa lentillifera*

**Wui Ting Lim**[*1], Yen Chieh Huang[1], Pei An Hwang[1]

[1] *Bioscience and Biotechnology, National Taiwan Ocean University, Taiwan*

Spectral light changes evoke different morphogenetic and photosynthetic responses that can vary among different algae species. The aim of this study is to investigate the photosynthetic characteristics of green macroalgae grown under different spectrum environments. In this study, *Caulerpa lentillifera* were cultured under blue, red, white light and three different ratios of red and blue light source combinations light: 1:1 (1B1R), 1:2 (1B2R) and 1:5 (1B5R) light-emitting diodes (LED). We also combine with three different light intensities 50, 100, 150 µmol photos m$^2$/s and three different light cycle 8L/16D, 12L/12D, 16L/8D (Light / Dark, L/D). The growth rate, pigment content (chlorophyll A, B, and β-carotene), antioxidant activities (ABTS oxidation and reduction ability) and phytoene desaturase (PDS) gene expression in different light spectrums were investigated. In order to correctly sequence PDS gene of *C. lentillifera* and to design highly efficient primers for quantitative polymerase chain reaction (qPCR), phylogenetic tree and vector transfer were employed to identify genes belonging to the *C. lentillifera*. The results revealed that the growth rate was significantly higher grown under 1B:5R LED light source. The pigment composition and PDS gene expression were greater under blue LED light although it has disadvantageous effects in growth rate. It was suggested that blue LED light was a stress condition to *C. lentillifera*, and it needs to increase antioxidant accumulation by up-regulated PDS gene to survive under blue LED light. The results revealed that the photosynthetic efficiency and increased growth rate of *C. lentillifera* benefitted from light spectrums such as 1:5 (1B5R) LED light source.

Furthermore, we found that *C. lentillifera* has a significantly higher growth rate in light intensities 100 µmol photos $m^2$/s and light cycle 12L/12D. Accordingly, the results show that *C. lentillifera* has special react under a specific ratio of blue and red light combination.

## PP 75

### Establishment of a tumbling cultivation system For *Osmundea pinnatifida*

**Cecilia Biancacci**[*1], John Day[2], Gordon McDougall[3], Michele Stanley[4]

[1] *Microbial & Molecular Biology, SAMS, United Kingdom*
[2] *CCAP, SAMS, United Kingdom*
[3] *Environmental and Biochemical Sciences Group, The James Hutton Institute, United Kingdom*
[4] *Associate Director for Innovation, SAMS, United Kingdom*

*Osmundea pinnatifida* is a red seaweed sold dried as a seasoning. Nowadays, it is only harvested from the wild. This exerts pressure on the wild stocks, makes the resource dependent on the seasonality and is not sustainable. Establishment of a cultivation technique would guarantee a continuous supply of the resource that could be potentially tailored according to the market needs. This will result in a sustainable and high-value final production. Samples were collected in September 2018 from Easdale (56°17'22.20" N -5°39'21.59" W). They were cleaned and treated with 0.5 % KI and acclimated for four weeks prior to the experiment. The tumbling cultivation system consisted of six tanks of 55 L, 200 g (±0.05) of culture per tank, continuous supply of filtered and UV treated seawater and aeration supplied from the bottom. The light (Growth Lux type, Sylvania®) was on 24/7. HOBO loggers were used to measuring temperature and light and a digital pH and TDS probe for pH and salinity measurements (TekcoPlus). Nutrients were provided through dosing pumps. Three different treatments were tested: F/2 media (control), 0.5 $mg*L^{-1}$ Acadian Marine Plant Extract solution and F/2 media after bathing with 20$g*L^{-1}$ AMPEP solution. Growth and fluorescence quantum yield were recorded monthly. Cultures doubled their weight after one month in the cultivation system, showing no epiphytes, dark color and a thick texture. They kept increasing their weight for all the length of the trial (3months) showing a vertical and horizontal growth. No statistical differences were reported among the treatments tested in terms of weight increase ($p<0.05$). This was the first time that tumbling cultivation of *O. pinnatifida* was successfully established. This is a promising experiment with great potential for a commercial scale-up of the production of this species.

## PP 76

### Decreasing iodine content in *Saccharina latissima* by hydrothermal processing and determining the possible loss of nutritive and bioactive compounds

**Cecilie Wirenfeldt Nielsen**[*1], Susan Løvstad Holdt[1], Jens Jørgen Sloth[1], Maren Sæther[2], Jon Funderud[2], Turid Rustad[3]

[1] *National Food Institute, Technical University of Denmark, Denmark*
[2] *Processing and Quality, Seaweed Energy Solutions AS, Norway*
[3] *Biotechnology and Food Science, Norwegian University of Science and Technology, Norway*

The brown seaweed *Saccharina latissima* contains high levels of iodine, which in excess intake can cause adverse human health effects. Norwegian cultivated *S. latissima* were undergoing hydrothermal processing by steam and water blanching to attempt reduction of iodine content to ensure a safer food product. The experiment executed focused on the process variables; time and temperature. The temperatures were between 30 to 100°C and processing time between 0 to 5 minutes. Moreover, the nutritional composition together with quality compounds (amino acids and total phenols) were analyzed to evaluate their loss during processing. Water blanching was efficient to reduce iodine and lowered the content below the unofficial French threshold value of 2,000 mg iodine per kg dry weight. The process variables interacted with each other from which it could be concluded that both process time and temperature have an influence on the iodine reduction, although around 350 mg iodine per kg dry weight was the reduction going towards a constant level. The water blanching at the tested process variables affected water, ash and calculated carbohydrates, but not lipid or protein concentration significantly. It was found that a processing time above 30 seconds would decrease the total phenolic content significantly. Regarding protein quality were no significant changes found when evaluating by essential amino acid to amino acid ratio and amino acid score. However, a significant decrease of the amino acids alanine, aspartic- and glutamic acid occurred, which could lead to a change of flavor. Low processing temperature and time such as 45°C for 30 seconds is recommended for decreasing the iodine content sufficiently due to nutritional and quality aspects of the final product and additionally due to possible economical and environmental impacts.

## PP 77

### Tropical seaweed innovation network (TSIN): bringing innovation to business

**Ratih Pangestuti**[*1], Sudari Pawiro[2], Jana Anggadiredja[2], Ray Chandra Purnama[2]

[1] *Research Center for Oceanography, Indonesian Institute of Sciences (P2O-LIPI), Indonesia*
[2] *UNIDO SMART-Fish Indonesia Programme, Indonesia*

Seaweeds is one of Indonesia's potential marine commodities that contribute to the national revenue and income for the local communities. In the last few years, Indonesia's seaweed production ranked the highest in aquaculture compared to the production of shrimp, grouper, snapper, carp, milkfish, tilapia and catfish (According to the Ministry of Marine Affairs and Fisheries/MMAF). As one of the largest seaweeds producers in the world, Indonesia plays an important role in seaweeds chain; however in terms of seaweeds research, development and innovations, Indonesia somewhat left behind other countries. Public efforts in seaweed Research & Development and Innovation in Indonesia are scattered across a wide range of research institutes and universities, with qualified staff, but usually not fully dedicated to seaweed. While collaborations between institutions exist, it would be beneficial to increase the interactions between these institutions to combine expertise and equipment under a more global strategy. In parallel, it appears that interactions of public research with the industry are limited and focused mostly on dissemination/transfer. An earlier involvement of industry partners in the research strategy would be beneficial to develop market-driven R&D and Innovation. To address this, TSIN is established with full support from the government in particular the Ministry of Marine Affairs and Fisheries, Coordinating Ministry of Maritime Affairs, The Ministry of Research, Technology and Higher Education, the Ministry of Industry etc. TSIN tries to develop synergies between R&D seaweed centres, connecting researchers with industry players and bringing innovation to the seaweed community. Tropical Seaweed Innovation Network (TSIN) is virtual web base networking among R&D centres in Indonesia for Tropical Seaweed. TSIN is virtual platform for researchers and experts in seaweed to work together, establish synergies

and collaboration in research and development for seaweed and seaweed products and bring innovation to the business communities. TSIN is part of SECO (Swiss) funded SMART-Fish Programme which is jointly implemented by MMAF and UNIDO to improve competitiveness of the Indonesian seaweed industry. The programme runs from 2014-2019 closely work with various partners along the seaweed value chains including farmers, traders, co-operatives, processors and exporters. In the seaweed value chain the programme covers 21 districts n 8 provinces throughout Indonesia.

## PP 79

### Observation on haptera development of *Saccharina japonica* in culture and on longline in commercial farming

**Li Su**[*1]

[1] *Key Laboratory of Experimental Marine Biology, Institute of Oceanology Chinese Academy of Sciences, China*

China is a giant kelp farming industry, with an annual production of 1.4 million t (dry weight, DW) in a farming area of 145,263 ha. The haptera (holdfast) of kelps is very important for the production. Sufficiently-developed haptera guarantees the completion of the life cycle of a sessile kelp individual at its niche. In the same way on longline in commercial farming, well-developed haptera could lock the blade onto the rope preventing being stripped off by water current when the blade gets larger, securing the final harvest at the end of the season. Recently at Lvshun in northern China, one of the principal kelp farming region, high detachment rate of large sporophytes at stage close to the harvesting season has drawn attention. High rate of detachment of the adults leads to reduction of biomass output per line (8 m in length) up to 50% at the most severe situation. To elucidate the reason, hapteras of the individually farmed plants from different cultivars were checked on longline on site in the production season of 2016-2017. In the mean times, culture experiments were carried out in indoor flowthrough tanks so as to make us understand how haptera of this species develops on substrate. The investigation revealed that, proper plant density on rope and timely adjustment according to water transparency be implemented in farming practice. But for the long run, cultivar improvement is the essential issue that should be focused.

## PP 80

### Entrepreneurial capacity building of the seaweed farmers in Takalar District, South Sulawesi, Indonesia

**Djusdil Akrim**[*1], Gufran D. Dirawan[2], Bakhrani Rauf[3], Nurlita Pertiwi[4]

[1] *Environmental Education Studies, Universitas Negeri Makassar, Indonesia*
[2] *Public Administration Studies, Universitas Negeri Makassar, Indonesia*
[3] *Civil Engineering Studies, Universitas Negeri Makassar, Indonesia*
[4] *Public Administration Studies, Universitas Negeri Makassar, Indonesia*

The existence of seaweed farmers in Takalar District, South Sulawesi, Indonesia, has become one of the economic supporting of coastal communities, as one of the main livelihood source on cultivation based. The locus of this research is to study the development of entrepreneurial capacity building of seaweed farmers. Concerning to increasing knowledge, attitudes and motivation of the farmers through the management of independent and sustainable farming?. The purpose of this research is to finding the development of entrepreneurial capacity building of seaweed farmers to improve the farm management knowledge, attitude and motivation in an independent and sustainable. The research method used is development research The results of the study assume that the development of entrepreneurial capacity building can significantly improve the knowledge, attitudes and motivations of farmers who are competitive and the discovery of capacity building models can improve the management of independent and sustainable farming.

## PP 81

### Difference of cell shape and length of *Grateloupia asiatica* between crust and erect thalli in culture

**Joon Kim**[*1], Hyoung Hae Kim[1], Hyung Geun Kim[1]

[1] *Department of Marine Bioscience, Gangneung-Wonju National University, Republic of Korea*

*Grateloupia asiatica* is an edible alga which is consumed in Korea. This alga have two different shapes of thalli during the growth. Early growth form from spores is a crust which attach firmly to the substratum and have a thin thickness of several layers of cells. If crust grow up to certain size, the second form starts to appear: erect thalli. They start to grow vertically from the substratum. For artificial cultivation, crusts of this alga must successfully grow to cover all substratum before erect thalli growth. Initiation of erect thalli is important check point for aquaculture. We cultured this alga from filament seedling for 2 years in tank. It grown up to 7.40±3.12 cm. We sampled its crust along with erect thalli base. Cell shapes and sizes changes dramatically during this transition from crust to erect thalli. Crust cells are small and rectangular and erect thalli cells have three layers: periphery, cortex and medulla. Crustose cells gradually become oval up to several cells and finally begins to form medullary filament at a certain cell layer. This layer of changing cells is the Crust-to-Erect Thalli Transition Zone. In the transition zone, cell shape gradually changes from crustose to erect thalli. Cells became thicker and form more irregular layers than crust cell layer. And then cells form three different layers. Peripheral cells are small and divided in to two cells at the most outer layer. Cortical cells are linked by pit-plug and formed lines of cells up to several cells. Medullary cells are filamentous and form long lines from crust to the tip. We measured cell size in each type of cells; crustose, peripheral, cortical and medullary. Cell length was 9.4±1.9, 7.2±1.8, 5.6±1.3, 28.5±5.7 µm each. Understanding cell morphology will improve culture maintenance for this alga.

## PP 82

### Comparative growth of *Gelidium coreanum* (Gelidiales, Rhodophyta) in laboratory and in the field

**Hyung Geun Kim**[*1], Jeoung Sook Ko[2,3], Chan Kil Chun[3], Sung Min Boo[4]

[1] *Marine Bioscience, Gangneung-Wonju National University, Republic of Korea*
[2] *Biology Research Team, Chungnam National University, Republic of Korea*
[3] *Research Team, 21C Marine Development Company, Republic of Korea*
[4] *Biology, Chungnam National University, Republic of Korea*

*Gelidium* is an excellent source of food, agar, and agarose, and there is a great need of biomass for agar industry. However, because growth rate of *Gelidium* species is very slow, it is very difficult to cultivate *Gelidium* species in fishery farms. To increase biomass in culture, we studied the seasonal growth pattern of *G. coreanum*, a recently described from

Korea, at Gamchusa on the east coast and compared its growth with regenerated fragments in laboratory culture. During January and March, thalli were creeping stolons and lacked secondary branches. In April to June, creeping stolons were elongated, and erect branches started to grow. In July to September, erect branches with secondary branches grew long. In October, thalli had many secondary and tertiary branches and tetrasporangia occurred on the upper parts of these branches. During November and December, thalli degenerated into creeping stolons. Laboratory culture of small fragments (5 mm in size) was maintained in f/2 medium at 20℃. Up to 20 primary branches arose from each fragment after 4 weeks of culture, and up to 60 secondary branches from each fragment were produced after 7 weeks of culture. Regenerated branches revealed rapid growth rate (SGR = 7.3±0.1% day1) after 11 weeks of fragment culture. Regenerated fragments grew up to 5 cm and many secondary and tertiary branches after 13 weeks, showing a typical form of field thallus. The prolific growth of regenerated fragments of *G. coreanum* would be used for mass cultivation.

## PP 83

### Biosecurity policy and legislation of the seaweed aquaculture industry in Tanzania

**Sadock Rusekwa**[*1], Flower Msuya[1], Amelia Buriyo[1], Iona Campbell[2], Elizabeth Cottier-Cook[2]

[1] *Botany, University of Dar es Salaam, United Republic of Tanzania*
[2] *Global Seaweed STAR, The Scottish Association for Marine Science( SAMS), United Kingdom*

Biosecurity involves the identification, management and prevention of risks to living organisms and the environment. Commercial seaweed farming *Eucheuma/Kappaphycus* species in Tanzania was established in 1989 and has been a source of income for thousands of people in the country, particularly women. Production initially increased, however, from 2002 onwards the production of *Kappaphycus* and *Eucheuma* has been limited due to the effects of pests, disease, epiphytes and climate change. The purpose of this study was to identify current legislation and policies relating to biosecurity and to assess their component and core values based on the methodology of Dahlstrom et al. (2011). For each step in the cultivation process, all the national policies and legislative frameworks, relating to biosecurity, were identified. A total of eight legislative instruments were found to be related to seaweed in Tanzania, with 50% of these binding and containing a section that explicitly covers seaweed aquaculture. Only four regulations that deal with seaweed, also refer to biosecurity, but the measures are not explicit. Seaweed farmers, therefore, have introduced informal biosecurity measures to prevent the introduction of pests and disease, as no specific biosecurity policy/ regulation exists. Recommendations are provided to assist policy makers in establishing formal biosecurity policies to encourage sustainable seaweed farm management in Tanzania.

## PP 84

### Microscopic observation of reproductive apparatus and fertilization initiation of *Gracilaria vermiculophylla*

**Di Xu**[*1], Hao Yan[1], Xiaohui Pan[1], Weifang Zhu[1], Fengting Li[1]

[1] *College of Marine Life Sciences, Ocean University of China, China*

The study of sexual reproduction of algae will not only help to understand both the process of reproductive evolution and its regulation mechanisms, but also help to guide the algal cultivation method and even the industrial upgrading. Due to the non-motility of spermatia, red algal fertilization has been regarded as inherently inefficient. However, the facts that the carpogonium has long trichogyne extending to algal surface and the high efficient recognition and adhesion between sperm and trichogyne may enhance the efficiency of fertilization. Here we focused on agarophytic red algae *Gracilaria vermiculophylla* to observe its reproductive apparatus on female and male gametophytes and sperm-carpogoniam recognition situation at the starting point of fertilization using optical/fluorescence microscope as well as scanning electron microscope. And these images for the first time showed clearly the sperms and how they adhering to the surface of female gametophyte of *Gracilaria*.

## PP 85

### The role of UKRI-GCRF-GlobalSeaweedSTAR project in meeting the challenges of the Philippine seaweed industry

**Anicia Hurtado**[*1], Ma. Rovilla Luhan[2], Victor Marco Emmanuel Ferriols[3], Elizabeth Cottier-Cook[4], Claire Gachon[5], Juliet Brodie[6], Louise Shaxson[7]

[1] *Consultancy, Integrated Services For The Development of Aquaculture and Fisheries (ISDA) Inc., The Philippines*
[2] *Aquaculture Department, Southeast Asian Fisheries Development Center, The Philippines*
[3] *College of Fisheries and Ocean Sciences, University of the Philippines in the Visayas, The Philippines*
[4] *Scottish Marine Institute, Scottish Association for Marine Science, United Kingdom*
[5] *Scottish Marine Institute, Scottish Association of Marine Science, United Kingdom*
[6] *Botany, National History Museum, United Kingdom*
[7] *Social Science, Overseas Development Institute, United Kingdom*

Eucheumatoid (*Kappaphycus* and *Eucheuma*) farming was pioneered by the Philippines in the early 1970s followed by semi-refined carrageenan processing few years after. Seaweed farming became the number one marine aquaculture industry since the start to the present providing economic gains among coastal families thereby resulting to an improved economic life. Despite several successful stories documented on seaweed farming, it is not spared from several challenges like: 1) decreased production brought by deteriorating quality of cultivars, pest and disease infestation, poor crop management and post-harvest handling, 2) natural calamities like typhoons, 3) insufficient capital to start or rehabilitate damaged farms or even expand cultivation areas, and 4) lack of innovation on culture techniques to mitigate climate change and limited product application of the seaweed-hydrocolloid. Government and non-government agencies, academia, research institutions, the private sector led by the Seaweed Industry Association of the Philippines, multi-national companies and international agencies are at the forefront to answer the challenges of the seaweed industry. The collaboration of UKRI-GCRF-GlobalSeaweedSTAR with the Philippines (2017-2021) is a big boost to meet the several challenges of the seaweed industry of the country.

## PP 86

### Fertilization of *Kappaphycus alvarezii* with biofloc effluents: effects on growth and carrageenan yield

**Leila Hayashi**[*1], Rodrigo De Martino Ucedo[1], Luiza Vieira Mariot[1], Fernando Zwierzikowski da Silva[1], Alex Alves dos Santos[2]

[1] *Aquaculture Department, Federal University of Santa Catarina, Brazil*
[2] *Centro de Desenvolvimento em Aquicultura e Pesca, Empresa de Pesquisa*

*Agropecuária e Extensão de Santa Catarina, Brazil*

*Kappaphycus alvarezii* farmed in Southern Brazil needs to be kept in tanks under controlled conditions of temperature during winter period until the sea conditions become favorable. The aim of this work was to establish the best fertilization regime for *K. alvarezii* during winterization using 25% effluent from the *Litopenaeus vannamei* shrimp reared in a biofloc system (BFT25) and its subsequent effect on growth and carrageenan production during the farming period. Three treatments (n=3) with different BFT25 fertilization regimes were run for four weeks: one week of fertilization and 3 weeks of cultivation just in seawater (SF); fertilization in alternated weeks (AF); and continuous fertilization (CF). In all treatments, seawater or BFT25 was changed weekly. 7 g $L^{-1}$ of seedlings were cultivated in 50 L boxes, in 12 h photoperiod, 165 µmol photons $m^{-2}$ $s^{-1}$ irradiation, constant aeration, 23 ℃ temperature and 35‰ salinity. After the fertilization period, 100 g were removed from each experimental unit, transferred to the sea and cultivated for 5 weeks. In indoor conditions, the seedlings growth rate in SF and AF had no significant differences (0.67 ± 0.15 % $day^{-1}$ and 0.74 ± 0.04 % $day^{-1}$) and were higher than CF (0.44 ± 0.07 % $day^{-1}$). All treatments showed similar carrageenan yield (22.45%, 22.71% and 21.33%, respectively). In the sea cultivation, the growth rates of AF and CF treatments had no significant differences (4.16 ± 0.19 %day-1 and 4.01 ± 0.06% day-1, respectively) and were higher than SF (3.46 ± 0.18% $day^{-1}$). Again, no significant difference in carrageenan yield was observed (21.63%, 20.53% and 19.91%, respectively). AF regime presented better growth results in indoor and outdoor conditions, and the carrageenan yield was not influenced by the treatments.

## PP 87

### The use of carbon dioxide followed by irradiance increment as a strategy to improve the cultivation of the red seaweed *Kappaphycus alvarezii* in tanks

**Leila Hayashi**[*1], Thallis Felipe Boa Ventura[1], Camila Pereira Bruzinga[1], Fernando Zwierzikowski da Silva[1], Alex Alves dos Santos[2], Carmen Simioni[3]

[1] *Aquaculture Department, Federal University of Santa Catarina, Brazil*
[2] *Centro de Desenvolvimento em Aquicultura e Pesca, Empresa de Pesquisa Agropecuária e Extensão de Santa Catarina, Brazil*
[3] *Cellular Biology, Embryology and Genetics Department, Federal University of Santa Catarina, Brazil*

The tank cultivation of *Kappaphycus alvarezii* has been developed in Southern Brazil as an alternative when the sea temperature is low in winter time. This work aimed to verify if $CO_2$ and irradiance can be used as strategy to improve this species' tank cultivation. An initial biomass density of 21 g L-1 of seedlings were cultivated in vitro for two weeks with addition of three concentrations of $CO_2$: 0.1 L $min^{-1}$ ($1CO_2$), 0.2 L $min^{-1}$ ($2CO_2$) and 0.3 L $min^{-1}$ ($3CO_2$) in irradiance of 50 µmol photons $m^{-2}$ $s^{-1}$. After this period, the $CO_2$ addition was interrupted and plants were cultivated in higher irradiance (200 µmol photons $m^{-2}$ $s^{-1}$) for more two weeks. Seedlings with no $CO_2$ addition were used as control (C). After the $CO_2$ addition phase and high irradiance phase, the growth rate (GR), chlorophyll a and carotenoids were determined, and samples of treatments and control were observed by light and transmission electronic microscopy. Significant differences in GRs were only observed in $2CO_2$ and $3CO_2$ treatments when the phase is considered. *K. alvarezii* from $3CO_2$ showed cell wall thickening and increasing quantity of starch granules, chlorophyll a and carotenoids than the control. After the irradiance phase, control samples showed stress signs as chloroplasts alterations, decrease in starch granules quantities and an increase in total chlorophyll a and carotenoids. However, samples cultivated with $CO_2$ showed increase in the quantity and size of the starch granules, mitochondria and Golgi complex. Such alterations suggest a cell response after $CO_2$ addition as a strategy to prepare the plants to growth when the cultivation conditions are appropriate.

## PP 88

### Effect of a carrageenan feed additive on pacific-white shrimp growth and white spot virus resistance

**Leila Hayashi**[*1], Luiza Vieira Mariot[1], Rodrigo De Martino de Ucedo[1], Fernando Zwierzikowski da Silva[1], Delano Dias Schleder[2], Felipe Do Nascimento Vieira[1]

[1] *Aquaculture Department, Federal University of Santa Catarina, Brazil*
[2] *Instituto Federal Catarinense, Brazil*

The use of bioactive compounds from seaweeds is considered a sustainable alternative to improving the productivity of marine shrimp farms and minimize the losses caused by several diseases. The aim of this work was to evaluate the effect of carrageenan from *Kappaphycus alvarezii* as feed additive on growth performance of the white-leg shrimp *Litopenaeus vannamei* and their resistance after a white spot syndrome virus (WSSV) challenge. *L. vannamei* were reared in 800 L tanks for five weeks, at a density of 30 animals *per tank*, under controlled temperature (28.5 ℃), constant aeration and 100% daily water exchange. Four times a day, 4.5 g animals were fed with diets containing four concentrations of carrageenan: 0.5%, 1.0%, 1.5% and 2.0%. Shrimps fed with a non-carrageenan diet were used as control. The experiment was run in triplicate. After the rearing period, the growth performance and feed conversion were determined. For the WSSV challenge, 30 animals from each treatment and control were infected with the viral inoculum and the cumulative mortality was monitored for 96 h. There was no significant difference in weight gain and food conversion among treatments and controls. Final weight varied from 8.50 g to 10.30 g, and food conversion rate from 1.42 to 1.67. The results of WSSV infection showed that the control group had a higher mortality rate (36.7%) than the treatments (16.7%; 20.0%; 10.0%; 20.0% respectively). We conclude that although no significant differences on growth were detected among the treatments with carrageenan, there was a positive influence in reducing the mortality of *L. vannamei* infected with the white spot syndrome virus.

## PP 89

### Small-scale cultivation of *Chondracanthus chamissoi* in a suspended system in southern Chile

**Jaime Zamorano**[*1], Humberto Pavez[2], Mario Nunez[2], Hernan Cortes[2]

[1] *R&D, Gelymar SA, Chile*
[2] *Aquaculture, Sarco Seaweed SpA, Chile*

*Chondracanthus chamissoi* (C. Agardh) Kützing is a species of economic importance, which is distributed from Peru to Chile forming beds between 0 and 15m deep in protected bays. This species is used for direct human consumption, either fresh or dry. In addition, it is used for the extraction of carrageenan for different uses in the food, pharmaceutical, and personal care industries. Through time, knowledge has been created to develop the cultivation of *C. chamissoi* , is possible to assert that the state of the art for this resource allows passing from the experimental or pilot level to small or medium scale. In this work, productive scale-up cultivation of 1 Ha was evaluated. Using a novel, low-cost system, compatible with the environment. It is based on the use of ropes and flotation elements, with 100-meter length cultivation units, 20 units per hectare. The selected

system is based on the capacity of vegetative growth, inserting thallus into braided polypropylene ropes. These ropes were installed in the sea at the surface level. After 1 year of cultivation, the results obtained are promising in terms of growth and productivity. The problems that must be faced are related to the adhesion of epibionts and the discoloration of the fronds during summer, being key an adequate site selection for the cultivation of this species. This study is an important advance because through this type of cultivation it will be possible to reduce the extractive pressure that is currently exerted on *C. chamissoi* , contributing to the conservation of this species and other associated organisms. In addition, it will provide work and increased incomes to small coastal farmers.

## PP 90

### Optimal cultivation and harvest strategies for Bladderwrack

**Sigrid Elgaard Mikkelsen**[*1], Jacob Nepper-Davidsen[2], Mette Møller-Nielsen[3], Michael Bo Rasmussen[1], Dorte Krause-Jensen[1], Teis Boderskov[1], Mette Albrechtsen[4], Karen Lise Krabbe[5], Annette Bruhn[1]

[1] *Department of Bioscience, Aarhus University, Denmark*
[2] *Department of Natural Sciences and Environment, Roskilde University, Denmark*
[3] *DTU Aqua, National Institute of Aquatic Resources, Denmark*
[4] *Seaweed Matters, Denmark*
[5] *Organic Seaweed, Denmark*

Bladderwrack, (*Fucus vesiculosus*), is a keystone species in the littoral ecosystems along the Danish shores, contributing to e.g. shore protection and a diverse habitat ensuring biodiversity. A growing interest in seaweed as an industrial product has increased market demand for *F. vesiculosus*. The species is not yet cultivated, and all commercial harvest is from wild-stock populations. This research investigated the regrowth potential in wild-stock populations and optimization of germling production for cultivation. A coastal F*ucus* bed was harvested using four different methods and the regrowth was subsequently measured every second month. Drone footages were taken before and after harvest to establish a non-destructive biomass relation between *F. vesiculosus* (kg WW and kg DW) and pixels (n/m$^2$). Germlings were produced in the laboratory and exposed to two light levels, three nutrient levels and saltwater with or without previous contact with adult *F. vesiculosus* individuals. Growth was measured weekly. The study showed a significant non-destructive biomass relation, enabling determination of biomass quantity using drone footages. Harvest of the apex shoots resulted in biomass re-growth, but harvest at the basal disc did not. High light levels were essential for growth of germlings, nutrient concentration became significant 35 days post fertilization, and saltwater with a previous exposure to other individuals was significantly reducing growth and survival, possibly due to a negative impact on the light level. This research shows how harvest method has impact on regrowth potential, stressing the importance of developing sustainable harvest guidelines. Growth success of germlings depends on light and nutrient availability. More parameters must be studied to optimize and develop *Fucus* cultivation, to up-scale the seaweed industry and to spare the coastal ecosystem from negative impact by unsustainable harvesting.

## PP 91

### Thermal stress effect on growth and color histogram of *Pyropia* collected from different vertical habitats

**Sol Han**[*1], Palas Samanta[1], Sojin Jang[1], Sookkyung Shin[1], Jang K. Kim[1]

[1] *Marine science, Incheon National University, Republic of Korea*

*Pyropia* is an economically important red algal species. *Pyropia* grows from intertidal down to subtidal zones. The intertidal *Pyropia* is exposed to various abiotic stresses, including high light/UV, extreme temperature, desiccation, and osmotic shock. Temperature is typically an important environmental factor for seaweeds as global warming accelerates. The present study is designed to investigate temperature effects on growth and color histogram in three *Pyropia* species collected from different vertical habitats. *Pyropia* was collected from Jebudo seaweed farm (JB), from the upper-most intertidal zone in Jawaldo (JW) and Tongyeong (TY). *Pyropia* stains were cultivated at four different temperatures (10, 15, 20 and 25℃) for 20 days. *Pyropia* were cultured in von Stosch enriched (VSE) medium under 80 μmol photons m$^{-2}$ s$^{-1}$ of photosynthetically active radiation (PAR) and 12:12 L:D photoperiod. Blade areas were measured every 5 days to calculate growth rate. Additionally, microscopic cell images were taken using a Nikon Ts2R microscope and KOPTIC HK6.3E3S digital camera. The findings from this study will provide critical information to understand physiological responses in *Pyropia* under thermal stress and to select *Pyropia* cultivar for aquaculture considering global climate change.

## PP 92

### Growth, pigment contents and nutrient uptake capacity of *Pyropia yezoensis* under LED lightings

**Hyein Song**[*1], Palas Samanta[1], Sojin Jang[1], Sookkyung Shin[1], Jang K. Kim[1]

[1] *Marine science, Incheon National University, Republic of Korea*

Solid-state lighting based on the use of light-emitting diodes (LEDs) is potential light source in seaweed cultivation due to energy efficiency. Spectral light changes caused morphogenetic, photosynthetic responses and nutrient uptake capacity *etc.*, in algae. *Pyropia yezoensis* is an economically important species throughout the world. The objective of this study is to examine the effects of different LED lights on growth, pigment contents and nutrient uptake capacity of *Pyropia yezoensis*. *Pyropia yezoensis* is cultured in von Stosch enriched (VSE) medium under three pure primary LED lights (red, green and blue) and one mixed three-color (the color of all monochromatic light in this experiment) LED as control for a period of 21 days. Environmental conditions are maintained at 10 ℃, 12:12 L:D photoperiod, 100 μmol m$^{-2}$ s$^{-1}$ of photon flux of LED lighting and 30 psu salinity. The medium is replaced every alternate day. The growth, pigment composition (chlorophyll a, carotenoids and phycobiliproteins), nutrients uptake and tissue composition are measured. Specific growth rate, nutrient uptake, and pigments contents of *P. yezoensis* under different treatments will be presented. The results in the present study will provide critical information on potentiality of LED lighting for the cultivation of *Pyropia* and the selection of appropriate LED light for optimal production of *Pyropia*.

## PP 93

### Effect of Kelpak® on growth and temperature tolerance in *Pyropia*

**Yu Jung Cho**[*1], Jang K. Kim[1], Sookkyung Shin[1], Palas Samanta[1], Sojin Jang[1], Charles Yarish[1]

[1] *Marine Science, Incheon National University, Republic of Korea*

Seaweed extracts as biostimulants have recently received much attention.

Kelpak®, the extract from the brown seaweed Ecklonia maxima, is one of commercially available seaweed biostimulants. Kelpak® is known to stimulate the growth of plants over artificial fertilizer. However, few studies have conducted using Kelpak® in seaweed. The aim of this study is to investigate the effects of Kelpak® on growth performance and to determine how this extract affects the temperature tolerance in *Pyropia*. *Pyropia* is exposed to different concentrations of Kelpak® (0, 0.001, 0.005, 0.05 and 1 ml/L) for 30 and 60 minutes. For assessment of temperature tolerance, *Pyropia* is cultivated at four different temperature conditions, 10, 15, 20 and 25℃, for 15 days. *Pyropia* is cultured in von Stosch enriched (VSE) medium with germanium dioxide at 100 of irradiance, 12:12h light and dark photoperiod and 30 psu of salinity. The specific growth rate and cell structure of *Pyropia* at different Kelpak® treatments under different temperature conditions will be presented. The suitable concentration of Kelpak® and exposure time for optimal growth will also be determined for *Pyropia*. The results from this study will provide critical information if Kelpak® can be used in commercial *Pyropia* aquaculture in Korea.

## PP 94

### Commercial seaweed extract (AMPEP) effect on nutrient uptake, pigment and thermal resistance of *Gracilaria*

**Sookkyung Shin**[*1], Charles Yarish[2], Jang K. Kim[1]

[1] *Marine science, Incheon National University, Republic of Korea*
[2] *Department of Ecology and Evolutionary Biology, University of Connecticut, United States of America*

Water temperature is expected to continuously rise due to global climate change and will affect the seaweed aquaculture production. Therefore, it is very important to develop high temperature tolerant strains of seaweeds that can withstand the global climate change. Acadian marine plant extract powder (AMPEP) is a commercial extract of the brown seaweed, *Ascophyllum nodosum*. According to recent research, this commercial extract can enhance the temperature tolerance of some seaweed species. *Gracilaria* is one of the most cultivated seaweeds throughout the world. The aim of the present study is to determine the efficiency of commercial seaweed extract (AMPEP) on growth, nutrient uptake, pigment contents and thermal resistance of *Gracilaria*. *Gracilaria* tetrasporophytes are dipped in the extract solutions at different concentrations (0, 0.05 and 3 mg $L^{-1}$) for 60 min at the beginning of experiment. Gracilaria is cultivated in von Stosch enriched (VSE) medium at 12:12 L:D photoperiod and 160 ± 10 µmol $m^{-2}$ $s^{-1}$ of photosynthetically active radiation (PAR). To determine the thermal tolerance, *Gracilaria* tetrasporophytes are exposed to three different temperature conditions (20, 25 and 34℃) for a period of 20 days. Growth rate, pigment contents, total protein content and nutrient uptake of *Gracilaria* at different extract concentrations and temperature conditions are analyzed. The findings from this study will provide critical information if AMPEP can enhance growth and the quality of *Gracilaria*.

## PP 95

### Shell-inhabiting conchocelis growth characteristics of cultured *Pyropia* species in Korea

**Jin Suk Heo**[*1], Eun Jung Park[2], Dong Soo Ha[2], Han Gil Choi[3]

[1] *Aquatic Plant Variety Center, National Institute of Fisheries Science, Republic of Korea*
[2] *Seaweed Research Center, National Institute of Fisheries Science, Republic of Korea*
[3] *Faculty of Biological Science and Institute for Environmental Science, Wonkwang University, Republic of Korea*

In South Korea, seed industry of *Pyropia* species was only 13.6 billion won in 2017. However, it has been expected to create an added value of 3 trillion won including aquaculture production, processing as well as domestic and export market. Although, seeds of *Pyropia* species have an important industrial value involving *Pyropia yezoensis, Pyropia dentate* and *Pyropia seriata* in aquaculture of South Korea, the technology of shell-inhabiting conchocelis production culture was limited to Japanese aquaculture technology of the past only to P*yropia yezoensis*. Therefore, it is certainly necessary to improve *Pyropia* species shell-inhabiting conchocelis cultivation methods that can be applied to Korean patterns. Hence, our study was focused to produce shell-inhabiting conchocelis on the farm through means that was carried out by a variety of conditions such as five temperatures, six photon fluence rates and one photoperiods using five sizes of conchocelis. First, 0.1g of conchocelis was pulverized from 50ml of seawater using a blender and then was diluted 100 times. The 10ml diluted solution was used for experiment of various conditions. In conclusion, the production of infiltrating conchocelis to the oyster shell is controlled by the combination of the temperatures, photon fluence rates and size of conchocelis.

## PP 96

### Variation of the number of periphytic diatom *Licmophora* sp. according to the presence or absence of *Pyropia yezoensis* at low dissolved inorganic nitrogen concentration

**Kwanhyuk Kwak**[*1], Soung Youn Choi[1], Hyeon Jeong Lee[1], Ji Hyo Lee[1], Yong Yi Kim[1], Young Sik Kim[1]

[1] *Dept. of Marine Biotechnology, Kunsan National University, Republic of Korea*

The color change of Pyropia (laver) thallus from red to yellow or white, called 'Pyropia chlorosis', appears in the low concentration (< 5 µM L-1) of dissolved inorganic nitrogen (DIN) in seawater. The phenomenon is common at the western and southern laver cultivation farms in the Korean coastal water. In Pyropia cultivation farms, periphytic diatom Licmophora sp. is dominant and grows on thalli of Pyropia. Therefore, the objective of this study was to investigate the changes in the number of Licmophora sp. according to the presence or absence of Pyropia yezoensis at low DIN concentrations. The experiment was carried out on the three material sections; (P. yezoensis, Licmophora sp. and P. yezoensis + Licmophora sp.). It was carried out under different combinations of three nitrate concentrations (2.5, 5 and 10 µM) with potassium nitrate (KNO3) in artificial sea water medium, two temperatures (8 and 13 °C), 100 µmol photons m-2 s-1 and 12L:12Dh (light: dark) photoperiod regime for 12 days. At the end of the experiment, the number of Licmophora sp. and the concentration of DIN were counted and compared with the values before the start of the experiment. The number of Licmophora sp. cultured at a low concentration of less than 5 µM was higher than that of Licmophora sp. cultures grown with P. yezoensis and Licmophora sp. The difference increased with increasing concentration, and the DIN uptake was lower at low concentration than the other sections.

## PP 97

### The effects of temperature and irradiance on the growth of regenerated basal crust of *Gloiopeltis tenax* (Rhodophyta)

**Yong Yi Kim**[*1], Hyeon jeong Lee[1], Kwan hyuk Kwak[1], Young Sik Kim[1], Ki Wan Nam[2]

[1] *Marine Biotechnology, Kunsan National University, Republic of Korea*
[2] *Marine Biology, Pukyong National University, Republic of Korea*

The effects of varying temperature and irradiance on the growth of crust of the commercially important red alga *Gloiopeltis tenax* was investigated in laboratory cultures. Tetrasporophyte of *Gloiopeltis tenax* was sampled at Gyeokpori, Buan-gun, Jeollabuk-do seashore in Korea. The tetraspores developed into basal crusts. After spores had germinated to form basal crusts, the basal crusts were cut into quadrisect. The fragments of basal crusts were cultured at (10, 15, 20 and 25 ℃) temperature ranges and two irradiance ranges (30 and 85 μmol·m-2s-1) with a photoperiod 12L: 12Dh (light: dark). Regenerated basal crusts were developed for oval-cylindrical shapes. Under 85 μmol·m-2s-1 at 20 ℃, upright thalli was formed after 14 days of incubation while at 25 ℃, it was formed after 21 days. Under 30 μmol·m-2s-1 at 20 ℃, upright thalli were formed after 28 days of incubation. However, at 10 ℃ and 15 ℃ of all irradiance condition, upright thalli were not formed. Maximum growth rate of basal crust was recorded under 85 μmol·m-2s-1 at 20 ℃ while the minimum growth rate of basal crust was recorded 30 μmol·m-2s-1 at 10 ℃.

## PP 98

### Comparative growth of *Gelidium coreanum* (Gelidiales, Rhodophyta) in laboratory and in the field

**Jeoung Sook Ko**[*1], Chan Kil Chun[1], Sung Min Boo[2], Hyung Geun Kim[3]

[1] *Research Team, 21C Marine Development Company, Republic of Korea*
[2] *Biology, Chungnam National University, Republic of Korea*
[3] *Marine Bioscience, Gangneung Wonju National University, Republic of Korea*

*Gelidium* is an excellent source of food, agar, and agarose, and there is a great need of biomass for agar industry. However, because growth rate of *Gelidium* species is very slow, it is difficult to cultivate *Gelidium* species in fishery farms. We studied the seasonal growth pattern of *G. coreanum*, a recently described species from Korea, at Gamchusa on the east coast and compared its growth with regenerated fragments in laboratory culture. During January and March, thalli were creeping stolons and lacked secondary branches. In April to June, creeping stolons were elongated, and erect branches started to grow. In July to September, erect branches with secondary branches grew long. In October, thalli had many secondary and tertiary branches and tetrasporangia occurred on the upper parts of these branches. During November and December, thalli degenerated into creeping stolons. Laboratory culture of small fragments (5 mm in size) was maintained in f/2 medium at 20℃. Up to 20 primary branches arose from each fragment after 4 weeks of culture, and up to 60 secondary branches from each fragment were produced after 7 weeks of culture. Regenerated branches revealed rapid growth rate (SGR = 7.3±0.1% day1) after 11 weeks of fragment culture. Regenerated fragments grew up to 5 cm and formed many secondary and tertiary branches after 13 weeks, showing a typical form of field thalli. The prolific growth of regenerated fragments reveals that *G. coreanum* is a suitable candidate for mass cultivation in fishery farms.

## PP 99

### Growth and survival rates of *Sargassum macrocarpum* and *Ecklonia cava* transplanted on artificial reefs

**Jeong Chan Kang**[*1], Chong-Hyun Hong[2], Dae Jong Kim[3]

[1] *Phycology, Manta's Marine Lab., Republic of Korea*
[2] *Department of Civil Engineering, Jeju International University, Republic of Korea*
[3] *Jeju Marine Engineering & Construction, Republic of Korea*

The method of fixing holdfasts using zip tie on Poly Ethylene (P.E.) rope have been used for several decades for transplantation of the perennial laminarian algae such as *Ecklonia* spp., *Saccharina* spp. and *Eisenia* spp.. The transplantation methods of the order Fucales, such as *Myagropsis* and *Sargassum*, have been not available because the most of them have discoid or conical holdfast. We examined the growth and survival rates of the transplanted *Sargassum macrocarpum* fixed on artificial reefs using P.E. rope with epoxy resin adhesive and instant glue. For comparing the rates using zip tie, we also transplanted *E. cava* on the artificial reefs. The test groups were set to three groups, such as *Ecklonia, Sargassum* and mixed group, and monitored the number of survived individual and length of the frond by monthly. In the results, 44.1% of *E. cava* were survived and 56.9% of *S. macrocarpum* were survived after four months of transplantation. The survival rates were better in mixed group (64.1%) than *Ecklonia* group (45.0%) and *Sargassum* group (42.1%). The growth rate of *E. cava* was higher in mixed group (19.3%) than *Ecklonia* group (12.0%), while that of *S. macrocarpum* was higher in *Sargassum* group (19.5%) than mixed group (14.1%). This study indicates that the transplantation method used in this study is a very attractive technique for creating marine forests on the artificial reefs.

## PP 100

### Biorefinery processing of green macroalgae for the production of high added-value products

**Angelos Photiades**[*1], Ana Winters[1], Andrew Woolmer[2], Jessica Adams[1]

[1] *IBERS, Aberystwyth University, United Kingdom*
[2] *Bridge Innovation Centre, GreenSeas Resources, United Kingdom*

Eutrophication and climate conditions have promoted the exacerbation of algal phenomena in recent years. Scientists predict the rise of these occurrences with serious environmental and socioeconomic impact. Macroalgae have been widely used in cosmetics, food/feed industry and are considered a promising substrate in biogas production. Additionally, seaweeds appear to present particular interest for the medical sector due to their compositional characteristics, the properties of specific seaweed-derived compounds to interfere with cell functions, as well as their bio-stimulatory effect in plants. The present project intends to create a sustainable biorefining process pipeline able to extract and isolate compounds of particular interest such as pigments, polysaccharides, antioxidants, lipids, while optimizing the biogas production through anaerobic digestion and the production of efficient fertilizers, promoting circular economy and ecologically viable practices. Green extracting methods are applied, using Deep Eutectic Solvents (DES), for the optimization of the extraction process. Liquid chromatography-mass spectrometry (LC-MS) and high-performance counter-current chromatography (HPCCC) will be used for the identification/isolation of seaweed-derived compounds. Using DES and HPCCC will enable high-purity fractions of high-value compounds to be extracted from the algae which will be suitable for use in a wider range of end-products than those using currently available chemicals. LC-MS will provide identification confirmation and quality control. Findings from this project will assist *GreenSeas Resources* in identifying a range of new products for marketing and through them will benefit a number of industries servicing the growing natural product demand. These include the nutraceuticals, cosmetics and potentially pharmaceuticals markets.

## PP 102

### Empowering the *Gracilaria* producers in sorsogon

**Ida Capacio**[*1], Lilia Mabborang[2], Maria Janice Obias[3], Rey Samaniego[2]
[1] *Department of Agriculture, BFAR-National Seaweed Technology Development Center, The Philippines*
[2] *Department of Environment and Natural Resources, Provincial Environment and Natural Resources Office, The Philippines*
[3] *Department of Agriculture, Philippine Crop Insurance Corporation, The Philippines*

A Rural Development Action Plan and Project (RDAPP) was implemented to empower the Gracilaria Seaweed Producers of Sorsogon in four aspects: 1) Technical capability on *Gracilaria* farming and drying; 2) Link to market; 3) Operation and management of the Cooperative; and, 4) Economic opportunities on Gracilaria farming and trading. The project has focused on the newly organized Seaweed Farmers and Producers Cooperative (SSFAPCO) engaged on Gracilaria production and trading to serve as the pilot model. The current status of empowerment of SSFAPCO officers and members in terms of the four variables was assessed through Focus Group Discussion (FGD); Key Informant's Interview (KII) with the concerned government agencies; analysis of secondary data; and, actual field observations/immersions. The results showed that : 1. SSFAPCO officers and members were knowledgeable on the technical aspects of Gracilaria farming and drying but the practice of drying seaweeds is inappropriate; 2. SSFAPCO officers and members market fresh and dried Gracilaria to walk-in buyers. They do not have a target buyer for their produce. 3. Decision making and problem solving were perceived by the officers as most relevant basic skills in managing and operating the cooperative but rated themselves as moderately skilled on these aspects whereas, the members perceived teamwork as the most relevant and rated themselves as moderately skilled on said skill. 4. SSFAPCO officers and members have high expectations that Gracilaria farming and trading will improve their income having seen people succeed through this business, and taking into consideration the abundance and farm suitability of the resource in the area, the increasing demand of dried Gracilaria and agar in the international market, and the emerging industry for fresh and dried Gracilaria. The SSFAPCO officers and members need to enhance their capabilities on the 4 variables. Support and assistance from government agencies may be availed of through proper coordination.

## PP 102-1

### Indoor cultivation of *Pyropia tenera*

**Kyounghyoun Moon**[*1]
[1] *SEAWEED Inc. Fishery Company, Korea*

Global climate is changing rapidly every year. The climate change causes changes in water temperature. Many species would be suffering by change of temperature. Unfortunately, algae is one of the most sensitive plant about water temperature. Economically, seaweeds are more dependent than freshwater algae by climate. In Korea, *Pyropia*(laver) is very important seaweed for income of fisheries. Production of laver has been changing even until this year. Good and bad harvest appear every year alternately due to temperature. High water temperature causes serious disease; Red-rot disease, *Olpidiopsis*-bright and Green-spot disease. These diseases make thallus of *Pyropia* weak, yellowish and value of products are down finally. Above all, high temperature causes shorten of periods of cultivaition. General cultivation term of *Pyropia* is end of November untill May however end of present cultivation of *Pyropia* is on April. As losing about 1 month of cultivation term, production of *Pyropia* was decreasing. In the future, term of cultivation would be shorter than now if global climate chaging would not be solved. For that above reasons, we are doing a research about indoor cultivation of *Pyropia*. Water temperature, light sources and nurtrients are controlled in cultivation space. If optimal conditon of indoor cultivation would be equipped, indoor cultivation could be commercialization. Many species will be cultivated and cemercialized in isoloation.

## PP 103

### Darkness and low nighttime temperature modulate the growth and photosynthetic performance of *Ulva prolifera* under lower salinity

**Yahe Li**[*1], Mingshan Zheng[1], JiaJia Lin[1], Shidan Zhou[1], Tiancheng Sun[1], Nianjun Xu[1]
[1] *School of Marine Sciences, Ningbo University, China*

In order to understand how darkness/irradiance, as well as temperature might alter physiology of Ulva prolifera under lower salinity conditions, we analyzed the growth rates, water content, SOD activity, as well as total soluble protein and sugar at the end of dark and light period under three temperature levels (25--25°C treatment: 25°C for day and night; 15--15°C treatment: 15°C for day and night; 25--15°C treatment: 25°C for day with 15°C for night) and two salinity conditions (15, 25), meanwhile, the pigment content (chlorophyll a and b), chlorophyll fluorescence and photosynthetic oxygen evolution also were determined during light phase. We found that the U. prolifera showed higher growth rate and SOD activity during dark phase at 25°C, but this dark-induced increase could not be observed at 15°C. The reasons for this increase varied, however, maybe not included water content and total soluble protein content (SPs) for no significant difference in water content observed under all the treatments, and lower SPs were observed under dark period except for at 15°C and salinity 15. Compared to other two temperature treatments, the thalli grown under 25--15°C treatment, showed higher growth rate and the photosynthetic oxygen evolution rate in light phase under salinity 15 conditions, although the maximum rate of rETR (rETRmax) showed higher value at day and night temperature 25°C conditions. These results indicate that the darkness and the lower temperature in dark phase maybe responsible reason for the rapid growth of these green tide algae.

## PP 104

### Macroalgal blooms: is the sustainable harvesting of opportunistic macroalgae a solution for associated ecological, social and economic problems?

**Catherine Oliver**[*1], Pippa Moore[1], Andrew Woolmer[2], Jessica Adams[1]
[1] *Institute of Biological, Environmental and Rural Sciences, Aberystwyth University, United Kingdom*
[2] *N/A, GreenSeas Resources, United Kingdom*

Eutrophication, coupled with the reduction of herbivorous grazers from marine, coastal and estuarine ecosystems can cause unwanted macroalgal blooms globally. Opportunistic macroalgal blooms (predominately *Ulva* spp.) are increasingly becoming a problem in Milford Haven Estuary, southern Wales, United Kingdom, where the waterbody has recently been classified as 'unfavourable status' in the European Union Water Framework Directive. This project, which commenced in September 2018, aims to assess: A) the biomass in the estuary; B) affected habitats and species;

C) nutrient sequestration; D) macroalgal species composition and E) socio-economic costs related to public goods and services. The project is working alongside GreenSeas Resources, a company who intend on sustainably harvesting macroalgal blooming species in the estuary. The methods will include satellite and aerial mapping of biomass hotspots; DNA species sequencing; bird ethogram surveys; infauna sampling; crustacean trapping and macroalgal clearance experiments which will be coupled with socio-economic surveys to create a mixed-methods approach. Preliminary data from Unmanned Aerial Vehicles (UAVs) have been used to create 2D and 3D models of macroalgal bloom hotspots which can be used to calculate the biomass available for sustainable harvesting. Alongside assessing the ecological, social and economic impacts of harvesting macroalgae in Milford Haven, it is hoped that removal of macroalgae via harvesting may be able to translate into a local nutrient trading scheme due to *Ulva* spp. having the capacity to sequester excess nutrients and heavy metals. By combining traditional and novel techniques to collect data regarding ecological, social and economic impacts related to nuisance macroalgal blooms in the UK, we hope to demonstrate a value in removing excess opportunistic macroalgae via harvesting. Furthermore, findings from this project will be globally relevant. This project is funded by the European Social Fund and GreenSeas Resources which is facilitated by KESS 2.

## PP 106

### Extraction and characterization of antioxidant compounds in *Sargassum* spp. from the Mexican Caribbean

**Adrian Fagundo Mollineda**[*1], Yolanda Freile Pelegrin[1], Emanuel Hernandez Nuñez[1], Daniel Robledo[1]

[1] *Marine Resources, CINVESTAV, Mexico*

Antioxidant compounds have a high importance as metabolites isolated from plant organisms, due to their wide variety of uses and applications. Phenols are among the main compounds reported as antioxidants. The efficient extraction of these compounds depends on the method of stabilization of the biomass as well as the extraction solvents and their correct polarity. *Sargassum* species, which are abundant in tropical and subtropical Seas are becoming a problem due to their recurring influx into the Caribbean Sea. In this work the content of phenolic compounds in different species of *Sargassum* (*Sargassum* sp., *S. fluitans* and *S. natans*) was evaluated using different stabilization methods of the biomass (dried, lyophilized and fresh) and different proportions of extraction solvents i.e. Ethanol (ET) 100%, H2O/ET in the following proportions (2:1; 1:1). The phenolic compounds were extracted further analysis of their antioxidant activity (DPPH) and characterization by means of NMR. The extracts from fresh biomass showed the highest polyphenol content, between 3.9 ± 1.82% and 4.0 ± 1.87%. The extracts obtained with a H2O/ET (2:1) mixture showed greater antioxidant activity at the concentration of 0.64 µg / ml, as well as a higher quantity of phenols. The extraction made with 100% ethanol did not turn out to be efficient (0.13 µg / mL). The drying of the *Sargassum* biomass in an oven at 60ºC reduces the number of phenolic compounds and their antioxidant activity. The spectra obtained by 1H NMR showed 3 main phenols in the aromatic region. In addition, mannitol was identified as a major component in all trials and other minor compounds were found (amino acids, lipids and biogenic amines). The most efficient method for the extraction of phenols turned out to be with the fresh biomass with H2O / ET 2:1.

## PP 107

### Gauging the impact of climate change on the physiology of the mangrove-associated *Bostrychia tenella* (Rhodophyta)

**Sze-Wan Poong**[*1], Sing-Kit Thian[1,2], Phaik-Eem Lim[1], John Arthur West[3], Acga Cheng[2], Siew- Moi Phang[1]

[1] *Institute of Ocean and Earth Sciences, University of Malaya, Malaysia*
[2] *Institute of Biological Sciences, Faculty of Science, University of Malaya, Malaysia*
[3] *School of BioSciences 2, University of Melbourne, Australia*

Climate change, which includes global warming and changes in precipitation patterns, is identified as a significant threat to various marine ecosystems. Below-average rainfalls, drought, record high temperatures, increased evaporation and lower sea levels due to El Nino have been reported as the main climactic drivers of mangroves diebacks. Mangroves provide essential ecosystem services including filtering water runoff from the land, breeding grounds for fish stock and absorbing large amounts of carbon from the atmosphere. Likewise, mangrove-associated seaweeds such as *Bostrychia tenella* are important as primary producers and they serve as food and shelter for invertebrates and juvenile fishes of various species. Changes in environmental parameters such as elevated temperature reportedly led to adverse effects to the physiology and the productivity of diverse seaweed species, and this will indirectly impact the energy and nutrient transfer throughout the food chain and may eventually affect the sustainability of the fisheries industry. The present study was undertaken to determine the growth including fresh weight and pigment content, and photosynthetic responses of *B. tenella* to increased salinity (i.e. 30, 35, 40 and 45 psu) and temperature (i.e. 28, 32, 36, and 40 °C). Growth and photosynthesis of *B. tenella* were adversely affected at above 36°C and incubation at 40°C led to loss of pigmentation and biomass and reduced maximum quantum yield within six days. The seaweed, however, displayed good salinity tolerance within the test range, presumably owing to its natural habitat which experiences frequent fluctuations in salinity. These results allow us to assess the resilience of *B. tenella* to climate changes and to subsequently generate projection of climate change vulnerabilities and impacts on the important marine resources. More intensive efforts in mitigation of climate change are vital not only for a sustainable blue economy but also to enhance the resilience of marine ecosystems.

## PP 108

### *Gracilariopsis lemaneiformis* in the future ocean: potential for carbon acquisition, PSII function and biochemical production

**Chunxiang Liu**[*1], Dinghui Zou[2], Zhiwei Ji[2]

[1] *Iollege of life science, Huaibei Normal University, Anhui,China, China*
[2] *School of Environment and Energy, South China University of Technology, China*

Impacts of ocean warming, elevated $CO_2$ and eutrophication on the physiological properties of Gracilariopsis lemaneiformis were investigated. Thalli were cultured at two levels of: temperature (20 ℃, LT; 24 ℃, HT), $CO_2$ levels (400 µl $L^{-1}$, LC; 1000 µl $L^{-1}$, HC) and nutrients (low (LN)-25 µM N as nitrate and 2.5 µM P as phosphate; high (HN)-500 µM N and 50 µM P) for 2 weeks. The growth, photosynthesis and biochemical components were determined. Both the photosynthetic- (Pm) and respiratory (Rd) rates were sensitive to measurement temperature, with the Q10 values being higher in 24 ℃- than 20 ℃-grown algae. The enhancement of Pm rates was much larger than that of Rd rates response to higher temperature.

As a result, the photosynthetic products (soluble carbohydrates, SC contents) accumulated to higher level as temperature increased. HTHCHN significantly decreased the maximum electron transport rates (rETRm) but increased the electron transport in an active reaction center (ETo/RC), maximum quantum yield of primary photochemistry (ψPo), the quantum yield of electron transport (ψEo) compared with the control (LTLCLN). Compared to LC, HC significantly decreased the density of reaction centers (RC/CS) ratios, and such decline was much alleviated when temperature rose. The nitrate reductase activity (NRA) decreased obviously when the appearance of HN levels in contrast with the control. The antioxidant characteristics (super oxide dismutase, SOD; catalase, CAT; peroxidase, POD; malondialdehyde, MDA) were nearly unchanged among treatments. Additionally, LTHCLN increased the relative growth rates (RGR) by 86.2% but decreased the contents of chlorophyll a (Chl a), carotenoids (Car), phycoerythrin (PE), phycocyanin (PC) by 48.6%, 41.7%, 24.7% and 47.8%, respectively, compared with the control. We suggested that the capacities for carbon acquisition and PS II function of *G. lemaneiformis* might be enhanced with the future warming ocean and/or increased N loading resulted from coastal eutrophication.

## PP 109

### The interactive effects of elevating temperature and nutrient concentrations on the *Ulva linza* Linnaeus (Ulvales, Chlorophyta)

**Jee Eun Lee**[*1], Jin Woo Kang[2]

[1] *Seaweed Research Center, National Institute of Fisheries Science, Republic of Korea*
[2] *Project Management Division, East Sea Branch, Korea Fisheries Resources Agency, Republic of Korea*

In coastal areas, environmental problems such as ocean warming and eutrophication were affected physiology of marine macroalgae. We tested the interactive effects of increased temperature and nutrient levels on physiological reactions such as photosynthetic rates, NH4+ uptake rates, relative growth rates, chlorophyll fluorescence, and tissue nutrient contents. The experiments were conducted at four temperature (15, 20, 25, and 30 °C) and three NH4+ concentrations (4, 60, and 120 μM). The interaction between temperature and NH4+ levels were influenced photosynthetic rates, uptake rates of NH4+, relative growth rates, photosynthetic efficiencies, tissue nitrogen contents, and C:N ratios within the tissues. Temperature strongly affected photosynthetic rates, NH4+ uptake rates, and photosynthetic efficiencies. Nutrient enrichments enhanced photosynthetic rates, nutrient uptake rates, relative growth rates, photosynthetic efficiencies, tissue nitrogen contents, and tissue C:N ratio. Our study results could help to understand the physiological responses of U. linza under future ocean environmental conditions such as ocean warming and eutrophication.

## PP 111

### Scotland's blue carbon: the contribution from seaweed detritus

**Alasdair O'Dell**[*1], Michael T. Burrows[1], Dan A. Smale[2], Pippa J. Moore[3]

[1] *Ecology, Scottish Association for Marine Science, United Kingdom*
[2] *Ecology, Marine Biological Association, United Kingdom*
[3] *Animal and Aquatic Sciences, Aberystwyth University, United Kingdom*

Macroalgae are now widely accepted as contributors to 'blue carbon' stores (the carbon sequestered by marine autotrophs), and play a significant role in fixing atmospheric and oceanic CO2. Kelp regularly produces a large amount of biomass as detached plants and fragments during storms and as a natural part of its life cycle. The role this detritus plays in long-term carbon sequestration is not well understood. This study aims to uncover the factors that indicate detrital production, accumulation and movement on temperate beaches, and how this relates to gross detrital production and carbon storage. To understand the processes of deposition, movement and re-suspension of beach-cast detritus, this study used Unmanned Aerial Vehicles (UAVs) and 3D photogrammetry combined with ground-based studies to monitor beaches with detrital accumulations in the Oban area. Quadrats were used to assign detritus to abundance categories at 1m intervals along transect lines, the weight of seaweed detritus and different parts of the seaweed thallus were further recorded in quadrats at 4m intervals along the same transects. 3D models of beaches, including piles of cast weed, and repeated monthly surveys of beach-cast detritus allowed estimates of the volume and mass of detritus to be compared across beaches and among the different months measured. Differences in the composition of detritus (i.e. stipe, blade and holdfast) were also seen among beaches. Large changes in detritus volume appear after storm events and deposits of seaweed appear to change with the direction beaches face. Differences among beaches are highlighting where and when seaweed detritus is being generated. The seasonal and spatial changes in composition may have consequences for variation in production of particulate material as well as transportation of nutrient rich material away from beaches.

## PP 112

### Effects of carbon dioxide levels on sea lettuce, *Ulva rigida* C. Agardh (Ulvales, Chlorophyceae)

**Rapeeporn Ruangchuay**[*1,2], Arnas Intan[1], Nuttapong Bovornreungroj[1]

[1] *Department of Technology and Industries, Prince of Songkla University, Thailand*
[2] *Discipline of Excellence in Sustainable Aquaculture, Prince of Songkla University, Thailand*

A study on effect carbon dioxide on growth of sea lettuce, *Ulva rigida* C. Agardh in a photobioreactor was aimed for environmental arrangement. The concentration carbon dioxide was used in 3 levels: 0, 1, 3 % volume/volume with air flow rate of 3 L $min^{-1}$ in 12.0 liters of polyethylene bioreactor which set at 25±2°C, 30 ppt salinity under 12L:12D photoperiod, 40 umol $m^{-1}s^{-2}$ light intensity. The round shape of the algal tissue in 1 cm diameter were used with the initial weight of 0.05 g $L^{-1}$ The wet weight and diameter length of the alga were measured in every week for 4 weeks. Photosynthetic efficiency, photosynthetic pigments, and color of tissue were check. Some water quality parameters were investigated. The result showed that significant growth of the alga at 1% carbon dioxide provided the highest growth and followed by 3 and 0 % with the final weight of 0.23±0.03, 0.20±0.02 and 0.19±0.02 g $L^{-1}$, respectively and the specific growth rate by weight of 2.47±0.38, 2.36±0.45 and 2.32±0.47 g $day^{-1}$, respectively, and the percentage of increased weight of 52.52±28.21, 35.33±14.05 and 29.67±12.56 %, respectively. The addition of carbon dioxide in different concentrations provided a different of pH, hardness and alkalinity but a*, b* and L* color showed non-significantly differences among the treatments. Chlorophyll a and be content showed not significantly differences. Maximum photosynthetic production was achieved in the increasing of 1% carbon dioxide. No reproductive formation during the period but sexual reproductive and zooid were achieved in the tissue treated with 3% of carbon dioxide. Thus, tissue culture of Ulva rigida under 1% carbon dioxide at 40 umol $m^{-1}s^{-2}$, 30 ppt salinity and 12L:12D provided the maximum biomass within 3 weeks. At 3% of carbon dioxide addition will inhibit the growth of the alga but

stimulate the reproductive cell.

## PP 113

### Physiological response of *Ulva lactuca* to ocean acidification in nitrogen-limited environment

**Jianrong Xia**[*1], Yingying Jiang[1]
[1] *Environmental Science and Engineering, Guangzhou University, China*

The rise of atmospheric $CO_2$ is expected to lead to ocean acidification and global warming which will induce changes in nutrient supplies in the ocean. These changes can affect the physiological performance of phytoplankton. In this study, we investigate the physiological response of *Ulva lactuca* to three levels of $CO_2$(aq) (HC, IC and LC) at nitrogen-limiting condition. Our results show that increasing $CO_2$(aq) concentration promotes its growth and increase the maximum photosynthetic rate(Vmax), pigment content (chla and Car), Rubisco and nitrate reductase (NR) activity, and decrease the content of soluble protein, however did not significantly affect carbonic anhydrase (CA) activity under the N-limiting environment. Moreover, the actual photochemical yield of PSII (Yield) increased and the non-photochemical quenching coefficient (NPQ) decreased. The results suggested that the response of *Ulva lactuca* to ocean acidification by $CO_2$ enrichment in N-limitation were diversified by regulating the energy allocation, CCM activity and C fixation enzyme.

## PP 114

### Effect of fresh diet of macroalgae on survival, growth, feed conversion and gonadic index of the sea urchin *Loxechinus albus* in laboratory, Puerto Montt, Chile

**Marcela Avila**[*1], Gesica Aroca[1], Ricardo Riquelme[1], María Inés Piel[1], Eduardo Bustos[1,2], Andres Mansilla,[3,4]
[1] *Instituto Ciencia y Tecnología, Universidad Arturo Prat, Chile.*
[2] *Aquaculture and Fisheries Research Center, Santo Tomas University, Puerto Montt*
[3] *Laboratory of antarctic and subantarctic Marine Ecosystems. University of Magallanes, Chile*
[4] *Institute of Ecology and Biodiversity(IEB), Chile*

The red sea urchin is an echinoderm of economic and social importance in Chile. The objective of this work was to evaluate the effect of four species of seaweeds on survival, growth, gonad color, feed conversion and gonad index of juvenile sea urchins in laboratory. Individuals of 30-40 mm diameter, were collected at Maullín, Chile and acclimated for 7 days in laboratory at 10 °C with permanent aeration. As a first experiment to select best fresh macroalgae in growth 4 treatments were performed: *M. pyrifera*, *Pyropia* sp., *S. crispata* and *Ulva* sp. Three replicates were used in each treatment and sea urchins were maintained in aquarium of 10 L capacity for 83 days. A second experiment was performed to compare the effect of inert diet with selected seaweed. Seawater and food were renewed weekly, weight of sea urchins was recorded every two weeks. In all treatments a survival of 100% of sea urchins was observed. Growth rate was higher in sea urchins fed with *M. pyrifera* (0.35%/day) and *Ulva sp.* (0.39% / day) ($p < 0.05$). Maximal consumption was recorded with *M. pyrifera*, resulting in a higher feed conversion index (44 ± 1.6 g / g), while S. crispata was lower (32 ± 3g / g). *Pyropia sp.* and *Ulva* sp., were lower with 17 and 20 g/g, respectively ($p < 0.05$). After 3 months of culture, all the individuals developed gonads, achieving the highest gonadic index with *Pyropia sp*. (3.6%) compared to *S. crispata* (1.7%). In the second experiment best growth was achieved with fresh seaweeds (0.5%/day). The highest levels of gonad coloration were reached with *M. pyrifera* (dark yellow to light yellow), followed by *Pyropia* sp. (yellow to pale yellow). The obtained results will be used to formulate diets for the production of juveniles of *L. albus* in hatchery.

## PP 115

### A benthic marine algal community characteristics of Ulleung-do and Dok-do, Eastern Coast of Korea

**Seung Wook Jung**[*1], Chang Geun Choi[1]
[1] *Ecological Engineering, Pukyong National University, Republic of Korea*

A benthic marine algal community of Ulleung-do and Dok-do, located on the eastern coast of Korea, were investigated by quantitative survey using a quadrat(50㎠) method during 2017 to 2018. A total of 177 species were identified, including 11 Chlorophyta, 38 Phaeophyta, and 128 Rhodophyta. The biomass(dry weight) was 132.94g/㎡(including 0.85g/㎡ Chlorophyta, 95.61g/㎡ Phaetophyta, and 36.48g/㎡ Rhodophyta) in Ulleung-do and 1,054.34g/㎡(including 1.99g/㎡ Chlorophyta, 999.96g/㎡ Phaetophyta, and 52.39g/㎡ Rhodophyta) in Dok-do. The benthic marine algal community state of Ulleung-do was confirmed as "Good-High" and Dok-do as "High" according to EEI-c model. In order to investigate the change of benthic marine algal community characteristics, compared with previous studies. It was compared with Kim et al. (2016), the number of species was similar to 148 species, and the average dry weight was higher than 94.8g/㎡ in Ulleung-do. It was compared with Choi et al. (2009), number of species was about twice of 95 species, and the average wet weight was 1.6 times higher than 1,834.77g/㎡ in Dok-do. These results showed that Ulleung-do and Dok-do maintain healthy marine algal communities dominated by kelp species from the past to the present, and continuous monitoring and conservation survey are required to maintain these excellent benthic marine algal communities.

## PP 116

### Marine algal flora and invertebrate fauna of uninhabited island in Sinan-gun, Jeollanam-do, Korea

**Chang Geun Choi**[*1], Seung Wook Jung[1], Hyung June Kim[2]
[1] *Dept. of Ecological Engineering, Pukyong National University, Republic of Korea*
[2] *Dept. of Taxonomy and Systematics, National Marine Biodiversity Institute of Korea, Republic of Korea*

This study was conducted in the summer of 2018 to investigate the marine algal flora and invertebrate fauna of uninhabited islands located in Sinan-gun, Jeollanam-do. A total of 41 uninhabited islands were surveyed, and the survey method was applied qualitatively to marine biota. The survey area was selected for the intertidal zone based on spatial distribution, management type, and survey type. As a result of the survey, total of 37 species, 7 of green algae, 8 of brown algae, 22 of red algae, and 90 of invertebrates were appeared. Because uninhabited islands are not a lot of people's activities and is free from pollution sources, it has a unique biota or characteristics for a long time. Among the growing species, *Silvetia siliquasa* (brown algae) and *Gloiopeltis furcata* (red algae) are useful algae that can be used variously for anti-aging and anti-cancer. Recently, the growth of these marine algae in the coast of Korea is rapidly declining, and habitat preservation and species maintenance are very urgent. Uninhabited islands are designated as available, developable, and absolute conservation depending on the management type, and there is

a need to investigate the conservation value of the natural environment and ecosystem. In addition, underwater scenery needs to be preserved even if its value is high, and there is a risk of pollution and damage of coast area, so it is necessary to approach restoration and improvement instead of necessity of utilization and development.

## PP 117

### Depth-related responses of kelp *Ecklonia cava* community to seasonal disturbance in Jeju Island, Korea

**Sangil Kim**[*1], Hyuk Je Lee[2], Sang Rul Park[3]

[1] *Ocean Climate & Ecology Research Division, National Institute of Fisheries Science, Republic of Korea*
[2] *Biological Sciences, Sangji University, Republic of Korea*
[3] *Marine Life Sciences, Jeju National University, Republic of Korea*

*Ecklonia cava* is the dominant species of kelp forests on the eastern and southern coasts of Korea, including the area around Jeju Island. This species is a primary producer and provides habitats, shelter and nursery areas for commercially and ecologically valuable marine organisms. However, *E. cava* bed has been regularly destroyed or damaged by large-scale disturbance, typhoons. Recently, intensity, frequency and timing of typhoon have been increased or changed by climate change. The aim of this study was to investigate responses of *E. cava* community to the large disturbance. We hypothesized that timing of disturbance affects post-disturbance recolonization, which was related with water depth. Sixteen permanent plots (50 × 50 cm) were set up, with seasonal disturbance (spring vs. fall) and water depth (5 m vs. 10 m) incorporated into the experimental design at the study site (Munseom Island) in Jeju Island, Korea. We also established four permanent unmanipulated plots to monitor natural seasonal variation in benthic community abundances. In 2-3 months after the disturbance, understory macroalgae was rapidly recovered in both spring- and fall -removed plots. *Ecklonia cava* in fall-removal plots was recruited in large numbers in spring, 6 months after fall disturbance and dominated at both 5 m and 10 m of water depth. In spring-removal plot, a large number of Sargassum recruitment were observed at 5 m of water However, *Sargassum* and *E. cava* co-dominated at 10 m of depth water. The recruitment and settlement of *E. cava* were suppressed by *Sargassum*, indicating alternative state by replacement of dominant species in the macroalgal community. Thus, *E. cava* community responses to seasonal disturbance can be greatly affected by the recruiting time of dominant species at each depth. This study will provide valuable information in making management policy for restoration and conservation of *Ecklonia* community under global climate change.

## PP 118

### Evaluations and comparisons in carbon and nitrogen stable isotopes and in heavy metal contents of mariculture kelp *Undaria pinnatifida* and *Saccharina japonica* in Gijang, southeastern Korea

**Jeong Hee Shim**[*1], Jeong Bae Kim[2], Dong-Woon Hwang[2], Jeong-Min Shim[1]

[1] *Fisheries Resources and Environment Research Division, East Sea Fisheries Research Institute, Korea*
[2] *Marine Environment Research Division, National Institute of Fisheries Science, Korea*

Korean mariculture *Undaria pinnatifida* and *Saccharina japonica* were collected during their culturing seasons in 2010 and 2011 to investigate the changes in the carbon and nitrogen stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) and heavy metal with respect to those growth and to identify the factors that influence such changes. The blades of *U. pinnatifida* and *S. japonica* showed $\delta^{13}C$ in the range (mean) of -13.11 to -19.42‰ (-16.93‰) and -11.68 to -18.62‰ (-15.09‰), respectively. And for $\delta^{15}N$, the range (mean) in *U. pinnatifida* and *S. japonica* were 2.99 to 7.57‰ (4.71‰) and 5.82 to 8.35‰ (7.24‰), respectively. There was a very high positive linear correlation between the monthly average $\delta^{13}C$ and the absolute growth rate in weight ($r^2 = 0.89$) in *U. pinnatifida*, whereas little relations between δ13C and the growth rate in *S. japonica*. However, nitrogen isotope ratios in both species tended to be relatively lower when nitrogen content in the blades were higher, probably due to the strengthening of isotope fractionation stemming from plenty of nitrogen in the surrounding environment. In fact, very high negative linear correlations were observed with the nitrate concentrations in the nearby seawaters ($r_2 = 0.83$ and 0.90). Concentrations of Cu, Cd, Pb, Cr, Hg, and Fe in the blades showed a rapid decrease in their concentration per unit weight and/or per unit length in the more mature *U. pinnatifida* and *S. japonica*. Specifically, compared to adult samples, Cu, Hg, and Pb in the young blades were concentrated by 30, 55, and 73 folds in *U. pinnatifida*, and by 29, 2, 16 folds in *S. japonica*, respectively. Therefore, $\delta^{15}N$ values and heavy metal concentrations in both *U. pinnatifida* and *S. japonica* serve as tracers that reflect the environmental characteristics, while *U. pinnatifida* tissue $\delta^{13}C$ is as an indirect indicator of its growth rate.

## PP 119

### *Lessonia berteroana* in northern Chile: effects of harvest on populations and communities

**Julio A. Vasquez**[*1]

[1] *Departamento de Biología Marina, Facultad de Ciencias del Mar, Universidad Católica del Norte, Chile*

Chile provides 10% of the world's biomass of brown algae for alginate production, exceeding 400,000 dry tons/year. Since there are no aquiculture of Brown seaweeds, all the biomass landed comes from natural populations, constituting the artisanal benthic fishery of greatest social and economic importance in the north of the country. Direct and indirect sampling (use of drones and multi-expectral images) of *Lessonia berteroana* (2017-2018), in intertidal rocky environments, show effects of its intense harvest and collection, despite the restrictions imposed by the State, which prohibits direct harvesting and limits the collection of plants cast ashore. Evaluations of standing stock and standing crops in exposed rocky intertidal areas show populations of *Lessonia berteroana* with high density of juvenile individuals, which contribute little to the harvestable biomass. As a consequence, populations are composed mainly by juvenile individuals presenting: (1) a low frequency of reproductive structures, which negatively impacts on the dynamics of replacement of adult sporophytes, (2) small plants shows reproductive structures, showing a "juvenileization" of natural populations, (3) a significant loss of invertebrate biodiversity associated to adult plants, and (4) a decrease in the available biomass of adult plants, strongly impacting the brown seaweed fishery and the economy of artisanal fishermen.
The decrease of employment in mining activities as a consequence of the low price of copper, and the pressure of international markets for raw material for the extraction of high viscosity alginates, contribute negatively to the restoration of natural population of *Lessonia* in northern Chile.

## PP 120

## Environmental factors (nitrogen, light and temperature) effects and genetic background implications on the reproduction success of the giant kelp *Macrocystis pyrifera*

**Alejandro Buschmann**[*1], Sandra Pereda[1], Karina Villegas[1], Luis Vallejos[1], Maria C. Hernández-González[1], Robinson Altamirano[1], Carolina Camus[1]
[1] *Centro i-mar & CeBiB, Universidad de Los Lagos, Chile*

*Macrocystis pyrifera* has a highly variable morphology, but we still don´t understand how morphological plasticity can contribute to explain adaptations to different environment and to maintain high productivity. Also, it seems that kelp morphology has a genetic background. Yet, the expression of the sporophyte morphology and physiology goes through a "black box" of biological processes during kelp microscopic stages. Evidence shows that gametophytes can respond in complex ways to environmental factors; therefore, it may have implications on population dynamic and productivity. We hypothesise that environmental factors, regardless the genetic background of *Macrocystis*, determine developmental pattern and reproduction potential of female gametophytes, producing sporophytes with different morphologies. Fertile sporophylls were collected from 2 genetically distinct *Macrocystis* populations (Central and Southern Chile). Sporulation was induced following established protocols, and zoospores were collected (pure Valparaíso, pure Los Lagos and Valparaíso-Los Lagos mixed) for seeding petri dishes with known zoospore concentration. Two set of experiments under controlled conditions were run: 1) temperature (8°, 16° and 18 °C) versus nutrient concentration (seawater + full Provasoli and seawater + N-limited Provasoli); and 2) temperature (as before) versus photon flux (5-8 and 40-45 µmol $m^{-2}$ $s^{-1}$) with no nutrient limitation. We determined germination success, gametophyte size and density, number of oogonia and embryonic sporophyte per female gametophyte. These are the first results of an ongoing research and they show morphological plasticity in female gametophyte; as well as, differential responses of microscopic phases to environmental factors (temperature, nitrogen and light). Significantly better results were achieved for cultures at 16°C + full Provasoli, independently of the sporophyll´s origin. However, when light intensity is included, the effect of the genetic background cannot be fully ruled out. So far, our preliminary results show no mayor effect of genetic background during early development of kelp, but physiological parameters remain to be measured.

## PP 121

## Photosynthetic activity including the chilling-light sensitivity of a temperate Japanese brown alga, *Sargassum macrocarpum*

**Ryuta Terada**[*1], Yuto Nakashima[2], Iris Ann Borlongan[1], Hiromori Shimabukuro[3], Jumpei Kozono[1], Hikaru Endo[2], Satoshi Shimada[4], Gregory N. Nishihara[5]
[1] *United Graduate School of Agricultural Sciences, Kagoshima University, Japan*
[2] *Faulty of Fisheries, Kagoshima University, Japan*
[3] *National Research Institute of Fisheries and Environment of Inland Sea, Japan Fisheries Research and Education Agency, Japan*
[4] *Faculty of Core Research, Natural Science Division, Ochanomizu University, Japan*
[5] *Institute for East China Sea Research, Nagasaki University, Japan*

The effects of irradiance and temperature including the chilling-light stress on the photosynthesis of a temperate alga, *Sargassum macrocarpum* (Fucales) were determined by the Pulse amplitude modulation (PAM)-chlorophyll fluorometer and dissolved oxygen sensors. Oxygenic photosynthesis–irradiance curves at 8, 20, and 28°C revealed that the maximum net photosynthetic rates (NPmax) and saturation irradiance were highest at 28°C, and lowest at 8°C. Gross photosynthesis and dark respiration determined over a range of temperatures (8–36°C) at 300 µmol photons m-2 s-1 revealed that the maximum gross photosynthetic rate (GPmax) occurred at 27.8°C, which is consistent with the highest seawater temperature in the southern distributional limit of this species in Japan. Additionally, the maximum quantum yields of Photosystem II (Fv/Fm) during the 72-hour temperature exposures were stable at 8–28°C, but suddenly dropped to zero at higher temperatures, indicative of PSII deactivation. Continuous exposure (12 hours) to irradiance of 200 (low) and 1,000 (high) µmol photons m-2 s-1 at 8, 20 and 28°C revealed greater declines in their effective quantum yields (ΦPSII) under high irradiance. While ΦPSII under low irradiance were mostly consistent with the initial at 20 and 28°C during exposures, values were apparently low at 8°C. Their final Fv/Fm were not restored to initial even after 12 hours of dark acclimation, suggesting the sensitivity of the alga to photoinhibition at such low temperature. These photosynthetic characteristics reflect both the adaptation of the species to the general environmental conditions, and its ability to acclimate to seasonal changes in seawater temperature within their geographical range of distribution.

## PP 122

## Comparison of spatio-temporal distribution characteristics of phytoplankton at four weirs in the downstream of the Nakdong River

**Yeon-Jeong Park**[*1], Kwangsoon Choi[1], Suna Chong[1], Hye-Suk Yi[1], Seungryong Baek[1], Jisun Yu[1], Yu-Sik Jeong[1], Heesuk Lee[1]
[1] *Water Resources Research Center, K-water Research Institute, Republic of Korea*

Harmful Algal Blooms are caused by a variety of environmental factors, such as increases in the water temperatures due to climate change which could favor the persistence of cyanobacteria blooms during the summer period. In this study phytoplankton analyses were carried out at the four main weirs in the downstream of the Nakdong River (Gangjeong-Goryeong weir, Dalseong weir, Hapcheon-changnyeong weir and Changnyeong-Haman wier) from May to December in 2017 and April to November in 2018. Each weir was analyzed at nine points such as the left side (upper, middle, and lower), middle area (upper, middle, and lower), and right side (upper, middle, and lower) at representative points in the Nakdong River. In 2017, *Aphanizomenon* appeared as a dominant species at all nine sites in Gongjeong-Goryeong weir in June and was the dominant species again between October and December. However, in 2018, it did not reappear as a dominant species in October-December. *Microcystis* was the dominant species at all of the nine sites in the year 2017 from the beginning of July. In 2018, however, other species including *Microcystis* were dominated in nine sites except the dominant sites in Dalseong weir from the beginning of August. However, in the places where they appeared as dominant species, they showed higher cell densities in comparison with 2017. This is due to the combination of various environmental factors, including rainfall in May and June of 2018 compared with 2017, and the persistent summer heat from mid-July to late August after a short rainy season that concluded in early July. By analyzing the spatio-temporal distribution and the seasonal transition of nine points in each of the four weirs in the downstream of the Nakdong River, it is possible to obtain objective and reliable data for the selection of future monitoring points.

## PP 123

## Population biology and chemical composition of the edible red alga *Callophyllis variegata* (Rhodophyta; Cryptonemiales) in southern Chile

**Renato Westermeier**[*1], Marcela Robles[1], Marisol Barría[1], David Patiño[1], Liliana Muñoz[1], Pedro Murúa[2], Dieter Müller[3]

[1] *Acuicultura, Universidad Austral de Chile Sede Puerto Montt, Chile*
[2] *PDRA in Molecular Algal Pathology Sams, Scottish Marine Institute, United Kingdom*
[3] *Fachbereich Biologie, Konstanz Univerity, Germany*

The cosmopolitan red alga *Callophyllis variegata* has been harvested since 1997 in southern Chile, and exported as food alternative to Asia. This study aimed to describe temporal changes in population structure and chemical composition by comparing intact (Pichicuyén) and exploited populations (San Antonio) of southern Chile. Abundance parameters and size classes were higher in summer months, whereas reproductive stages (tetrasporophytes and carposporophytes) were more abundant in autumn – winter periods. Recruitment was plentiful towards late winter – spring months. Geographical differences were also detected and San Antonio –the disturbed sector where *C. variegata* landings have been reported since several years- exhibited lower productivity but similar coverage in comparison to Pichicuyen (intact location). Phosphorous, protein, lipid, soluble carbohydrate and fiber composition also showed a clear seasonal trend, but expectably no differences between localities. Since *C. variegata* showed good productivity and interesting chemical composition, we concluded this species is feasible for extraction in southern Chile, as long as specific management protocols and market studies are developed.

## PP 124

## Photophysiology of intertidal seaweeds along the fluctuated light condition

**Eun Ju Kang**[*1], David J. Garbary[2], Ju-Hyoung Kim[3]

[1] *Research Institute for Basic Science, Chonnam National University, Republic of Korea*
[2] *Department of Biology, St. Francis Xavier University, Canada*
[3] *Faculty of Marine Applied Biosciences, Kunsan National University, Republic of Korea*

Intertidal seaweeds are exposed to dynamic light, particularly those that are directly exposed to sunlight experienced shaded conditions caused by cloud and thallus fluttering in a short period of time. Seaweeds have several mechanisms such as heat dissipation to survive under sharp fluctuations, which is closely related to photosynthesis. Here, we measured chlorophyll a fluorescence and oxygen production of nine species of seaweeds collected from various habitats to describe photophysiological properties of each species under two light conditions. The first light condition consisted of gradually increasing from 0 to 540 μmol photons $m^{-2}$ $s^{-1}$, and the second one which is called fluctuation condition was alternately changed from 540 μmol photons $m^{-2}$ $s^{-1}$ to lower light intensity. Photosynthesis was lower in the fluctuation environment than that in the light condition increasing gradually except for *Porphyra linearis*. NPQs under light fluctuation condition were 1.5- to 11-fold higher than that of steady state, i.e. induced NPQ still remained at low light after they exposed high irradiance. The slow recovery of NPQ under fluctuation environment would directly affect oxygenic photosynthesis. Based on these data, sharp light fluctuation negatively affects photophysiology of most intertidal seaweeds and may be a significant factor in suppressing the growth of intertidal seaweeds.

## PP 125

## Ecological studies on the seasonal changes of *Pyropia katadae* and its host species in Mie prefecture, Japan

**Man Gu Kang**[*1], Ryu Higa[1], Hiroto Fujiwara[1], Akira Kurashima[1]

[1] *Graduate school of Bioresources, Mie University, Japan*

*Pyropia katadae* is designated an endangered species on the Red List of Japan's Department of Fisheries. It is distribution in Ise City, Mie Prefecture, Japan, but the range of growth is very limited. *P. katadae* lives epiphytically on *Grateloupia catenata* and *Gracilaria vermiculophylla*. This study was investigated the changes in the inhabitation density and physiological and ecological characteristics of *P. katadae* and its host species, *G. catenata* and *G. vermiculophylla*. The survey was performed by randomly placing 20 x 20 cm quadrates and counting the coverage of the hosts in the quadrates and the number of *P. katadae* attached to the hosts from November 2016 to January 2019 at the mouth of the Miyagawa River in Ise City. The rate of attachment of *P. katadae* to the hosts was estimated as below. Five individuals of the hosts were cut into a size of ca. 1 cm fragments. Then, 100 fragments were observed under microscope to count the number of *P. katadae* on each fragment. The temperature at the time of the survey was slightly increasing from -4.2 to 22 ℃ in 2016, -4.2 to 27.5 ℃ in 2017, and -3.7 to 22.8 ℃ in 2018. Coverage of the host species have decreased drastically from 2016 to 2017. The attachment rates to hosts were 15.4~100% and 0.6~84% respectively in 2016; it declined to 25~100% and 6~55% in 2017, and 5~95%, 10~25% in 2018. The cause of the decreasing of *P. katadae* and host species was considered to be the disturbance of their habitat by typhoons in 2017. Based on the physiological, ecological and aquaculture study of *P. katadae*, this research will contribute to the preservation of endangered species and further to the aquaculture industry.

## PP 126

## The dynamics of nutrients within a *Zostera marina* at Arikawa Bay, Nagasaki, Japan

**Naoki Nishihara**[*1], Nao Hatata[2], Dominic Belleza[3], Azusa Kawate[2], Yuhei Matsuda[2], Hoshimi Kamisaki[3], Yukio Inoue[3], Kenjiro Hinode[3]

[1] *Organization for Marine Science and Technology, Nagasaki University, Japan*
[2] *Faculty of Fisheries, Nagasaki University, Japan*
[3] *Graduate School of Fisheries and Environmental Sciences, Nagasaki University, Japan*

Throughout the world's coastal ecosystems, seagrass and seaweed ecosystems have been degraded due to human activity. Besides climate change, coastal reclamation, the intensification of herbivory due to the loss of top predators, and eutrophication and oligotrophication are a few factors involved in the loss of vegetated ecosystems. In Japan, intense fishing pressure has led to the decrease in top predators, which has led to the increase in herbivores. Additionally, due to strict environmental regulations, coastal waters have become oligotrophic. In the Goto Islands of Nagasaki, almost 90% of the vegetated ecosystems have disappeared. To better understand why ecosystem deterioration is occurring, we focused on the nutrient dynamics of one of the few healthy *Zostera marina* beds in the Goto Islands. Our goal was to reveal how tidal and diurnal state affected the concentrations of inorganic phosphate, nitrite, and nitrate in and around a seagrass meadow. Over a period of one tidal cycle, water samples were collected during both high tides and alternate low tides. Four stations were setup to sample water within the meadow, at the meadow edge, and away from the meadow in an unvegetated area. A fourth station was setup on the opposite of a seawall, which served as a control. A clear spatial gradient was observed for mean concentrations of nitrite-nitrate, being higher outside of the meadow and lower within it. A

diurnal pattern in concentrations were also detected, with concentrations higher during the day for both nutrients. Concentrations were also higher during the flood tide.

## PP 127

### High acclimation capacity of *Sargassum horneri* (Phaeophyta) floating on the sea surface to a changing environment

**Jingjing Li**[*1], Yunlong Pang[2], Song Qin[2], Zhengyi Liu[2]
[1] *College of Oceanography, Hohai University, China*
[2] *Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences, China*

*Sargassum horneri* is a foundation species in marine forest and a contributor to the floating seaweeds in coasts of northeastern Asia. We compared the phenotypic plasticity and photosynthetic traits of floating (collected on the aquaculture rafts) and benthic (collected on rocks) thalli of *S. horneri* in Bohai bay of China (37.91°N, 120.73°E) through the field (at different water depths, 0 m and -3 m) and laboratory (under high light 400 umol m-2s-1 and normal light 40 umol m-2s-1 conditions) measurements. Floating thalli had higher density and smaller volume of vesicles. After long-term (from Oct. to Dec. in 2017) acclimation at different water depths, both thalli demonstrated phenotypic plasticity (e.g. pigment and biochemical compounds, photosynthetic performance) to adapt the changing environment, and higher relative growth rates, photosynthetic efficiency and thermal dissipation ability were still found in floating thalli at the sea surface, indicating higher acclimation capacity. Similarly, photoinhibition occurred in both thalli under high light stress during 21 d culture in the laboratory, and floating thalli demonstrated greater high light tolerance via increased photosynthetic efficiency and heat dissipation. Besides, the effective quantum yield of both thalli recovered after 6 d treatment under normal light, suggesting a reversible mechanism characterized by the down regulation of PSII rather than chronic photoinhibition. In general, great photoacclimation capacity is imperative for floating *S. horneri* to adapt the rapid changing environment at the sea surface. These findings are to extend our understanding of acclimation responses of subtidal seaweed to different environmental conditions and the outbreak of seaweed bloom in the Northwest Pacific.

## PP 128

### Environmental disturbance index (EDI) based on the frequency of indicator seaweeds for anthropic impacts: a study on tropical reefs from Brazil

**Juliane Bernardi**[*1], Edson Vasconcelos[1], Arsenio Areces[2], Adilma Cocentino[1], Mutue Fujii[3]
[1] *Oceanography, Universidade Federal de Pernambuco, Brazil*
[2] *Departamento de Medio Ambiente, Instituto de Geografia Tropical, Cuba*
[3] *Núcleo de Pesquisa em Ficologia, Instituto de Botânica, Brazil*

Despite it's great importance for the coastal biodiversity, only a few environmental indexes are stablished to assess intertidal communities from tropical regions when compared to temperate regions. Our goal was to demonstrate the structure and relevance of the environmental disturbance index (EDI) based on relative frequency of indicator seaweeds. Metrics of the proposed index are based on species list, theorical relative frequency and real relative frequency of indicator taxa. The index was tested through a study performed at Brazilian northeastern coast along an urbanization degree, which was classified by proxy variables (demographic density, population, residence occupancy and sewage collection) into: non-urbanized (NU), urbanization process (PU) and consolidated urbanization (UC) and into two types of reef structure: sandstone reef (RA) and coral-algae reef (CA). Ecological data, specific literature and professional judgment were used to classify those indicators. Frequency of the seaweeds *Palisada perforata*, *Osmundaria obtusiloba, Gelidiella acerosa* and *Sargassum* spp. were used as indicator of pristine locations, while *Bryopsis* spp., *Chondracanthus acicularis* and *Ulva lactuca* were used as indicator of impacted locations. EDI responded significantly to the tested urbanization degree, presenting five indication levels (pristine, low impact, medium impact, impacted and very impacted) with values next to zero indicating pristine locations and negative values indicating high anthropic pressure. Locations classified as PU and NU urbanization degrees obtained values within the range of low impact and pristine. However, locations classified as urbanization process could be vulnerable to future impacts due to populational growth projections on the region. Such index could be an effective tool to evaluate the ecological quality of coastal regions, through a simple and feasible analysis of seaweed communities.

## PP 129

### Photosynthetic characteristics of *Pyropia yezoensis* ueda measured in situ by Diving-PAM in the Jindo-Haenam region on the southwestern coast of the Korean Peninsula

**Jeong Bae Kim**[*1], Won-Chan Lee[1], Hyung Chul Kim[1], Sokjin Hong[1]
[1] *Marine Environment Research Division, National Institute of Fisheries Science, Republic of Korea*

The morphological characteristics, carbon and nitrogen concentrations, stable isotope values, and photosynthetic rates of *Pyropia yezoensis* were studied at the primary purple laver production areas on the southwestern coast of Korea in March 2014. Leaf length, width, and weight of *Pyropia* blades were 3.8–52.0 cm, 1.7–13.8 cm, and 6.3–8.3 g DW m-2, respectively. Carbon (C) and nitrogen (N) concentrations of *Pyropia* blades were 276.1–350.6 mg DW g-1 and 42.6–57.3 mg DW g-1, respectively. The C/N ratio was 6.1–6.5. The ranges of δ13C and δ15N values of *Pyropia* blades were from -24.0 to -21.5‰ and 4.4 to 7.4‰, respectively. C and N stable isotope rates of *P. yezoensis* showed significant differences between the survey stations. In addition, stations 3 and 4 showed relatively high N stable isotope rates. The average C isotope values at the two stations were significantly different(1.8‰) from the other stations, suggesting a different inlet source of nutrients. The concentrations of photosynthetic pigments Chl a, phycoerythrin, phycocyanin zeaxanthin, pheophytin a, and β-carotene in Pyropia blades were 89–1,872 μg DW g-1, 3,935–14,691 μg DW g-1, 2,397–5,524 μg DW g-1, 89–1,872 μg DW g-1, 3,935–14,691 μg DW g-1, and 2,397–5,524 μg DW g-1, respectively. Maximum quantum yield of *Pyropia* blades was between 0.40–0.54. Maximum relative electron transport rate (rETRmax) of *Pyropia* blades was between 5.4–15.0 μmol electrons m-2s-1. Photosynthetic efficiency (α) was between 0.05–0.11. Minimum saturating irradiance (Ek) range was 99–311 μmol photons m-2s-1. The primary productivity of *Pyropia* blades was 807–2,052 mg C m-2d-1. Assimilation number of indicates in the study area that there were high at the stations 1 and 4. The photosynthetic characteristics showed high photosynthetic rates because the high maximum quantum yields and high maximum relative electron transport rate.

## PP 130

## Temporal and spatial variations in growth and reproduction of a field population of *Chondrus ocellatus*

**Seo Kyoung Park**[*1], Han Gil Choi[2], Young Sik Kim[3], Ki Wan Nam[4]

[1] *Faculty of Biological Science, College of Natural Science, Wonkwang University, Republic of Korea*
[2] *Faculty of Biological Science, College of Natural Science, Wonkwang University, Republic of Korea*
[3] *Department of Marine Biotechnology, Kunsan National University, Republic of Korea*
[4] *Department of Marine Biology, Pukyong National University, Republic of Korea*

A upper and lower shore heights of *Chondrus* zone seasonal biomass frond weight, and G:T ratio of *Chondrus ocellatus* were examined to determine the effect of season and shore height. We examined whether: (1) the growth of *C.ocellatus* is greater at lower shore with less environmetal stress than higher shore, (2) gameotophytes are dominant at upper shore as many Gigartinaceae species, and (3) G:T ratio of *C. ocellatus* fluctuates depending on season and shore height due to environmental changes. Biomass and frond weight of *C. ocellatus* at lower shore were significantly greater than those at upper shore. Significant differences were also found between seasons, with the highest biomass (1,695.82g wet wt./㎡) In July and the highest frond weight (797.27㎎) in October. Gametophytes were dominant at upper shore whereas tetrasporophytes were abundant at lower shore. Seasonal and spatial reproductive patterns of tetraspophytes and carposporophytes were similar with the maximum in October and the minimum in April. However, tetrasporophytes were more abundant than carposporophyte plants over te study period. G:T ratio of *C. ocellatus* popoulation ranges from 0.05 to 2.45, was significantly different between seasons and shore heights. These results indicate that envionmental stresses in the intertidal zone are very importat when determining abundance and reproduction patterns of *C. ocellatus* with growth period between July- October and reproduction period in October and January.

## PP 131

## Field experiments on the growth conditions of halophyte (*Salicornia europaea, Suaeda glauca, Suaeda japonica, Suaeda maritima*) from Daebu-do tidal flats, West Sea of Korea

**Jongil Bai**[*1], Sungil Hwang[2], Yujin Kim[2], Suekyung Jun[2], Seongcheol Kim[3], Sangho Baek[3], Yongwoo Park[3]

[1] *Faculty of Marine Technology, Chonnam Natinal University, Republic of Korea*
[2] *Underwater Ecology Institute, Republic of Korea*
[3] *Ecological restoration, Korea Fisheries Resources Agency, Republic of Korea*

In this study, to restore the community of four species of halophyte (*Salicornia europaea, Suaeda glauca, Suaeda japonica, Suaeda maritima*) living in the uppermost part of the tidal flat, we sowed by altitude, sowing time and depth of sowing in the Daebudo tidal flat on the West Sea of Korea. The germination density, growth rate and soil environment of the target area were measured, and the growth environment of the large-scale *Suaeda japonica* community formed nearby was investigated. As a result, the environmental factors that have a great influence on the germination and growth of the halophytes were the altitude and the mean grain size. *Salicornia europaea* and *Suaeda glauca*, *Suaeda maritima* are largely influenced by altitude, but *Suaeda japonica* are the effect of mean grain size was great. The germination rate of *Suaeda japonica* and *Suaeda maritima* seeds was high germination density of natural spring flowers but the artificial spring flowers was high the germination density of *Salicornia europaea*. and The germination density of all the halophytes was better with deep seeding depth. Germination density was significantly low in the case of the *Suaeda glauca*, so it was difficult to evaluate the environmental factors that affected the germination. This study was the first to conduct germination experiments in domestic tidal flats, and should be conducted to continuous monitoring the environmental pressures and to preserve them as a secondary nature through cultivation management.

## PP 132

## A study on the distribution of sedimentary environment and benthic macro-fauna community according to presence or absence of *Suaeda japonica* on the Daebudo, west coast of Korea

**Jongil Bai**[*1], Sungil Hwang[2], Yijin Kim[2], Seonmi Kim[2], Byeonghyeon Jeon[2], Sangjo Han[2], Bongjun Sung[2], Seongcheol Kim[3], Sangho Baek[2], Yongwoo Park[2]

[1] *Faculty of Marine Technology, Chonnam Natinal University, Yeosu, Republic of Korea*
[2] *Underwater Ecology Institute, Republic of Korea*
[3] *Korea Fisheries Resources Agency, Republic of Korea*

In this study, sedimentation environment and benthic macro-fauna community were collected from six Colony, three habitats and six non-habitats. The collection period is four times (May, July, September, and November, 2018). This were conducted in the first week. The colonies of *Suaeda japonica* were 466±60.8 indiv./㎡, Habitats 8±0.5 indiv./㎡, Non-habitat was not inhabited. The appearance of benthic macro-fauna communities in the community was 13 species, the mean density was 223 indiv./㎡ and the mean biomass was 213.97 gWWt / ㎡. The habitat consisted of 8 species, a mean density of 74 indiv./㎡, a mean biomass of 54.41 gWWt / ㎡, a non-habitat of 21 species, a mean density of 271 indiv./㎡ and a mean biomass of 201.82 gWWt/㎡. Colonies and habitats are similar in sedimentary environment and have high mud content. Non-habitat was found to be a mixture of mud and sand. *Heteromastus filiformis* as the dominant species in colony and habitats, *Cerithidea ornata* predominates in non-habitat. In this study, the highest environmental factors influencing to the inhabited of *Suaeda japonica* were 0.964 high positive correlation on the Silt content of the sediments, the showed negative correlation of -0.904 at the altitude. Polychaeta showed positive correlation to the inhabited of *Suaeda japonica*, Mollusca showed negative correlation.

## PP 133

## Principal considerations in marine afforestation

**Jong-Ahm Shin**[*1], Man-Gu Kang[2], Sung-Il Hwang[1], Sang-Jo Han[1], Ju Hyon Cho[3], Shin Ja Ko[4], Han Gil Choi[5], Jeong Ha Kim[6], Hyung Geun Kim[7]

[1] *Underwater Ecology Institute, Korea*
[2] *Mie University, Korea*
[3] *Aqua Dream, Korea*
[4] *Jeju National University, Korea*
[5] *Wonkwang University, Korea*
[6] *Sungkyunkwan University, Korea*
[7] *Gangneung-Wonju National University, Korea*

Marine environmental conditions are changeable with increasing uncertainty and disaster. Thus, we need to establish a valuable system coping with the environmental changes. Biological and environmental factors influence on the self-renewal process of macroalgae. Stability, resistance and restoration ability of marine forest are affected by dynamic equilibrium of the ecosystem. In Korea, the marine forest construction projects firstly started from 2002 by local governments in order to increase fisheries resources. The projects have been continued by National Institute of Fisheries Science from 2009, and then by Korea Fisheries

Resource Agency (FIRA) from 2011, and it has been expanded to the 'marine forest project' from 2015. During the period, many advanced skills to restore marine forest were developed. However, we have to discuss with many people for conservation and restoration of the marine forest ecosystem, health of sea and marine forest, and the mini-max strategy. We should think about the restoration methods of the marine forest in barren grounds, do find out the suitable cure and care ways, and try to help the self-restoration. Marine forest is our past, present and future.

## PP 134

### Can glacier melting influence marine macroalgal assemblages? : the case of canal de las montañas (51-52ºs) at subantarctic ecoregion of Chile

**Andrés Mansilla**[*1], Marcel Velásquez[2], Fabio Méndez[3], Juan Pablo Rodríguez[4], Francisco Bahamonde[5], Sebastián Rosenfeld[6]

[1] *Laboratorio de Ecosistemas Marinos Antárticos y Sub-antárticos, Universidad de Magallanes, Chile*

The present study addresses the composition of macroalgae assemblages in three stations along the Canal de Las Montañas, (51-52ºS). The sampling using random photoquadrats in transects along intertidal to subtidal region was carried out during winter 2018. Were considered areas characterized by direct glacial influence (stations 1 and 2), as well as one without direct glacial influence (control). In addition, from the diversity of species, the pigment concentration of two brown algae *Adenocystis utricularis* and *Macrocystis pyrifera*, common in all study sites, was studied. In total, 39 species of macroalgae were identified (12.8% Chlorophyta, 25.6% Ochrophyta and 61.5% Rhodophyta). The highest species richness (n = 36) corresponds to the control station, while the lowest occurred in stations 1 and 2 with 26 and 27 species, respectively. Significant differences ($p < 0.05$) were determined regarding the diversity of macroalgae species between sampling sites at different levels, intertidal (high, medium and low), 5 and 10 meters deep. The MDS analysis allowed the separation of two groups of study sites: one related to direct glacial influence and the other without direct glacier effect (control). In *A. utricularis*, the concentrations of pigments (chl a, chl c and Fucox) were higher in site 1, however significant differences were only recorded for Chl a and Fucox. The kelp *M. pyrifera*, of great commercial interest for Chile, did not show significant variations in the pigment concentration between study sites. The preliminary results show a decrease in the diversity of species in places with direct glacial influence. In contrast, the giant kelp *M. pyrifera*, a species of great commercial and ecosystemic importance, shows greater tolerance to the effects of melting and retreating glaciers. This is the first result of the FONDECYT- 1180433 project. Palabras clave: Subantarctic, climate change, glaciar melting.

## PP 135

### Effects of the sources of light on growth, phosphate uptake and photosynthetic efficiency in *Ulva*

Hohyeon Lee[1], Palas Samanta[1], Hojun Lee[1], Sojin Jang[1], **Sookkyung Shin**[*1], Jang K. Kim[1]

[1] *Department of marine science, Incheon National University, Korea*

Fluorescent lamps and light-emitting diode (LED) are the most commonly used sources of light for seaweed cultivation. However, it still remains unknown to scientific community which lighting sources are most efficient for culturing seaweeds. Therefore, present study is designed to determine the efficacy of fluorescent lamps (T-5 and T-8 fluorescent lamps) and LED on growth, phosphate uptake and photosynthetic efficiency in *Ulva*. This alga was exposed to three different light sources at three photosynthetically activate radiation (PAR) conditions i.e., 80, 150 and 300 $\mu mol \cdot m^{-2} \cdot s^{-1}$ for a period of 25 days. *Ulva* was cultured in von Stosch enriched (VSE) medium at 10 °C and 12:12 L:D photoperiod. The specific growth rate of *Ulva* was higher at LED than T-5 or T-8 under all PAR conditions, with the highest at 300 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of LED (41.22 $\%\cdot d^{-1}$). The electron transfer rate max (ETRm) was highest at 300 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of T-8 (57.08 µmol electrons $m^{-2} \cdot s^{-1}$) and lowest at 300 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of T-5 (35.83 µmol electrons $m^{-2} \cdot s^{-1}$). The phosphorus uptake was, however, highest at 80 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of T-5 (20.80 $\mu mol \cdot d^{-1}$) and lowest at 300 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of LED (4.98 $\mu mol \cdot d^{-1}$). *Ulva* shows that LED is more advantageous in growth of *Ulva*, but T-5 appears to be a better light source for photosynthetic efficiency and phosphorus uptake.

## PP 136

### Stress response to high light of two benthic seaweeds

**Jun Zhu**[*1], Xing Su[1], Xiaoxiao Zou[1], Shixiang Bao[1]

[1] *Institute of Tropical Bioscience and Biotechnology, Chinese Academy of Tropical Agricultural Sciences, China*

The light environment has a great role in promoting the evolution of algae. But little is known about the high light stress response of *Betaphycus gelatinum* and *Caulerpa lentillifera*. The mechanism of high light stress response of two benthic seaweeds were analyzed by means of MINI-PAM and transcriptome sequencing. Under 40 and 10 mol/(m2·s) light intensity, the Fv/Fm of *B. gelatinum* and *C. lentillifera* can be stable at about 0.63 and 0.75 respectively, while when the light intensity rises to 120 mol/(m2·s) and 360 mol/(m2·s), the values of Fv/Fm are significantly reduced. *C. lentillifera* could withstand the light intensity of 120 µmol/(m2·s), while the electron transport activity was inhibited under the light intensity of 360 µmol/(m2·s). But *B. gelatinum* could withstand the light intensity of 120 and 360 µmol/(m2·s). The changes of related metabolic pathways under different light conditions indicated that the synthesis of chlorophyll a was down-regulated, and the light capture ability of antenna protein was reduced under high light of *B. gelatinum* and *C. lentillifera*. By up-regulating the expression of anti-oxidation-related genes, *B. gelatinum* could improve the ability of anti-oxidative and thus the light tolerance. But *C. lentillifera* would reduce the light damage by the lutein cycle, and enhance the photosynthetic carbon fixation to consume excess ATP. Under high light, the both species of benthic seaweed could improve the ability of the light tolerance by the light energy regulatory mechanism.

## PP 137

### Stomach contents and marine algal flora of sea hare, *Aplysia kurodai* habitat in the east coasts and the south coasts, Korea

**Nam-Gil Kim**[*1], Min Ju Kim[1]

[1] *Marine Biology and Aquaculture, Gyeongsang National University, Republic of Korea*

Sea hare, *Aplysia kurodai* is belongs to the class Gastropoda, order Anaspidea, family Aplysiiae, and is major species in coast of Korea. The purpose of this study was to investigate the stomach contents of *A. kurodai* and its relationship with marine algae community around their

habitat. Sampling sites of *A. kurodai* and marine algae of habitat were Yeongjin, Bukpyeong, Chuam, Changpo, Daebo, Wollaeri, Dongbaekri in the East Sea and Yeongunri, Maemuldo, Yokjido, Mijodo, Cheongsando in the South Sea. Collected *A. kurodai* was dissected and its stomach was cut off. The marine algae occurred at stomach and surrounding marine algae of habitat were identified. In addition, the marine algae that identified from stomach contents classified according to functional form. The number of seaweed species collected in the East Sea of Korea were totally 134 species. Among them, Chlorophyta was 12 species, Ochrophyta was 32 species, Rhodophyta was 89 species and Marine phanerogam was 1 species. The number of marine algae identified from stomach contents of *A. kurodai* collected from the East Sea of Korea were totally 39 species. Among them, Chlorophyta was 7 species, Ochrophyta was 6 species and Rhodophyta were 26 species. The number of seaweed species collected in the South Sea of Korea were totally 75 species. Among them, Chlorophyta was 5 species, Ochrophyta was 21 species, Rhodophyta was 48 species and marine phanerogam was 1 species. The number of marine algae identified from stomach contents of *A. korudai* collected from the South Sea of Korea were totally 26 species. Chlorophyta was 2 species, Ochrophyta was 3 species, Rhodophyta was 20 species and marine phanerogam was 1 species. The number of marine algae identified from stomach contents of *A. kurodai* collected from overall survey sites were totally 51 species.

## PP 138

### Role of trehalose and trehalase in stress response of *Gracilariopsis lemaneiformis* (Rhodophyta)

**Xue Sun**[*1], Yan Lv[1], Yingying Zhang[1], Wenyan Xuan[1], Danli Wang[1]
[1] *Department of Marine Sciences, Ningbo University, China*

The non-reducing disaccharide trehalose is ubiquitous in the organisms. Trehalose is not only a source of carbon and energy, or as a signal molecule, but also can be used as a structural stabilizer and stress protector under abiotic stress. From the genome of *Gracilariopsis lemaneiformis* (Rhodophyta), we identified one gene encoding trehalase, which catalyzes the degradation of trehalose. Then, we studied the transcriptional level and activity of trehalase combined with the trehalose content under the stress conditions in order to reveal the role of them in defense responses. The results showed that the expression of trehalase gene was up-regulated, and its activity was significantly inhibited and trehalose content was significantly increased under high temperature (30°C) condition; trehalase gene expression and its activity were almost unchanged under high salinity (45 salinity) condition; trehalase transcription and its activity were significantly promoted by drought stress, while trehalose content only significantly declined at 12 h. It can be deduced that trehalose, its degradation enzyme trehalase play an important role in response to high temperature stress, but they are insensitive to high salt stress; meanwhile, trehalase is markedly influenced by drought stress, but trehalose accumulation are almost unchanged that might be due to the change of trehalose synthesis-related enzymes.

## PP 138-1

### Study on the variations in temporal and spatial distribution of micro-algae in a resident aquatic ecosystem

**Suk Min Yun**[*1], Sang Deuk Lee[1], Pyo Yun Cho[1], Seung Won Nam[1], Jin-young Kim[1], Jong-Suk Lee[1], Chung Hyun Choi[2]
[1] *Freshwater Bioresources Research Office, Nakdonggang National Institute of Biological Resources, Republic of Korea*
[2] *Department of Oceanography, Kunsan National Uiverstiy*

A weir is a structure constructed to direct a certain amount of water flow along an intake channel, by maintaining a constant water level upstream of a river, blocking the river for the purpose of taking agricultural and domestic water. Currently, 8 weirs are installed in the Nakdong River. In order to understand the environmental information, the variation in the temporal and spatial distribution of microalgae, and the community composition of microalgae, which are the basic producers in aquatic ecosystems, were analyzed in Sangju Weir, located in Jung-dong, Sangju, North Gyeongsang Province. Microalgae communities were sampled every two weeks, from April to November during 2018, at six sites, and in 3h intervals every sampling day, in the Nakdong River, South Korea, to investigate how microalgae communities reflect the characteristics of their aquatic environment, and the vertical distribution of microalgae. Three major types of river are recognized in this study: the main stream of the river (sites 1, and 3 - 5); stream (site 2), and downstream of the weir (site 6). They show significant variability in terms of physicochemical environmental factors, microalgae community structure, and floras. They are variously dominated by microalgae, such as diatoms (e.g. *Fragilaria crotonensis, F. acus,* and *Aulacoseira ambigua*), green-algae (e.g. genus *Eudorina* and *Desmodesmus*), cyanobacteria (e.g. genus *Anabaena* and *Microcystis*), and flagellates. Multidimensional Scaling (MDS) indicated that the microalgae community structure in the three major river types, showed differences to the Nakdong River stream. Species composition and diversity was very similar for all sites, except site 2 (the area around the Yeonggang Stream). In addition, the vertical distribution of microalgae showed that species composition and diversity in the bottom layer was different to the surface and middle layer. Vertical migration of the microalgae in this study area was somewhat difficult because of the formation of the thermocline in the survey area, and high turbidity in the lower layer. There was also a difference between species composition and diversity.

## PP 138-2

### Development of sandwich hybridization integrated with nuclease protection (NPA-SH) probes to monitor *Heterosigma akashiwo*

**Mirye Park**[*1,2], Mingyeong Kang[1], Seung Won Jung[3], Chang Soo Lee[2], Z-Hun Kim[2], Sang Deuk Lee[2], Seung Won Nam[2], and Taek-Kyun Lee[1]
[1] *South Sea Environment Research Department, Korea Institute of Ocean Science and Technology, Korea*
[2] *Microbial Research Department, Nakdonggang National Institute of Biological Resources, Korea*
[3] *Library of Marine Samples, Korea Institute of Ocean Science & Technology,Korea*

*Heterosigma akashiwo* is a globally distributed raphidophyte that forms blooms and causes great losses to the aquaculture industry in many coastal countries. Therefore, development of a fast and sensitive detection method is required to facilitate appropriate warning of harmful algal blooms. In this study, a sandwich hybridization integrated with nuclease protection (NPA-SH) assay was developed to qualitatively and quantitatively detect *H. akashiwo*. The results show that this method has good applicability and effectiveness in analyzing cultured cells and field samples. A linear regression equation for quantitative analysis of *H. akashiwo* was obtained and the lower detection limit of the assay was $1 \times 10^4$ cells/mL. There was no statistically significant difference in the results of quantitation of *H. akashiwo* using NPA-SH compared to those

obtained using a microscope. The NPA-SH assay was successfully applied to environmental samples. These results indicate that NPA-SH can be a good alternative to the traditional microscopic method used to monitor *H. akashiwo*.

## PP 138-3

### Changing marine environments: do invasive seaweeds and blooms in the eastern mediterranean shores have really negative consequences?

**Alvaro Israel**[*1]
[1] *Marine Biology, Israel Oceanographic & Limnological Research Institute, The National Institute of Oceanography, Israel*

Within the Mediterranean Sea, the Eastern basin (The Levant basin) is exposed to temperatures, salinities, nutrients availability and other environmental surroundings harsher than all other basins. Generally viewed as oligotrophic, Mediterranean Sea waters have suffered from long-term anthropogenic disturbances, and since the opening of the Suez Canal in 1876, the Levant area is particularly receptive from on-going Indo-Pacific migrants. As such, from the >700 marine organisms reported as invasive or alien to the Eastern basin, approximately 120 correspond to marine macroalgae. Some have established and thrive in the area creating on occasions massive blooms of organic material that remain for extensive periods on the shores. Long-lasting environmental pressures have favored some of the species, both local and exotic, while others have retrieved or disappeared. Such events have been documented for the coasts of Turkey, Greece, Cyprus and Israel. A description of these blooms, their potential ecological impacts which may not necessarily be regarded as nuisance, and the associated environmental factors behind these changes will be presented.

## PP 139

### Pyruvate production by *Halomonas* sp. using carbon source from the green seaweed *Ulva reticulata*

**Hoang Thi Lan Anh**[*1], Hoang Thi Lan Anh[1], Nguyen Cam Ha[1], Luu Thi Tam[1], Ngo Thi Hoai Thu[1], Kawata Yoshikazu[2], Dang Diem Hong[1]
[1] *Algal Biotechnology, Institute of Biotechnology, Vietnam Academy of Science and Technology, Vietnam*
[2] *Biomedicine group, Biomedical Research Institute, National Institute of Advanced Industrial Science and Tehcnology (AIST), Japan*

Currently, green macroalgae have gained attention as promising renewable sources for biorefining. Despite the huge potential availability, their utilization is limited to ethanol production, hindering its further application. In this study, we report that a bacterium, *Halomonas* sp. strain BL6 (isolated from Bach Long, Giao Thuy, Nam Dinh on 2017), produces pyruvate from saccharified solution of green seaweed Ulva reticulata and secretes it into the medium. Pyruvate known as the most important α-oxocarboxylic acid, plays a central role in energy and carbon metabolism in living organisms. Currently, it is used mainly for the synthesis of various chemicals and polymers or as ingredient and additive in food, cosmetics, and pharmaceuticals. To investigate the possibility of using *Ulva reticulata* from the seashore in Vietnam as biomass feedstocks, the chemical composition and saccharification yield of this seaweed were studied. Dry biomass of *U. reticulata* was found to contain 60.5% carbohydrate, 12.3 % protein, 2.1% lipid, and 10.6 % ash. Successive saccharification with Viscozyme® L after pretreatment using thermal acid hydrolysis was obtained a high reducing sugar yield. The resulting sugars were fermented to produce pyruvate by *Halomonas* sp. strain BL6 with its maximal concentration of 10.75 g/l. These preliminaries results demonstrate the production of other valuable compounds as pyruvate than ethanol from saccharified solution of *U. reticulata*.

## PP 142

### Study on antibacterial activity of macroalgae in Zhejiang coast

**Siqi Sun**[*1], Xue Sun[1], Shanliang Xu[1], Nianjun Xu[1]
[1] *School of Marine Science, Ningbo University, China*

Seaweed is a rich source of potential new antibacterial drugs in aquatic cultures. The aim of our studies was to analyze the antimicrobial activities of the seaweeds collected from Zhejiang coast. Alcoholic extracts of 33 marine algal species (8 Chlorophyta, 7 Phaeophyta and 18 Rhodophyta) were evaluated for antibacterial activity against pathogenic bacteria (*Escherichia coli, Aeromonas hydrophila, Pseudomonas aeruginosa, Vibrio alginolyticus* and *Staphylococcus aureus*) by disc diffusion techniques. The results showed that all seaweed extracts except for *Codium fragile* were active against at least one of the five test microorganisms. The extracts of seaweeds exhibited different degrees of antimicrobial activities against different bacteria, the inhibitory effect on Gram-positive bacteria is more pronounced than Gram-negative bacteria. Alcoholic extracts of *Chaetomorpha aerea, Polysiphonia urceolata, Symphyocladia latiuscula, Grateloupia livida, Grateloupia carnosa, Pachydictyon coriaceum* and *Gracilaria lemaneiformis* exhibited a relatively broad spectrum of antibacterial properties with inhibition diameters ranging from 8 to 19 mm. *G.lemaneiformis* extract exhibits the highest inhibitory activity against *S.aureus* and *V.alginolyticus* and *Enteromorpha prolifera* showed highest inhibitory activity against *A.hydrophila*. In addition, the antioxidant capacity and polyphenol content of the seaweed extract were measured and significant positive correlations between antibacterial species and clearance rate of ABTS radicals was found. The results confirmed the potential application for using seaweeds as a source of antibacterial drugs for aquaculture.

## PP 143

### Effects of Indole-3-acetic acid on algal growth and components of the red alga, *Gracilariopsis chorda* from Japan

**Hirotaka Kakita**[*1], Hideki Obika[2]
[1] *Graduate School of Integrated Basic Sciences, Nihon University, Japan*
[2] *Health Research Institute, National Institute of Advanced Industrial Science and Technology, Japan*

Some kind of macroalgae interacts with attached bacteria. The attached bacteria use the organic compounds secreted by a macroalga as sources of nutrition. Some macroalgae assimilates vitamins and phytohormones, such as indole-3-aceticacid (IAA), produced by bacteria for algal growth. On the other hand, the Japanese species of the red algal family Gracilariaceae are important industrial macroalgae, because they have been harvested in Japan as commercial sources of agar and for food additives. Japanese Gracilariaceae also produces bioactive substances such as enzymes and hemagglutinins. However, details of the environmental microorganisms on Japanese Gracilariaceae have never been reported on.

Thus, in this study, we investigated the epiphytic bacteria on a red alga, *Gracilariopsis chorda*. We also studied the effects of a bacterial auxin, IAA, on algal growth and components. Naturally occurring algal and cultured algal samples were rinsed with sterile seawater to remove the bacteria originating from environmental seawater. Ten-fold dilutions of the seaweed samples were spread on agar plates. The plates were incubated at 20ºC for 14 days before colonies were counted. The genetic analysis based on partial 16S rRNA gene sequences (ca. 450 bp) was carried out. Algal components, such as saccharide and protein, were determined by colorimetric assay and high performance liquid chromatography. *Moraxella* sp. and *Vibrio* sp. were predominant on naturally occurring *G. chroda*. But the dominant bacteria were changed during bacteria and alga co-culture. *Flavobaterium – Cytophaga* sp. were predominant on cultured *G. chorda*. A bacterial product, IAA, accelerated algal growth rate and changed algal amino acid and saccharide compositions. These findings suggest that *Flavobacterium – Cytophaga* sp. is predominant on Japanese *G. chorda*. A bacterial product, IAA, seems to be useful for algal growth.

## PP 144

### Artificial biofilm for growth of *Ulva fasciata* spore

**Sinyang Kim**[*1], Dong Soo Hwang[1], Jihyun Park[2]
[1] *IBB, Postech, Republic of Korea*
[2] *Environmental Engineering, POSTECH, Republic of Korea*

The present study attempted to promote the growth of *Ulva fasciata* spores in artificial biofilms using alginate composed of silica particles by mimicking marine biofilm. Alginate, one of the main extracellular polymeric substances in biofilms, was used as a base polymeric scaffold for the artificial biofilm, and silica particles were added in the biofilm. As expected, the germling length of *U. fasciata* spores in alginate was 3 folds longer than that of the free spores for 7 days. In addition, in the presence of silica particles regardless their hydrophobicity in the alginate, the germling growth of *U. fasciata* spores was increased about 10 folds and 8 folds than that in the alginate for 7 days. Presumably, the stiff substrates like inorganic materials are likely to promote the germination and growth of *U. fasciata* spores. To explore the mechanism for stimulating the growth of *U. fasciata* spores with the addition of silica particles, I carried out the related experiment in which the germination and growth of *U. fasciata* spores on the three types of substrates (4.5% (w/v) alginate hydrogel, polystyrene, glass) having theoretically different stiffness, 184 kPa, 3,500 MPa, and 50,000 MPa, respectively. The addition of antibiotic mix was tested to rule out the effect of biofilms in the experiment. As a result, it is difficult to explain that the germination is affected by the stiffness of substrates, but the growth of *U. fasciata* spores increased on the stiffer substrate. Both the germination and growth of *U. fasciata* spores were not changed with the addition of the antibiotic mixture. In summary, it was confirmed that the growth of *U. fasciata* spores was promoted in artificial biofilm containing alginate and silica particles, and I find clues that the growth of *Ulva* spores seems to be affected by mechanical properties of the substrates.

## PP 146

### Comparative genomics of Alphaproteobacteria associated with the dinoflagellate Symbiodiniaceae

**Eiichi Shoguchi**[*1], Kanako Hisata[1], Koki Nishitsuji[1], Asuka Arimoto[1], Noriyuki Satoh[1]
[1] *Marine Genomics Unit, OIST, Japan*

The symbiotic dinoflagellate Symbiodiniaceae live together with many host organisms in coral reefs, including corals, bivalves, sponges, and foraminiferans, in addition to existing as free-living cells. It is known that the associated bacteria to the Symbiodiniaceae are included in cultures. Although the bacterial-algal interactions are likely important to the dinoflagellate growth, the molecular mechanisms underlying the relationship between bacteria and dinoflagellates are unknown. To establish the experimental system of bacterial-algal interactions, we isolated three bacteria from the cultures of the genome decoded Symbiodiniaceae (clades A3, B1, and C). The 16S ribosomal RNA sequences of two isolated bacteria from Symbiodiniaceae cultures (B1 and C) showed similarities to the sequences of uncultured bacterium in NCBI database. The sequence similarity between the isolates was 99%. Molecular phylogenetic analysis on 16S rRNA supported that the isolated clones belong to the family Rhodobiaceae within the order Rhizobiales of the class Alphaproteobacteria. The sequence of the other strain had similarity to 16S rRNA of Flavobacteria *Muricauda aquimarina*. Interestingly, the analyses of whole-genome sequence data showed the Rhodobiaceae clones are the only major bacteria in antibiotic-treated Symbiodiniaceae cultures. Therefore, we focused and compared draft genomes of two Rhodobiaceae bacteria. The Rhodobiaceae genome (B1) from Symbiodiniaceae *Breviolum minutum* culture was ~3.8 Mbp in the assembled length and encoded 3846 genes. The genome of the Rhodobiaceae (C) associated with Symbiodiniaceae *Cladocopium* sp. was ~3.9 Mbp and encoded 3925 genes. These GC contents are 55.4% and 56.9%, respectively. Both the Rhodobiaceae genomes encoded gene clusters for bacteriocin and terpene productions. By comparing with published genomes of the Rhodobiaceae *Parvibaculum lavamentivorans* and *Candidatus* Phaeomarinobacter ectocarpi, which is associated with the brown alga *Ectocarpus,* the gene contents in the associated bacteria are characterized. We will discuss on the possible interaction between Rhodobiaceae bacteria and Symbiodiniaceae.

## PP 147

### Removal and bioremediation of Chlorpyrifos by *Chlorella sorokiniana* isolated from Korean paddy fields

**Ha Jun Park**[*1], Hyungki Do[2], Wilhelm Holzapfel[1]
[1] *Advanced Green Energy & Environment, Handong Global University, Republic of Korea*
[2] *Department of Life Sciences, Handong Global University, Republic of Korea*

Chlorpyrifos, a triphosphoric acid ester, is an extensively used organophosphate pesticide and commercially available chemical under different brand names. It finds wide application in agriculture for crop protection, and in a household for pest eradication. Although considered as only "moderately hazardous" by the WHO, its potentially toxicity to humans and environment has been heavily debated in recent years. In contrast to its EPA approval, a court decision in the USA has now suggested its ban in late 2018. Its provisional approval in the EU has been extended periodically, presently up to January 31$^{st}$, 2020. This study attempts to describe a biological mechanism for the removal of organophosphorus pesticides in an aqueous phase by the green microalgae *Chlorella sorokiniana*. *C. sorokiniana* showed the highest resistance to chlorpyrifos at 60 mg $L^{-1}$ among strains of four tested species (*Chlamydopodium starrii, Desmodesmus* sp., *Coelastrum proboscideum*, and *Chlorella sorokiniana*). Biochemical characteristics including chlorophyll contents and antioxidant enzymes were affected by chlorpyrifos at comparatively high concentrations of up to 40 mg $L^{-1}$.

Gas chromatography-mass spectroscopic (GC-MS) data showed that the chlorpyrifos concentrations in the medium significantly decreased after 7 days cultivation. A number of reports in literature describe the bio-adsorption of organic pollutants on the microbial cell walls as the first phase of bioremediation. We investigated the bio-adsorption of chlorpyrifos on cell walls by quantifying pesticide residues on microalgal cells and cultivating enzymatically treated *C. sorokiniana* which have partially removed cell walls.

## PP 148

### Physiological responses and biofilter potential of *Gracilaria domingensis* (Gracilariales, Rhodophyta) cultivated in different concentrations of nitrate and phosphate

**Jonatas M.C. Souza**[*1], Vitor G. Chiozzini[2], Elisabete S. Braga[2], Nair S. Yokoya[1]

[1] *Núcleo de Pesquisa em Ficologia, Instituto de Botânica, Brazil*
[2] *Departamento de Oceanografia Física, Química e Geológica, Instituto Oceanográfico, Universidade de São Paulo, Brazil*

Benthic marine algae can be biofilters by nutrient uptake and assimilation. *Gracilaria* spp. Greville are exploited as raw material for agar production, and studies on their development are necessary for the sustainable production of biomass. The present study aimed to evaluate the physiological responses of *Gracilaria domingensis* J. Agardh cultivated in different nitrate and phosphate concentrations. Treatments were composed of sterilized seawater enriched with half strength of von Stosch solution (VSES/2) prepared without nitrate and phosphate. Nitrate concentrations varied from 0.0 to 500 µM, and phosphate concentrations varied from 0.0 to 50 µM or 0.0 to 5 µM in the N:P ratio of 10:1 or 100:1, respectively. Each treatment was tested with four replicates (n=4). Growth rates of *G. domingensis* increased with addition of 100:1 and 10:1 N:P ratios, and higher values were observed in treatments with 100:1 than 10:1 N:P ratio. Pigment contents increased with N:P addition, and treatment with 125:1.25 µM stimulated the highest contents of phycoerythrin (354.7±64.9 mg.g-1 FM), phycocyanin (131.4±28.4 mg.g$^{-1}$ FM) and allophycocyanin (173.3±28.4 mg.g$^{-1}$ FM). Chlorophyll a concentrations ranged from 5.8±4.8 mg.g-1 FM (VSES/2 without N:P) to 32.8±1.1 mg.g$^{-1}$ FM (500:50 µM of N:P), but effects of treatments with N:P in both ratios did not vary significantly. Similar effects were observed for protein contents, except for higher protein content in treatment with N:P of 500:50 µM than 500:5 µM. The highest efficiency of nitrate removal (99.8±0.0%) was observed in 50:5 µM of N:P, and decreased with increase of N:P concentrations. Efficiency of phosphate removal increased with N:P addition (89.6±0.8% in treatment with 500:50 µM). Our results showed that *G. domingensis* has potential as biofilter, and could be cultivated in integrated multitrophic aquaculture due to its efficiency in nutrient removal from seawater. Supported by FAPESP (2017/13259-3), CAPES (23038.001431/2014-75) and CNPq (310672/2016-3).

## PP 149

### New approach to the restoration of seaweed beds by *Sagassum* sp.

**Sang Mok Jung**[*1], Ji Hyun Lee[2], Seung Hee Han[1], Chang Yeon Lee[1], Won Bin Jeon[1], Ga Yeon Kim[1], Sangsik Kim[3], Hwa-Rim Lee[4], Dong Soo Hwang[5,3,6], Sungjune Jung[5,3,4], Hyun Woung Shin[1]

[1] *Life Science and Biotechnology, Soonchunhyang university, Republic of Korea*
[2] *Project management division, Korea Fisheries Resources Agency East Sea Branch, Republic of Korea*
[3] *Division of Integrative Biosciences and Biotechnology, Pohang University of Science and Technology, Republic of Korea*
[4] *Department of Creative IT Engineering, Pohang University of Science and Technology, Republic of Korea*
[5] *School of Interdisciplinary bioscience and bioengineering, Pohang University of Science and Technology, Republic of Korea*
[6] *School of Environmental Science and Engineering, Pohang University of Science and Technology, Republic of Korea*

Seaweeds especially provide a habitat and serve places as spawning, breeding and feeding for fish and shellfish as well as other marine productivities in marine ecosystem. Among them, brown algae such as Ecklonia sp., Undaria sp. and *Sargassum* sp. are main role species. Recently, kelp forest consist of them are reducing due to environmental changes and pollutions. This is called "whitening event" or "urchin barrens" which coralline algae appear, resulting in preventing their spores not to attach on substrates. In this reason, many technologies have been conducted for seaweed restoration such as artificial reef, seaweed rope, spore bags and trans-planted cultures. But those are lack of overcome seaweed changes which disappearing from costal area. So this study approached new technic which is for encapsulating seaweed spores and zygotes with polysaccharide like alginates to improve attachment artificially. Therefore, we examined the forest restoration by encapsulation zygotes of brown alga, *Sargassum* sp., which plays an important role in the seaweed forest, and then tested their efficacy using poly vinyl chloride (PVC) panels and cement bricks combined with zygote-encapsulation in the sea area. In results, the *Sargassum* zygote-encapsulation was germinated 70±1.6 % similar to non-encapsulation in laboratory. In field experiment, the PVC panels and cement bricks were coated with zygote-encapsulation, compared to non-encapsulation. The encapsulated zygote of germination density and growth rates were appeared the 4 times or 7 times higher than non-encapsulation ($p<0.001$, $p<0.016$). Cement bricks also showed higher germination density and growth rate than non-encapsulation. This attempt proved that attachments of seaweed spores are higher by encapsulation technology than by natural attachment in marine environments.

## PP 150

### Purification of wastewater derived from fish farming by a red alga, *Gracilariopsis chorda*

**Hirotaka Kakita**[*1], Yoshio Okuyama[2], Yoshiaki Takahashi[2], Hideki Obika[3]

[1] *Graduate School of Integrated Basic Sciences, Nihon University, Japan*
[2] *Fisheries Experimental Station, Wakayama Research Center of Agriculture, Forestry and Fisheries, Japan*
[3] *Health Research Institute, National Institute of Advanced Industrial Science and Technology, Japan*

The worldwide expansion of intensive marine culture has often been accompanied by degradation of the natural environment. One of the most visible effects of fish cage aquacultures is releases of dissolved nitrogen and phosphorus. Total dissolved nitrogen released from fish marine farms in Japan was estimated at 39,400 ton per year in 1991. It was equal to the total nitrogen in excretion and drainage for 9,000,000 people. Because the dissolved nitrogen and phosphorus were bad for the human health (e.g., the development of toxic microalgal blooms), any effective solutions to the environmental problem are now requested. On the other hand, dissolved nitrogen and phosphorus are necessary for algal growth. To design an algal biofilter for purification of wastewater derived from fish farming, the amounts of nitrogen and phosphorous generated from fish farming and nutrient reduction ability of a red alga, *Gracilariopsis chorda* in various culture conditions were measured. Fish were cultured

in 0.2 ton tanks with synthetic feeds. A part of seawater in the tank was collected. Nitrogen and phosphorous concentrations in the seawater were determined. Nitrogen and phosphorous in fish feeds, fish urines and fish excrements were also determined. Short term uptakes of nutrients by the red alga, *G. chorda* were measured. The amount of *G. chorda* which required to decrease of nutrient concentration to Japanese environmental standard values (JESV) (nitrogen and phosphorous are less than 1 mg/L and 0.09 mg/L, respectively) was determined. Although nitrogen and phosphorous in the fish tank were over JESV for only one day after feed, G. chorda biofilter (1 g / L) could reduce nutrient concentrations under JESV. Our results of fish wastewater purification treated with batch algal biofilters indicate that the red alga, *G. chorda* could be a potential species for wastewater purification applications.

## PP 151

### Assessment of phytoremediation potentiality of lead (Pb) by *Gracilaria*

**Youngwoo Kim**[*1], Palas Samanta[1], Sojin Jang[1], Sookkyung Shin[1], Jang K. Kim[1]

[1] *Marine Science, Incheon National University, Republic of Korea*

Heavy metals are non-biodegradable pollutants in both freshwater and seawater. Due to their high environmental persistence, heavy metals have adverse toxic effects on environment and humans. Lead (Pb) is one of the major heavy metals and the effect of this heavy metal varies depending on the level and duration of exposure. Phytoremediation has received more attention due to its high efficiency, coupled with a low operational cost. *Gracilaria* is a common seaweed and easily found on the Korean coasts. The phytoremediation capacity of this alga for Pb is unknown. The objective of this study is to determine phytoremediation potential of *Gracilaria* for lead (Pb). *Gracilaria* is cultured in von Stosch enriched (VSE) medium under 100 µmol photons m-2 s-1 of photosynthetically active radiation (PAR) and 12:12 L:D photoperiod. *Gracilaria* is exposed to various lead concentrations (0, 20, 200 and 2000ppb). Pb concentrations in culture medium and algal tissue are analyzed using inductively coupled plasma optical emission spectrometry (ICP-OES). Growth rate, and Pb uptake and removal will be presented. The findings from this study will provide critical information if *Gracilaria* can be a good accumulator of Pb with higher phytoremediation potential.

## PP 152

### Species specific detection for red rot disease pathogens (*Pythium chondricola / P. porphyrae*) of *Pyropia yezoensis* (Rhodophyta) using PCR-RFLP method

**Soon Jeong Lee**[*1], Bo Young Jee[2], Mun Gyeong Kwon[3], Dong-Soo Ha[4], Sang-Rae Lee[5]

[1] *Seaweed Research Center, National Institute of Fisheries Science, Republic of Korea*
[2] *Aquatic Life Disease Control DIvision, National Institute of Fisheries Science, Republic of Korea*
[3] *Aquatic Life Disease Control Division, National Institute of Fisheries Science, Republic of Korea*
[4] *Seaweed Research Center, National Institute of Fisheries Science, Republic of Korea*
[5] *Marine Research Institute, Pusan National University, Republic of Korea*

Red rot disease is one of the most well-known algal diseases infected on red algae *Pyropia* species. This disease has seriously decreased the quality and quantity of *Pyropia* aquaculture products in Korea, China and Japan. We first reported the new red rot disease pathogen infection by *Pythium chondricola* (Oomycetes) on the blade of *Pyropia yezoensis* from Korea (Lee SJ et al. 2015, 2017 Algae). Therefore, there are two species of the genus *Pythium* (*P. chondricola / P. porphyrae*) as red rot disease pathogens of *Pyropia* species. For the effective monitoring of red rot disease, we need more rapid and accurate molecular method to detect the pathogen infection rather than the normal sequencing steps. In this study, we developed the species-specific molecular marker to discriminate the two red rot disease pathogens (*P. chondricola / P. porphyrae*). Using polymerase chain reaction-restriction fragment length polymorphism (PCR-RFLP) method basing on mitochondrial *cox2* and nuclear LSU regions, we successfully identified two *Pythium* species without a sequencing step. We applied this PCR-RFLP method for *Pythium* strains including *P. chondricola* (CBS 203.85), *P. porphyrae* (NBRC 33126) and Korean *P. chondricola* isolate (Biando; NIFS-PC-001). Moreover, we adopted this method for field-cultured blades of *Py. yezoensis* and environmental seawater samples collected from *Pyropia* aquaculture farms. Our PCR-RFLP method showed high specificity and efficiency to detect red rot disease pathogens on the species level for field samples. Therefore, molecular markers developed in this study can be regarded as an effective toolkit for the long term monitoring on the infection and distribution patterns of *Pythium* species in *Pyropia* aquaculture farms. Moreover, the big database constructed by molecular monitoring system can provide the useful information to predict infection and prevent mass mortality due to red rot disease.

## PP 153

### Disease resistance strategies across Phaeophyceae are multi-layered and conserved mechanisms against phylogenetically unrelated pathogens

**Pedro Murua**[*1], Dieter G. Müller[2], Yacine Badis[1], Pieter Van West[3], Claire M. M. Gachon[1]

[1] *Science, The Scottish Asociation for Marine Science, United Kingdom*
[2] *Fachbereich Biologie, Universität Konstanz, Germany*
[3] *Aberdeen Oomycete Laboratory, International Centre for Aquaculture Research and Development, University of Aberdeen, United Kingdom*

*Anisolpidium ectocarpii* (Oomycota) and *Maullinia ectocarpii* (Phytomyxea) are two pathogens that can parasite several different orders of brown algae, making them potential threats for brown algal populations and aquaculture worldwide. In this study, phenotypic changes leading to resistance of 43 different brown algal strains from different clades within Phaeophyceae were characterized against both parasites using different microscopy techniques. We expand the host range of *A. ectocarpii* to one additional order (Syringodermatales) and of *M. ectocarpii* to four additional orders within brown algae (Asterocladales, Syringodermatales, Sporochnales and Tilopteridales). Additionally, we report four defence hallmarks that are conserved in Phaeophyceae and strongly correlated with immunity: i) cell wall reinforcements, based on local papilla formation beneath the infection site, sometimes accompanied of systemic cell wall thickening across the entire challenged thallus; ii) cell death, with host cells steadily dying off after being encysted by pathogens, which after EM evidence of swollen mitochondria, nuclear lysis and plasmodesmata obstruction supports its apoptotic nature; iii) phlorotannin metabolism upregulation, which may suggest a defensive role as much important as against grazers and iv) Inducibility of pathogen autophagy, where pathogens turn systematically autophagic in a suicidal manner, and would correspond as a last line of defence. Additionally, most of the investigated brown algal species show v) a strong hydrogen peroxide production after being co-incubated with both pathogens, confirming an oxidative stress pathway participation in these algal-pathogen interactions. From our study, we conclude that these responses are widely conserved across

Phaeophyceae, and altogether account to algal defences. However, we observed that in several strains these responses were not strong, yet they were still resistant, suggesting that more undescribed mechanisms are contributing to the overall immunity in brown algae.

## PP 154

### Hidden diversity in the oomycete genus *Olpidiopsis* may threaten red algal cultivation and conservation worldwide

**Yacine Badis**[*1], Tatyana A. Klochkova[2], Janina Brakel[1], Martina Strittmatter[3], Pedro Murúa[1,4], Andrea Garvetto[1], J. Craig Sanderson[5], Martin Ostrowski[6], Susanah G. Tringe[7], Gwang Hoon Kim[8], Claire M.M. Gachon[1]

[1] *Macroalgal Pathology, Scottish Association for Marine Science, United Kingdom*
[2] *Department of Biology, Kamchatka State Technical University, Russian Federation*
[3] *Laboratory of Integrative Biology of Marine Models, Station Biologique de Roscoff, France*
[4] *Aberdeen Oomycete Laboratory, University of Aberdeen, United Kingdom*
[5] *Institute of Marine and Antarctic Studies, University of Tasmania, Australia*
[6] *Department of Biochemistry and Biomolecular Science, Macquarie University, Australia*
[7] *US Department Of Energy, Joint Genome Institute, United States of America*
[8] *Department of Biology, Kongju National University, Republic of Korea*

Emerging diseases are hindering macroalgal cultivation, the fastest-growing of all aquaculture sectors. The oomycete genus *Olpidiopsis* notably encompasses pathogens of red seaweeds, including the most economically damaging disease of laver farms in Asia. We recently identified in Scotland two novel *Olpidiopsis* pathogens of *Palmaria palmata* and *Porphyra* sp. and describe them as *Olpidiopsis palmariae* and *O. muelleri* spp. nov., respectively. A new variety of *Olpidiopsis porphyrae,* a pathogen previously thought to be restricted to Japanese and Korean farms, is also described. We created a bioinformatic pipeline to decipher the extent of *Olpidiopsis* diversity and its biogeography. This screen, coupled with large scale metabarcoding campaigns evidenced numerous unknown *Olpidiopsis* taxa, with a worldwide distribution. Additionally, we performed cross-infection experiments on laboratory cultures to investigate the potential of non-native pathogens to jump between wild and cultivated seaweed populations. We show that the Scottish variety *O. porphyrae* is virulent on the most common laver cultivar in Korea and that conversely, a Korean strain of *O. porphyrae* successfully infects wild Bangia sp. strains isolated from Scotland. These results provide proof-of-concept that a native *Olpidiopsis* pathogen may threaten an introduced crop or that a crop-borne *Olpidiopsis* pathogen may threaten wild algae. In the light of their destructiveness in Asian farms, *Olpidiopsis* pathogens should be treated as a serious threat to the sustainability of red algal aquaculture. The capacity of some *Olpidiopsis* species to infect non-commercial algae may further impact marine ecosystems. Our findings call for the documentation of seaweed pathogens and the creation of an international biosecurity framework to limit their spread.

## PP 155

### Three causative pathogens infection pattern analysis of *Olpidiopsis* blight from *Pyropia yezoensis*

**Je Jin Jeon**[*1], Gwang Hoon Kim[1]

[1] *Biologycal science, Kongju National University, Republic of Korea*

Red rot disease and *Olpidiopsis* blight caused by Oomycete pathogens are one of the most serious threats for the *Pyropia* farming in East Asia. Four closely related *Olpidiopsis* species which infect Pyropia blade have been identified; *O. porphyrae* in Japan, *O. pyropiae* and *O. porphyrae* var. koreanae in Korea, and *O. porphyrae* var. *scotiae* in Scotland. We compared infection pattern of three *Olpidiopsis* species which showed different infectivity towards Korean *Pyropia yezoensis. O. pyropiae* showed strongest infectivity from the initial stage of infection and spread to whole blade much faster than the other two. Apoptosis of host cell was inversely related to the infectivity of the pathogen. The apotosis was most prominent in the host infected with var. *scotiae*, which showed weakest infectivity. The color of infected host cell changed differently when it was infected by *O. pyropiae* (yellow) and *O. porphyrae* (green), suggesting that the chloroplasts respond differently to each pathogen. The infection of *Olpidiopsis* pathogen was mediated by the lipid-raft of host cell membrane. When the PI3K inhibitor, LY294002 and Wortmannin, was treated prior to infection the infection rate decreased in all pathogens. These results suggest that three species of *Olpidiopsis* infect the host cell using similar lipid-raft mediated process, but the apoptosis of host cell after the initial infection affects the spread of disease in the infected blade.

## PP 156

### Metagenomics analysis of distribution of Phycodnavirus in the marine environment of the south sea in Korea

**Min Seok Kwak**[*1], Gwang Hoon Kim[1]

[1] *Department of Biology, Kongju National University, Republic of Korea*

Viruses are the most abundant biological entities in the oceans, and account for a significant amount of the genetic diversity of marine ecosystems. However, there is little detailed information about the biodiversity of viruses in marine environments. Rapid advances in metagenomics have enabled the identification of previously unknown marine viruses. In this study, we analyzed the distribution of virus after collecting seawater in Gwangyang Bay, Jindo Kim Farm, and Wando Abalone Farm where various environments exist depending on salinity. In Gwangyang Bay area, five points were selected from fresh water environment of Seomjin River to the sea in front of Gwangyang Bay In the case of Jindo Kim farm, the area where the form is performed, the area close to the inland away from the farm, In the case of the abalone farm, the study was conducted by setting the area where the abalone farming is performed and the two areas close to the inland farming area as the control. The virus was concentrated to 0.1 ~ 1kDa in size and then DNA was extracted and analyzed by metagenome. Among 86 virus groups, phycodnavirus, which has algae as a host, was analyzed by each marine environment

## PP 157

### *Pleurostomum flabellatum* genomics; new paradigm to unveil the adaptation of extreme salinity

**Khaoula Ettahi**[*1], Hwan Su Yoon[1], Jong Soo Park[2]

[1] *Biological Sciences, Sungkyunkwan University, Republic of Korea*
[2] *Oceanography, Kyungpook National University, Republic of Korea*

*Pleurostomum flabellatum,* a member of the Heterolobosea, thrives in extremely high salt (optimal 300‰ of salinity) environment (e.g., salt pond), which is the highest among the eukaryotes. This halophilic extremophile likely developed genetic tools to overcome significant restricting components in the harsh habitats. Many heterolobosean have adapted to various extreme environments; halophilic, acidophilic,

thermophilic, and anaerobic conditions, however, these lineages are considerably understudied despite their enormous ecological and morphological diversity. To investigate the molecular adaptation in the halophilic extremophilic habitat of *P. flabellatum*, we have conducted whole-genome sequencing and RNA-seq. We compare genome data with the available heterolobosean genome of *Naegleria gruberi*. We predicted protein-coding sequences as well as functional annotation based on transcriptome assembly. We also performed comparative orthologous gene analysis between *P. flabellatum* and *N. gruberi*. Based on the comparative genomic analysis, 4,876 orthologous gene families (OGFs) with 4,787 OGFs groups contained sequences from the two analyzed species. Also, a total of 14,269 annotations were determined from assembled contigs. Future more, 4,629 genes/transcripts were selected for future annotation with targeted manual curating. In this presentation, we will discuss our results in more detail.

## PP 158

### Transcriptome analysis of high-growth-rate *Pyropia yezonesis* mutant using RNA-seq

**Seo-jeong Park**[*1], Jong-il Choi[1]

[1] *Department of Biotechnology and Bioengineering, Chonnam national university, Republic of Korea*

*Pyropia yezonesis* is one of the marine red-algae and used as vegetable seaweeds in East Asia like Korea, China and Japan. *Pyropia* is called 'Gim' in Korea and 'Nori' in Japan. *P. yezonesis* is popular cultivated *Pyropia* strain with *P. tenera*. Korea is one of major producer of *Pyropia* in the world *Pyropia* market with China and Japan. The demand of *Pyropia* is getting increase, the people is getting attend to healthy foods. Producer needs to increase production of *Pyropia* to meet increase demand of *Pyropia*. The high-growth-rate *P. yezonesis* mutant was made by ethylmethansulfaonate (EMS) as mutagen to meet increased demand. Even though draft genome and plastid genome of *P. yezonesis* were published, the lack of genetic information for *P. yezonesis* makes difficulty to understand high-growth-rate in mutant. Therefore, this study has aimed to understand mechanisms of high-growth-rate with transcriptome analysis using RNA-seq. 267,320 unigenes were identified from RNA-seq data de novo assembled with Trinity. And 5,407 differentially expressed genes (DEGs) were found in identified unigenes.

## PP 159

### Genome-wide identification, phylogeny, and expressional profiles of the mitogen-activated protein kinase kinase kinase (MAPKKK) gene family in *Pyropia yezoensis*

**Fanna Kong**[*1], Na Li[1,2], Daoying Dong[1,2]

[1] *The College of Marine Life, Ocean university of China, China*
[2] *Key Laboratory of Marine Genetics and Breeding of Ministry of Education, Ocean University of China, China*

Mitogen-activated protein kinase kinase kinases (MAPKKKs) are pivotal components of mitogen-activated protein kinase (MAPK) cascades. Pyropia yezoensis, belonging to Rhodophyta, is an important macroalgae growing in the intertidal zone. Although genome-wide analyses of MAPKKKs and their potential regulatory mechanisms in response to environmental stressors have been conducted in many higher plant species, related research in red algae is scarce, particularly with regard how this gene family retained its ancient characteristics. In this study, we identified 33 MAPKKK proteins encoded by 33 MAPKKK genes in P. yezoensis by bioinformatics analysis. Phylogenetic analysis classified them into three subfamilies, including Raf, MEKK and ZIK group, which was consistent with the conserved domain classification. Conserved protein motif analysis showed that they contained a conserved motif with minor variations. Gene structure analysis showed that PyMAPKKK contained a few introns, ranging from 0 to three. Regulatory elements prediction indicated that the cis-acting elements included many motifs involved in the stress response, particularly drought stress and temperature stress. Furthermore, expression analysis of PyMAPKKKs under different stress conditions as well as dehydration and temperature stress revealed that numerous PyMAPKKK genes were involved in various signaling pathways with different expression patterns. An interactome network of PyMAPKKK was constructed to show that most of the interacting proteins were serine/threonine protein kinases, MAPKs, and ubiquitin-binding proteins. In summary, our study provided important information for the evolutionary and functional characterization of the MAPKKK family in P. yezoensis, which will facilitate a better understanding of the MAPK signaling pathway in P. yezoensis.

## PP 160

### The complete genome sequence of *Pyropia haitanensis* at chromosome level using shotgun, single-molecule sequencing and optical mapping

**Min Cao**[*1], Yunxiang Mao[1]

[1] *College of Marine Life Sciences, Ocean University of China, China*

*Pyropia haitanensis* (Bangiales, Rhodophyta), a representative species of the red alga, is one of the most economically important crops in China. The varied living environments and characteristics of *P. haitanensis* make it an ideal model organism for studying the genetics and genomics of seaweed in the intertidal zone. However, genomic information on *P. haitanensis* remains lacking at present. Hence, the whole genome of *P. haitanensis* was assembled using single molecule sequencing and bionano optical genome maps. Finally, the assembled genome is about 53.3 Mb, with a contig N50 length of 102,32kb and a scaffold N50 length of 5.8 Mb. The average GC content of this genome is 67.85%. What's more, we identified 10,903 genes and found9.55 % interspersed elements and 14.58 % tandem elements in the whole genome. The genome-wide phylogenetic tree demonstrated that the divergence time of *P. haitanenesis* and *Po. umbilicals* was ~204.4Ma (95% highest posterior density (HPD)=164.6-249.7 Ma). Comparative genomes in red algae showed that 445 gene families were expanded in *P. haitanenesis* when compared that with *Po. umbilicals*. The availability of these information will be valuable for understanding the tolerance mechanisms and evolution within red algae, also useful for improving the molecular breeding of *P. haitanensis.*

## PP 161

### Conspecificity of the peruvian *Corallina ferreyrae* with *C. caespitosa* inferred from genomic analysis of the type specimen

**Danilo Bustamante**[*1], Martha S. Calderon[1,2], Jeffery R. Hughey[3]

[1] *Instituto de Investigación para el Desarrollo Sustentable de Ceja de Selva (INDES-CES), Universidad Nacional Toribio Rodriguez de Mendoza, Peru*
[2] *Laboratorio de Ecosistemas Marinos Antárticos y Sub-antárticos (LEMAS),*

*Universidad de Magallanes, Chile*
[3] *Division of Mathematics, Science, and Engineering, Hartnell College, United States of America*

The genus *Corallina* is composed of thirty accepted species. Previous studies emphasized the need for an exhaustive revision of *Corallina* to determine the extent of its pseudocryptic diversity. In Peru, only two species of *Corallina* are currently recognized: *C. ferreyrae* E.Y.Dawson, Acleto & Foldvik 1964 and *C. chilensis* Decaisne in Harvey 1849. *Corallina ferreyrae* was originally described from Pucusana, Peru, and said to differ from other species by its prominent development of flagelliform branchlets. The name *C. ferreyrae* however, has been virtually ignored in the literature since. To determine its relationship to other *Corallina,* we performed high-throughput sequencing on an isotype specimen of *C. ferreyrae* (UC 1404138). The analysis yielded its complete plastid and mitochondrial genomes. Comparison of the organellar genomes to other published corallines found high levels of gene synteny. Phylogenetic analysis of *cox1, psbA,* and *rbcL* gene marker sequences of *C. ferreyrae* resolved it in a clade with *C. caespitosa* R.H.Walker, J.Brodie & L.M.Irvine 2009, a widely distributed species in the Pacific and Atlantic Oceans. These molecular data reveal that *C. caespitosa* is conspecific with *C. ferreyrae*. *Corallina* ferreyrae has priority of publication over *C. caespitosa*, which we hereby propose to be reclassified as a heterotypic synonym of *C. ferreyrae*. These data show that *C. ferreyrae* is not endemic to the Peruvian coast, instead it is widely distributed along the Atlantic and Pacific Oceans. Given the age of the genus and hundreds of names classified to *Corallina*, it has not escaped our notice that there are likely older binomials that have priority over this relatively new name, *C. ferreyrae.*

## PP 162

### Isolation of two sex-specific importin-alpha-like genes in the red alga *Bostrychia moritziana*

**Eun Young Shim**[*1], Giuseppe C. Zuccarello[2], Gwang Hoon Kim[1]
[1] *Department of biology, Kongju National University, Republic of Korea*
[2] *School of Biological Sciences, Victoria University of Wellington, New Zealand*

Differential expression of sex-related genes was analyzed in the gametophytes, carposporophytes and tetrasporophyte of a red alga, *Bostrychia moritziana*. RNAseq results showed that two importin-alpha-like homologues were specifically expressed in male and female gametophyte, respectively. Female specific homologue of importin-alpha-like (BFS) was expressed in female gametophyte as well as carposporophyte. Two sex-specific importin-alpha-like genes showed 77% sequence identity. Genomic PCR showed that both genes present only in respective gametophyte. Tetrasporophyte showed expression of both homologues. These results suggest that the sex in Bostrychia moritziana may be determined by sex chromosomes. After male spermatia bound to the female trichogyne the expression of female-specific importin-alpha-like gene(BFS1) sharply increased suggesting that it might be involved in fertilization signaling. Importin alpha is a type of karyopherin that transports protein molecules into the nucleus by binding to specific recognition sequences. Our results suggest that signal protein traffic to nucleus is deeply involved in sexual differentiation as well as fertilization signaling.

## PP 163

### First report on draft genome sequence of coenocytic green alga, *Bryopsis plumosa*

**Hyun Dae Hong**[*1], Jong Won Han[1], Jin-Woo Han[1], Gwang Hoon Kim[2], Hyun-Ju Hwang[1]
[1] *Genetic Resources research, Marine Biodiversity Institute of Korea, Republic of Korea*
[2] *Department of Biology, Kongju National University,, Republic of Korea*

*Bryopsis plumosa* is the most important marine coenocytic green alga containing useful features which is able to utilize to bio resources. *B. plumosa* genome was sequenced and assembled by Pac-bio II sequencing. The assembled sequence consisted of 7,767 contigs covers about 85% of 300 Mb genome. Average length of contig was 31 kb, and N50 value was 450 kb. Gene predictions on the assembled sequence suggested that the genome contains 32,485 genes which cover 24.5% of genome. This reference genome sequence will facilitate the identification of the genetic basis of important traits, and accelerate the development of useful materials (Proteins, peptides and organic compounds) for marine-bio science.

## PP 164

### Reappraising phylogenetic plastid markers of the red algae in the genomic era

**Chun Chi Shih**[*1], Shing Hei Zhan[2], Shao Lun Liu[1]
[1] *Life Science, Tunghai University, Taiwan*
[2] *Zoology, the University of British Columbia, Canada*

A well-supported phylogenetic backbone of the red algae (Rhodophyta) has recently been reconstructed from plastid genomes. It is unclear how popular plastid markers—particularly *rbcL, psbA, psaA,* and *psaB*—perform compared to other plastid genes for inferring the Rhodophyta phylogeny. Here, we developed and applied a bioinformatics strategy to seek attractive plastid phylogenetic markers that might have been overlooked. We ranked the core plastid genes of 107 published plastid genomes based on various sequence-derived properties and their tree distance to plastid genome phylogenies. We found that *rbcL, psbA, psaA*, and *psaB* are not necessarily the best markers. Instead, we propose a reduced plastid marker set (*apcE, gltB, rpoB, rpoC1*, and *rpoC2*) for phylogenetic studies of Rhodophyta. Additionally, we designed and tested PCR primers for *rpoB* and *rpoC1*, which were the least variable in the set and thus the most suitable for amplification. We successfully amplified *rpoC1*, but not *rpoB,* on a taxonomically broad set of red algal specimens. Nevertheless, the five-gene set can be employed in an approach that combines next-generation sequencing and target hybridization in future studies. We hope that the marker identification methodology, proposed plastid marker set, and the *rpoC1* primers will be useful to the phycological community.

## PP 165

### An investigation into the organellar genomes of brown algal relatives

**Seok-Wan Choi**[*1], Louis Graf[1], J. Mark Cock[2], Hwan Su Yoon[1]
[1] *Department of Biological Sciences, Sungkyunkwan University, Republic of Korea*
[2] *Integrative Biology of Marine Models Department, Station Biologique de Roscoff, France*

PX clade is an informal monophyletic group of photosynthetic heterokonts that includes two ecologically important and highly diverse classes,

Phaeophyceae (brown algae) and Xanthophyceae. Aside from these two relatively well-known classes, there are many other classes such as Schizocladiophyceae, Phaeothamniophyceae, and Aurearenophyceae in the clade. However, brown algae and their relatives do not share conspicuous synapomorphies and phylogenetic relationships among them remain unresolved, although multigene-level approaches to construct a phylogenetic tree of photosynthetic stramenopiles, in a broad sense, have been carried out. Furthermore, organellar genomic data of the PX clade, which are available at the moment, are greatly biased towards brown algal species. Therefore, we selected four species (*Phaeothamnion confervicola, Botrydiopsis pyrenoidosa, Tetrasporopsis fuscescens,* and *Nematochrysis sessilis*) that were assigned to distinct lineages of the PX clade based on previous studies using single or multiple molecular loci, but whose phylogenetic positions were determined with not so strong supports. We present here more resolved phylogenetic relationships among PX species, using organellar genomic data, than those formerly constructed. Furthermore, we compared their organellar gene contents and analyzed possible adaptation or transfer events they experienced, with respect to the metabolic functions of the organelles. This study will contribute to a comprehensive understanding of the evolutionary history of the PX clade beyond traditional taxonomical classifications and provide valuable resources for future researches on the PX clade.

## PP 166

### Comparative genomic study of the genus *Porphyridium*

**Dongseok Kim**[*1], Hwan Su Yoon[1]
[1] *Sungkyunkwan University, Republic of Korea*

The red algae (Rhodophyta) form a monophyletic lineage comprising around 7,100 species. The Rhodophyta consists of 7 classes (Bangiophyceae, Compsopogonophyceae, Cyanidiophyceae, Florideophyceae, Porphyridiophyceae, Rhodellophyceae, and Stylonematophyceae). For the class Porphyridophyceae, only 8 species are reported to date including one order, one family, and four unicellular genera (i.e., *Erythrolobus, Flintiella, Porphyridium* and *Timspurckia*). Moreover, the knowledge we have about *Porphyridium* solely comes from one mesophilic species, *Porphyridium purpureum*. Interestingly, four plastid genomes of *P. purpureum* exhibit high genetic variation, especially in Group II introns. Here, we analyze the plastid genome from *Porphyridium aerugineum* CCMP 1948, which is closely related to *P. purpureum*. We conducted comparative genome analysis with six available genomes including four *P. purpureum*, one *P. aerugienum* and one *P. sordidum* strain by comparing the variation within the gene sets. Based on comparative genomic results, here, we discuss a possible evolutionary scenario for the Porphyridiales

## PP 167

### Functional characterization and evolutionary analysis of Glycine-betaine biosynthesis pathway in red seaweed *Pyropia yezoensis*

**Dongmei Wang**[*1]
[1] *College of Life Sciences, Ocean University of China, China*

The red seaweed *Pyropia yezoensis* is an ideal research model for dissecting the molecular mechanisms underlying its robust acclimation to abiotic stresses in intertidal zones. Glycine betaine (GB) was an important osmolyte in maintaining osmotic balance and stabilize the quaternary structure of complex proteins under abiotic stresses (drought and salinity etc.) in plants, animals and bacteria. However, the existence and possible functions of GB in *Pyropia* remain elusive. In this study, we observed rapid accumulation of GB in desiccated *Pyropia* blades, indicating its essential roles in protecting Pyropia cells against severe osmotic stress. Based on the available genomic and transcriptomic informations of *Pyropia*, we computationally identified genes encoding the three key enzymes in GB biosynthesis pathway, PEAMT, CDH and BADH, respectively. *Pyropia* had an extraordinarily expanded gene copy number of CDH (up to seven) compared to other red algae. Phylogeny analysis revealed that in addition to the one conservative CDH in red algae, the other six might be originated from early gene duplication events. In dehydration stress multiple CDH paralogs and PEAMT genes were coordinately up-regulated and shunt metabolic flux into GB biosynthesis. An elaborate molecular mechanism might be involved in the transcriptional regulation of these genes.

## PP 168

### Proteomic changes of *Zygnema* sp. by gamma-irradiation

**Jong-il Choi**[*1]
[1] *Department of Biotechnology and Bioengineering, Chonnam National University, Republic of Korea*

To investigate the effect of ionizing radiation on an microalga, *Zygnema* sp. was gamma-irradiated, and cell damage was measured. The photosynthetic efficiency markedly decreased in gamma-irradiated *Zygnema* sp., whereas antioxidant capacity significantly increased. To investigate the metabolic changes, protein expression levels were compared by two-dimensional electrophoresis. Proteins involved in energy metabolism, isoprene biosynthesis, and protein biosynthesis were significantly downregulated. On the other hand, proteins related to DNA repair, quinone oxiredutase, regulation of microtubules, and cell wall biogenesis were upregulated in gamma-irradiated *Zygnema* sp.

## PP 168-1

### A study of heterozygous single nucleotide polymorphism loci in haploid gametophyte of *Gracilariopsis lemaneiformis* (Rhodophyta)

Yiyi Hu[1], **Zhenghong Sui**[*1], Wei Zhou[1], Jinguo Wang[1], Minjie Jiang[1], Haihong Chen[1], Jingyu Zhang[1], Wei Zhang[1], Xiaoqing Feng[1], Yuehua Lei[1], Baoheng Xiao[1], Peng Guo[1]
[1] *Key Laboratory of Marine Genetics and Breeding (Ocean University of China), Ministry of Education, Qingdao 266003, China*

*Gracilariopsis lemaneiformis* is a commercially important macroalga, which are mainly utilized for agar extraction and abalone aquaculture. Whole-genome resequencing were conducted to develop single nucleotide polymorphism (SNP) in a mapping population of 60 F1 gametophyte of *Gp. lemaneiformis* in this study. 9,989 SNPs located in non-repetitive sequence were obtained. Heterozygous SNPs which were identified as heterozygous genotype in at least one gametophyte accounted for 92.02%, and there are 48.07% SNP loci showed identical heterozygous genotype in all gametophytes. For each gametophyte, the proportion of homozygous loci, heterozygous loci and missing loci were counted, respectively: the ranges of heterozygous loci in each individual was between 66.36% and 83.59%, with an average of 77.12%; the percentage

of homozygous loci ranged from 13.74% to 21.61%, and the mean was 17.04%; the remaining were missing loci and the average proportion was 5.84%. A series of verification experiments were carried out, to test the reliability of heterozygous SNP loci. Source of heterozygous SNP was excluded the exogenous DNA contamination, cross contamination among individuals, plastid and mitochondrion sequences, chimera of different thallus parts or different cells, and repetitive sequences. Genotypes of heterozygous SNPs were tested by SNP primer designing, PCR amplification, product sequencing and monoclonal sequencing. Results of Sanger sequencing and monoclonal sequencing both verified the heterozygous genotypes. The duplication event of chromosomal rearrangement in the genome of *Gp. lemaneiformis* might be the reason that heterozygous SNPs existed in haploid gametophyte genome.
Keywords: *Gracilariopsis lemaneiformis*, Single nucleotide polymorphism, Whole-genome resequencing

## PP 169

### New records of cryptic introduced species of the red algal family rhodomelaceae in Tasmania (Australia)

**Pilar Díaz-Tapia**[*1], Cristina Piñeiro-Corbeira[1], Heroen Verbruggen[2]
[1] *BioCost Research Group, Universidade da Coruña, Spain*
[2] *BioSciences, University of Melbourne, Australia*

Cryptic introductions are common in the red algae, as many species are small in size and morphologically similar to native ones, so that they are easily overlooked. As a result, the development of diversity surveys using DNA sequence data for species identification often reveals the occurrence of new introduced species. During our sampling surveys in Tasmania (Australia) we found four rhodomelacean species that do not match morphologically with any of the species previously recorded in the area. DNA *rbcL* sequences were determined for these species and compared with the data available in GenBank. Our analysis revealed that they correspond to *Polysiphonia morrowii, P. delicata, Melanothamnus japonicus* and *M. strictissimus. P. morrowii* is native from eastern Asia and has been reported as introduced or cryptogenic in New Zealand, Europe and South America. *P. delicata* has been recently described as a new species based on materials collected in Europe and Victoria (Australia). It was considered as cryptogenic because whether it is native or introduced in its known distribution range is uncertain. *M. japonicus* is native from eastern Asia and has been recorded in Europe, North America, New Zealand and Southern Australia. Finally, *M. strictissimus* is native from New Zealand and this is the first time that it is recorded as an introduced species. *P. morrowii, M. japonicus* and *M. strictissimus* were found growing abundantly in intertidal habitats of several localities in Tasmania and they are candidates to be considered invasive. Four introduced species are reported here for the first time in Tasmania, including three well-known introduced species in other world regions, as well as a species that is here recorded as introduced for the first time.

## PP 170

### Deep genetic divergences among the regional populations of the red algae *Caulacanthus ustulatus* (Gigartinales)

**Mi Yeon Yang**[*1], Zhong-Min Sun[2], Gary W. Saunders[3], Myung Sook Kim[1]
[1] *Department of Biology, Jeju National University, Korea*
[2] *Key Lab of Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China*
[3] *Biology, University of New Brunswick, Canada*

A number of studies demonstrates that genetic differentiation and speciation in the sea occur on smaller spatial scales than previously appreciated given the wide distribution range of many macroalgal species. However, the knowledge on the pattern of genetic structure is often lacking despite being essential for the understanding, conservation, and management of marine biodiversity. The red algae, *Caulacanthus ustulatus*, is growing intertidally in various localities of worldwide. To determine genetic diversity and phylogeographic structure of this algae, we analyzed samples from Korea, Japan, China, Taiwan, Hawaii, Australia, New Zealand, British Columbia, France, and Spain using the mitochondrial COI-5P sequences. In the haplotype network, deep genetic divergences and substantial amounts of regional isolation among populations were uncovered. Asian groups from Korea, Japan, China, and some of Taiwan are clustered together in several fragmented haplotypes and also closely connected with haplotypes from France and British Columbia. Another regional haplotypes from Taiwan, New Zealand, Australia, Hawaii, and Spain are deeply separated, respectively, demonstrating longstanding isolation. Overall, the result pointed stepping-stone dispersal, resulting in high levels of regional isolation. Some long-distance genetic exchange, such as close-in haplotypes from Japan, France, and British Columbia with low genetic variation, suggest the introduction across the western Pacific to the eastern Pacific and East Atlantic. These results indicate that each isolated population should be considered as a cryptic species and they will have to be investigated using morphological characteristics.

## PP 171

### Comparative phylogeogaphy of two intertidal seaweeds, *Grateloupia asiatica* and *G. jejuensis* (Halymeniales, Rhodophyta), along the Northwest Pacific

**Mi Yeon Yang**[*1], Hyung Woo Lee[1],Su Yeon Kim[1], Myung Sook Kim[1]
[1] *Biology, Jeju National University, Korea*

Seaweeds from intertidal or shallow subtidal habitats have been recognized as good models for phylogeographic studies because they are susceptible to neutral processes of genetic differentiation. Species distributed in intertidal zone is frequently assumed to have high genetic structure due to greater variety of environmental stresses that may generate differential natural selection than in species from subtidal zone. *Grateloupia asiatica* and *G. jejuensis* are endemic red macroalgae from the Northwest Pacific, mainly in the intertidal zone. In this study, we compared the phylogeographic patterns of these two *Grateloupia* species that are partially co-distributed along the Korean coast with adjacent region. A total of individuals from *G. asiatica* and *G. jejuensis* were characterized using a plastid *rbc*L marker. *G. asiatica* from Korea, Japan, China, and California revealed 15 haplotypes with 1.4% sequence divergence. Dominant haplotype H1 was distributed in entire Korean coast, east China, and northern Japan. A portion of the Chinese haplotype (H14) was shared with that from the southern Japan. A Californian haplotype was considered to be introduced from Japan. On the other hand, *G. jejuensis* from Korea and Japan had higher genetic diversity with 20 haplotypes and 2.9% sequence divergence. Haplotype H1 was dominant in entire Korean coast as well as east part of Japan. Deeply separated haplotypes (H10, H13, and H12) can be considered putative genetic sibling species. Our phylogeographic study of two *Grateloupia* species provided the evidence showing that species respond differently to similar environmental variability, and more comparative evidence are needed to better understand species diversity in the Northwest Pacific.

## PP 172

### Phylogenetic relationships of the Antarctic Bangiales (Rhodophyta) from King George Island, Antarctica

**Han-Gu Choi**[*1], Sun-Mi Kim[1], Mi Sook Hwang[2], Tae-Kun Seo[1], Ji Hee Kim[1]
[1] *Division of Life Sciences, Korea Polar Research Institute, Republic of Korea*
[2] *Seaweed Research Center, NFRDI, Republic of Korea*

Members of the Bangiales (Rhodophyta) are distributed worldwide from tropic to Antarctic and Arctic waters. Three species of the Bangiales; *Bangia fuscopurpurea* (as *B. atropurpurea*), *Pyropia endiviifolia* (as *Porphyra endiviifolium*) and *Wildemania plocamiestris* (as *Porphyra plocamiestris*), have been reported in the Antarctic. Morphological and molecular data were investigated for the Bangiales from the Antarctic and its adjacent waters. Each six sequences of SSU rDNA, plastid *rbcL* and mitochondrial *cox1* gene were newly determined in this study. Molecular data from over 200 taxa of the Bangiales worldwide including previously published sequences, indicated that the genera *Bangia, Dione, Porphyra, Pyropia, Wildemania* and other related genera be recognized in the Bangiales as in the previous molecular study. *Bangia fuscopurpurea* from the Antarctic was different from *B. fuscopurpurea* from north Pacific (Korea and Japan) by 12 bp in cox1 gene sequence. *Pyropia endiviifolia* is olive green in color and it allied to a clade with three *Pyropia* species from Falkland Islands, Nabarino Island, Rio Seco and Punta Arenas, Chile. *Wildemania plocamiestris* growing on other macroalgae in sub-tidal zone grouped into the genus *Wildemania* with the species having one or two cell layers in molecular data. The diversity, taxonomic issues, phylogenetic relationships, distribution and evolution of the Antarctic members of the Bangiales were discussed.

## PP 173

### A new *Chlorella* species (Chlorophyta, Trebouxiophyceae) from Antarctica

**Hyunsik Chae**[*1], Sanghee Kim[1], Han-Gu Choi[1], Han Soon Kim[2], Ji Hee Kim[1]
[1] *Division of Polar Life Sciences, Korea Polar Research Institute, Republic of Korea*
[2] *School of Life Sciences, Kyungpook National University, Republic of Korea*

A new *Chlorella* species collected from Deception Island in maritime Antarctica and its morphological and molecular characteristics were investigated. The shapes of cells were spherical to oval, solitary life-form and the absence of mucilaginous envelope. A single chloroplast is parietal with a pyrenoid. Owing to their simple morphology, conspicuous morphological characters were not observed under the light microscope. However, molecular phylogenetic inferences are drawn from the concatenated small subunit (SSU) rDNA and internal transcribed spacer (ITS) sequence data indicated that this microalgal strain is closely related to *Chlorella pituita* and forms a distinct well-supported lineage with the genus. Compensatory base changes (CBCs) in the ITS2 secondary structure that serve as a key to identifying and describing Chlorella also supported its taxonomic position within the genus of *Chlorella*.

## PP 174

### Complete mitochondrial genome and phylogeny of *Sargassum yezoense* (Fucales)

**Kyeong Mi Kim**[*1], Jeong Kwang Park[1], Hyeong Seok Jang[1], Ji Won Hong[1]
[1] *Department of Taxonomy and Systematics, National Marine Biodiversity Institute, Korea*

*Sargassum* C. Agardh (Sargassaceae, Phaeophyceae) is a widely distributed genus on rocky intertidal shores worldwide and represents one of the most species-rich genera of the marine macrophytes. *Sargassum yezoense* (Yamada) Yoshida & T. Konno is a large fucacean brown alga that is distributed in Japan and Korea. This alga forms forests or meadows in sublittoral regions serving as nursery habitats and spawning grounds for marine invertebrates and fish. In this investigation, the complete mitogenome of *S. yezoense* was determined for the first time. The size of the circular mitogenome produced is 34,767 bp (GenBank accession number MG674825) which is similar to the previously reported *Sargassum* mitogenomes (34,606–34,925 bp). The nucleotide composition is 26.9% A, 36.6% T, 21.5% G, and 15.1% C. The overall GC content is 36.6%. The S. yezoense mitogenome contains 65 genes, including 37 protein-coding, three rRNA, and 25 tRNA genes. The ATG start codon is used in all protein-coding genes. Phylogenetic analysis was carried out using 11 reported brown algal mitogenome sequences. *Sargassum yezoense* combined tightly with *S. muticum, S. hemiphyllum, S. thunbergii, S. fusiforme*, and *S. horneri* with strong support values. Based on the complete mitogenome of *S. yezoense*, new mt DNA marker could be selected and employed to study the phylogeography and phylogeny for Fucales.

## PP 175

### Diversity and phylogenetic relationships of foliose Bangiales (Rhodophyta) from Korea

**Mi-Sook Hwang**[*1], Sun-Mi Kim[2], Il-Kee Hwang[1], Seung-Oh Kim[1], Sang-Rae Lee[3], Hyeong-Seop Kim[4], Han-Gu Choi[2]
[1] *Aquatic Plant Variety Center, NIFS, Republic of Korea*
[2] *Division of Life Sciences, Korea Polar Research Institute, KIOST, Republic of Korea*
[3] *Marine research Institute, Pusan National University, Republic of Korea*
[4] *Department of Biology, Gangneung-Wonju National University, Republic of Korea*

On the basis of the revised taxonomic system for the Bangiales, we made a generic revision of the foliose Bangiales from Korea by the analysis of the plastid *rbc*L gene. More than 160 sequence data from GenBank and newly analyzed 30 sequence data from Korea were used in this study. As results, 21 taxa of foliose Bangiales were detected in Korea. One taxon belongs to *Miuraea*, another belongs to *Wildemaina*, and the others belong to *Pyropia*. A taxon of *Wildemania* is an unrecorded or a new species. A cryptic species of *Pyropia* was also revealed in this study. The taxonomic issues, phylogenetic relationships, diversity and distribution for the Korean members of foliose Bangiales will be discussed.

## PP 176

### Algal diversity of marine national parks, Korea

**Jung Kwan Ahn**[*1]
[1] *Marine Research Center, National Park Research Institute, Republic of Korea*

The marine algal flora at marine national parks of Korea, were investigated annually form 2006. As a result, a total of 431 species including 65 greens, 96 browns and 270 reds were identified. The most species (310) found at Dadohaehaesang national park, while the fewest (113) were found at Byeonsanbando national park.

## PP 177

### Phylogeny and evolution of haptophytes based on three new mitogenomes

**Eun Chan Yang**[*1], Ha Eun Lee[1], Su Yeon Kim[1]
[1] *Marine Ecosystem Research Center, Korea Institute of Ocean Science & Technology, Republic of Korea*

*Emiliania, Chrysochromulina,* and *Phaeocystis* are important primary producers in the open ocean. *Diacronema* (known as *Pavlova*) and *Isochrysis* are famous microalgae with higher amounts of polyunsaturated fatty acids and are commonly used as feedstocks of marine shellfish and fish aquacultures. Despite of industrial, ecological and evolutionary importance of the haptophytes, genetic diversity and evolutionary history of the lineage are not well studied yet because of limited taxon sampling. In present study, we assembled new mitochondrial genomes (mtDNA) from three haptophycean taxa, i.e., *Chrysotila carterae* LIMS-PS-1065, *Diacronema lutheri* LIMS-PS-0073, and *Isochrysis galbana* LIMS-PS-1699. In the Haptophytes, total size of mtDNA was ranged from 26,188 bp to 41,838 bp in total, and encompassed 17-22 protein coding genes, 2-3 rRNAs, and 24-25 tRNAs. The best phylogeny based on mtDNA reveals a monophyly of Haptophyta, basal position of Pavlovales (*Diacronema* and *Pavlova*), and relationships among Coccolithophycean taxa, such as sister relationship of Coccolithales (*Chrysotila*) and Isochrysidales (*Eminiania* and *Isochrysis*). The gene content comparison based on mtDNA phylogeny suggested multiple gains and losses of atp4, atp8, rpl14, rps3 and rps8 within the haptophytes.

## PP 178

### Mitochondrial genome analysis and systematics of Halymeniaceae (Halymeniales, Rhodophyta)

**Eun Chan Yang**[*1], Su Yeon Kim[2], Sung Min Boo[3], Hwan Su Yoon[4]
[1] *Marine Ecosystem Research Center, Korea Institute of Ocean Science & Technology, Republic of Korea*
[2] *Department of Biology, Jeju National University, Republic of Korea*
[3] *Department of Biology, Chungnam National University, Republic of Korea*
[4] *Department of Biological Science, Sungkyunkwan University, Republic of Korea*

Halymeniaceae Bory is one of the largest family in Rhodophyta, including 35 genera and 332 species. Previous rbcL analysis showed promising utility for the taxonomy of Halymeniacean species, although it showed limitation to resolve deep phylogeny. Based on the rbcL (207 taxa) phylogeny, we selected 6 representatives for the 4 major clades of Halymeniaceae as follow; i) *Grateloupia angusta & Kintokiocolax agregato-cerantha*, ii) *Halymenia maculata,* iii) *Polyopes affinis & P. lancifolious*, iv) *Pacymenia lanciniata*. We determined new six mitochondrial genomes using Ion Torrent Personal Genome Machine (Life Technology, USA), and assembled using MIRA assembler. The overall mitochondrial gene synteny is highly conserved among the halymeniacean species with a few differences such as total size of mitogenome, intron positions, and numbers of tRNAs. The mitogenome variation mostly caused by intron and intronic-ORF of rrl and cox1. The other variations are followed as: 1) structural differences of intron and intronic ORFs in cox1 and rrl; 2) absence of ymf39 in *H. maculata* and atp8 and ymf39 in *P. lanciniata;* 3) different positions of two t-RNAs (trnG and trnL) among species and independent gain and loss of tRNA, i.e., two gain (trnD and trnH) and one loss (trnL) in *H. maculata;* one gain (trnR) and one loss (trnM) in *P. lanciniata*. Various combinations of mitochondrial genes were tested to resolve the relationships among 4 major clade of Halymeniaceae.

## PP 179

### *Derbesia maxima* sp. nov. (Bryopsidales, Chlorophyta) from Korea based on morphological and molecular data

**Jae Woo An**[*1], Pil Joon Kang[1], Ki Wan Nam[1]
[1] *Marine Biology, Pukyong university, Republic of Korea*

A green alga was collected from Daejin located on the eastern coast of Korea. It shows a typical siphonous thallus structure composed of erect and prostrate filaments like other *Derbesia* sporophytes, and is characterized by a relatively large sporophytic thallus, irregularly branched filaments with a basal septum and one pyrenoid per ovoid to lenticular, occasionally irregular chloroplast. Sporangia have a spherical to ovoid shape with a short pedicel and septum at the base. It appears to have a heteromorphic life history with a gametophytic Halicystis stage. In a phylogenetic tree based on rbcL sequence, the Korean entity nests in a sister clade of some species including the type *Derbesia marina*, and of these species, *D. fastigiata* is most similar to the Korean alga in genetic divergence at 3.1%. However, its value is considered to be involved in the inter-specific range for the genus. *Derbesia maxima* sp. nov. (Bryopsidales, Chlorophyta) is proposed for this siphonous green alga from Korea based on morphological and molecular analyses.

## PP 180

### Genetic diversity of regional populations of *Chondrus ocellatus-nipponicus* complex inhabiting the Korean peninsula

**Hyeong Seok Jang**[*1], Ji Won Hong[1], Kyeong Mi Kim[1], Hyung-Seop Kim[2]
[1] *Department of Taxonomy and Systematics, Marine Biodiversity Institute of Korea, Republic of Korea*
[2] *Department of Biology, Gangneung-Wonju National University, Republic of Korea*

Many species have been reported in the genus *Chondrus*, but their morphologies are very similar to each other causing difficulties in correct identification and classification. Although 10 species of the genus *Chondrus* have been reported from South Korea, their distributional evidences based on molecular comparisons have been remained unclear and controversial. Since most species of the genus *Chondrus* show a great morphological plasticity, species determination of the Korean *Chondrus* is quite challenging. In this study, 148 Korean *C. ocellatus* deposited at the Marine Biodiversity Institute of Korea (MABIK) were assessed by sequencing the *cox1*, *rbcL*, and ITS genes. Among them, 44 specimens (29.7%) corresponded to *C. ocellatus* Holmes and 104 specimens (70.3%) belonged to *C. nipponicus* Yendo based on the *cox1, rbcL* and ITS phylograms. Although both species were clearly distinguished from each other based on the molecular data, the gross morphologies were very similar and overlapped except for the presence or absence of marginal proliferous branches. In this study, we compared the morphologies and genotypes of the species belonging to the genus *Chondrus* and confirmed their morphological characteristics according to the growth season and site. These results will be useful for classification of the species belonging to the genus *Chondrus*.

## PP 181

### Assessing the coralline algae diversity in the sub-

## Antarctic Region of Chile

**Martha S. Calderon**[*1,2,3], Danilo E. Bustamante[2], Sebastian Rosenfeld[1,3], Andres Mansilla[1,3]

[1] *Laboratorio de Ecosistemas Marinos Antárticos y Subantárticos, University of Magallanes, Chile*
[2] *Instituto de Investigación para el Desarrollo Sustentable de Ceja de Selva (INDES-CES), Universidad Nacional Toribio Rodríguez de Mendoza, Peru*
[3] *Institute of Ecology and Biodiversity, IEB, Chile*

Coralline algae are an important group of photosynthesizers, calcifiers, paleoclimate archives, and ecologically important species, especially in the context of past and present global climate change and ocean acidification. Sixty-seven species of coralline algae have been recorded along the coast of Chile, of which thirty-one species were found in the sub-Antarctic Region of Chile. However, many of these records need to be verified and re-evaluated in a modern context combining morphological observations with molecular data. In this study, we investigated species of coralline red algae from representative sub-Antarctic environments, the Strait of Magellan and the Diego Ramírez-Paso Drake Islands Marine Park in The Cape Horn Biosphere Reserve, using plastid *rbcL* and *psbA* sequences and performing phylogenetic analyses. Our results revealed that the Chilean specimens were grouped in five clades within the Subclass Corallinophycidae. In the first clade, Chilean specimens consistently grouped with *Corallina caespitosa*, while the second clade was composed by *Bossiella orbigniana*. Other specimens formed a clade with *Arthrocardia*, a genus which species are distributed mostly in South Africa, and would represent a new report for Chile. Specimens placed in the fourth clade formed a monophyletic group which did not match with any published sequences and was closely related to *Pheophyllum fragile* from New Zealand. Finally, the fifth clade consisted of three Chilean unidentified species belonging to *Synarthrophyton*, close to *Synarthrophyton patena*, the generitype. This preliminary results will greatly contribute to the taxonomy of the corallines algae from the sub-Antarctic Region of Chile.

## PP 182

## Assessment of intraspecific diversity based on physiological and biochemical responses of colour strains of *Hypnea pseudomusciformis* (Gigartinales, Rhodophyta)

**Nair Yokoya**[*1]

[1] *Research Center of Phycology, Institute of Botany, Brazil*

*Hypnea pseudomusciformis* Nauer, Cassano & M.C. Oliveira (previously identified as *H. musciformis* (Wulfen) J.V. Lamouroux) is the main resource for carrageenan production in Brazil, and strains with selected characteristics could improve the commercial cultivation, and the production of bioactive compounds. Phycoerythrin-deficient strain (green phenotype) of *H. pseudomusciformis* was originated from only one green branch, which arised as a spontaneous mutation from a wild plant (brown phenotype). In the laboratory, unialgal cultures of the green and brown strains were initiated by clonal propagation of apical segments isolated from the same mother-plant collected at Ponta da Baleia Beach, Espirito Santo State, southeastern Brazil. Since 1994, these colour strains have been studied in our laboratory to understand metabolic processes, and the present work is a comprehensive assessment of intraspecific diversity based on several publications. The green strain is characterized by having a lower phycoerythrin concentration, and higher phycocyanin and allophycocyanin concentrations than the brown strain. However, the chlorophyll contents were similar in both strains. The brown strain presented higher concentrations of zeaxanthin and carotenes than the green strain. The brown strain presented higher photosynthetic efficiency, and lower saturation parameter and compensation irradiance than the green strain, characteristics of shade-adapted plants. Differences in nitrogen metabolism and phytohormone regulation were observed in the colour strains. Green and brown strains had similar growth rates, and similar carrageenan yields, indicating that both strains could be cultivated to improve the seaweed crop for carrageenan production. Furthermore, the green strain is more suitable for cultivation in brackish warm environments due to higher growth rates in lower salinity and higher temperature than the brown strain. In conclusion, the experimental data set showed that the colour strains of *H. pseudomusciformis* are a useful experimental system to understand intraspecific diversity in red algae. Supported by FAPESP (2007/50158-9), CAPES (23038.001431/2014-75) and CNPq (310672/2016-3).

## PP 183

## *Grateloupia fasciculata* sp. nov. (Halymeniaceae, Rhodophyta) from Korea based on morphology and rbcL sequences

**Pil Joon Kang**[*1], Jae Woo An[1], Ki Wan Nam[1]

[1] *Department of Marine Biology, Pukyong National University, Republic of Korea*

During an examination of marine algal flora, a *Grateloupia* species was collected from the eastern coast of Korea. This Korean entity is distinguished from other similar species of *Grateloupia* by cartilaginous thalli, branches with dichotomous division, and fasciculate proliferations near the apex. In particular, the fasciculate proliferations near the apex are unique for this alga within *Grateloupia*. In a phylogenetic tree based on rbcL sequence, this species nests in the same clade as *G. gibbesii*. However, it differs from *G. gibbesii* in having a relatively small thallus (up to 20 cm), narrow axis (1-5 mm) and fasciculate proliferations mainly produced near the apex rather than a large thallus (up to 60 cm), wide axis (1-5 cm) and many pinnate marginal proliferations. The genetic distance between the two species was 6.1%, which is considered to be the interspecific divergence range within the genus *Grateloupia*. Based on these morphological traits and the rbcL sequence data, *Grateloupia fasciculata* sp. nov. (Halymeniaceae, Rhodophyta) is described from Korea.

## PP 184

## Morphology and phylogenetic systematics of new species *Heterocapsa* sp. (Dinophyceae) from sand beaches of Jeju Island

**Su-Min Kang**[*1], Joon-Baek Lee[1]

[1] *Department of Earth and Marine Sciences, Jeju National University, Republic of Korea*

Dinoflagellates are a primary producer of marine ecosystems and most studies have been focused on planktonic species so far. Benthic dinoflagellates are distributed worldwide, but a few have been studied. According to the published literature on the Heterocapsa, all species are planktonic except for one species of benthic dinoflagellates *Heterocapsa psammophila*. This study were carried out to examine the morphology of the *Heterocapsa* sp. of sand-dwelling dinoflagellates around Jeju Island, and to analyze 28S LSU rDNA, 18S SSU rDNA and ITS rDNA for determining phylogenetic systematics. Sand samples were collected from intertidal zone at Hado-ri Beach and Pyoseon Beach of Jeju coast from March to April 2018. Three strains from the samples were isolated and then incubated.

The dinoflagellates were identified using light microscopes (LM) and scanning electron microscopes (SEM). In addition, DNA was extracted from each strains, and then PCR process was conducted. DNA sequences were determined, and then phylogenetic relations were analyzed using GTR+I+G model using MEGA v. 6.0 program. *Heterocapsa* sp. is a morphologically different morphology from the previously published *Heterocapsa* species. Especially cmpared to *H. psammophila, H. psammophila* is similar in size to epitheca and the nucleus is loacted at hypotheca. But *Heterocapsa* sp. is located in nuclear epitheca. Also, DNA analysis did not match any other *Heterocapsa* species and formed a different clade with *H. psammophila*. So, this study described *Heterocapsa* sp.

## PP 185

### A new species of *Phymatolithon* (Hapalidiaceae, Rhodophyta) from the Northeast Atlantic Ocean

**So Young Jeong**[*1], Boo Yeon Won[1], Tae Oh Cho[1]
[1] *Dept. of Life Science, Chosun University, Republic of Korea*

*Phymatolithon* was established by Foslie (1898) for a single species, *P. polymorphum* based on *Millepora polymorpha*. However, *M. polymorpha* was a superfluous substitute name for Millepora calcarea. Thus, *Phymatolithon calcareum* is accepted as the generitype species. *Phymatolithon* is distinguished from other members of Hapalidiaceae by the absence of an arborescent thallus, monomerous construction, cells of adjacent filaments joined by cell fusions, the absence of flared epithallial cells, subepithallial initials that are usually as short as or shorter than their immediate inward derivatives, adventitious and deep conceptacle primordium (more than 10 cells), absence of protective cells in male conceptacles, mature carposporophytes with discontinuous fusion cells, gonimobalst filaments developing across the entire upper area of the fusion cells, and multiporate tetra/bisporangial conceptacles. Worldwide, 21 *Phymatolithon* species are currently listed from the worldwide. We collected unidentified samples from the intertidal zones of United Kingdom and France. We analyzed the DNA sequences of them using *psbA* and COI-5P genes and also observed their morphology and anatomy of vegetative and reproductive thalli. In this study, we describe our unidentified samples as a new species, *Phymatolithon concavum* sp. nov. based on morphological and molecular data. *P. concavum* sp. nov. is characterized by encrusting to lumpy thalli, female conceptacles with raised rims, pitted tetra/bisporangial conceptacle roof with depressions, and degenerated uppermost cell of tetra/bisporangial conceptacle roof. We also provide evidence of their phylogenetic relationships with other similar species based on sequencing analyses. Our *psbA* and COI-5P sequences revealed sufficient divergence to warrant recognition of *P. concavum* as a new species.

## PP 186

### *Ulva grossa* sp. nov. (Ulvales, Chlorophyta) from Korea based on molecular and morphological analyses

**Pil Joon Kang**[*1], Jae Woo An[1], Ki Wan Nam[1]
[1] *Department of Marine Biology, Pukyong National University, Republic of Korea*

A marine green algal species was collected from the eastern coast of Korea. This species shares the generic features of *Ulva*, and is characterized by irregularly shaped thalli, relatively small and thick thallus, entire undulate margins without serrations and 1–2 pyrenoids per cell. In a phylogenetic tree based on sequences of the nuclear-encoded internal transcribed spacer region (ITS) of ribosomal (r)DNA, it nests as a sister clade of some species including *U. fasciata* with a relatively large thallus. This Korean alga differs from those species forming the same or subclades, such as *U. ohnoi, U. fasciata* and *U. reticulata*, in having a relatively small (3–8 cm) and thick (60–100 µm) thallus. Of these species, *U. ohnoi* shows a more or less thick thallus of 30–90 µm, but is distinguished from the Korean species in often having microscopic serrations in the thallus margin. The genetic distance between this Korean entity and those species was calculated as 1.8–6.7%, which is considered to be the inter-specific range with the genus *Ulva*. *Ulva grossa* sp. nov. (Ulvales, Chlorophyta) is described from Korea based on the morphological and molecular analyses herein.

## PP 187

### Potential DNA barcodes for red algae *Halymenia* C. Agardh (Halymeniaceae, Rhodophyta)

**Pui Ling Tan**[*1], Phaik Eem Lim[1], Siew Moi Phang[1]
[1] *Institute of Ocean and Earth Sciences, University of Malaya, Malaysia*

*Halymenia* is a red algal genus classified in the family Halymeniaceae of which exhibit immense morphological plasticity, making their specific identification difficult. The lack of distinct morphological characters has led to a need for molecular approach to address the taxonomic confusion in these red algae. Even though molecular analyses have been employed to elucidate the phylogenetic relationships and the taxonomic status of *Halymenia* species, DNA barcoding studies of this genus remain scarce. Hence, the aims of this study were to assess the utility of the genetic markers for molecular phylogenetics studies and their potential as DNA barcode for *Halymenia*. Four genetic markers were selected: the plastid rbcL and UPA, the mitochondrial COI-5P and the nuclear partial LSU (28S rDNA). Among these markers, both *rbcL* and COI-5P markers are effective for species identification in the genus *Halymenia* and also potential DNA barcodes for *Halymenia*. On the contrary, both UPA and LSU markers are not suitable markers for molecular phylogenetics and DNA barcoding studies in *Halymenia*.

## PP 188

### Seaweeds in the earliest Chinese catalog of marine creatures

**Zhongmin Sun**[*1], Dahai Gao[1], Bangmei Xia[1]
[1] *Department of Marine Organism Taxonomy and Phylogeny, Institute of Oceanology, Chinese Academy of Sciences, China*

*Hai Cuo Tu* is the earliest Chinese catalog of marine creatures, which was finished in 1698 by painter and biologist Nei-Huang and collected in the Forbidden City of Qing Dynasty. In this catalog, illustrations and narratives of more than 300 species of marine creatures were provided, including those of some seaweeds. Each creature was described with appearance, habitat, edible method, medicinal property and addition of a little poem. However, due to the limitations of scientific knowledge at that time, some exaggerated and unreliable contents were inevitable. In this study, the seaweeds described in the catalog were reannotated by using modern system of classification. We identified 11 species based on reexamination of the descriptions, illustrations and ancient literatures, consisting of *Pyropia haitanensis* (T.J.Chang et B.F.Zheng) N.Kikuchi et M.Miyata, *Bangia fuscopurpurea* (Dillwyn) Lyngbye, *Gloiopeltis furcata* (Postels et Ruprecht)

J.Agardh, *Gelidium elegans* Kützing, *G. divaricatum* Martens, *Sargassum fusiforme* (Harvey) Setchell, *Saccharina japonica* (Areschoug) C.E.Lane, *Ecklonia kurome okamura* , *Ulothrix flacca* (Dlillwyn) Thurne, *Ulva prolifera* O.F.Müller and *U. fasciata* Delile. These species were mainly utilized as food or herbal medicine in some provinces located on southeast coast of China, that indicates Chinese people have a long history of knowing and utilizing seaweed resources.

## PP 189

### A new species of *Rhodachlya* (Rhodachlyales, Rhodophyta) from Brazil, unmasked by *rbcL* DNA sequences, thallus development and ultrastructure

**Nair S. Yokoya**[*1], Luanda Pereira Soares[1], Silvia M.P.B. Guimarães[1], Yocie Yoneshigue-Valentin[2], Maria Gardênia Sousa Batista[3], Mutue Toyota Fujii[1]

[1] *Research Center of Phycology, Institute of Botany, Brazil*
[2] *Institute of Biology, Federal University of Rio de Janeiro, Brazil*
[3] *Center of Natural Sciences, State University of Piaui, Brazil*

Acrochaetioid algae are represented by small filamentous rhodophycean, structurally simple, usually found as epiphytes or endophytes. This group has a confused taxonomic history, mainly due to its small thallus and few reliable morphological characters. *Rhodachlya* is an acrochaetioid genus which was proposed from specimens isolated into culture on the basis of molecular, morphological and ultrastructural evidences. Two species of *Rhodachlya* are currently recognized: *R. madagascarensis* (generitype) and *R. hawaiiana*, so far known only from Madagascar (type locality) and Hawaii, respectively. Our study reports a new species of *Rhodachlya* isolated into culture from rhodoliths collected in 2016 from Piauí State, northeastern Brazil. Molecular analysis based on the plastid-encoded rbcL gene, besides morphological and ultrastructural data support the occurrence of a new species of *Rhodachlya*. The species was characterized in culture as dense red tufts, consisting of basal and erect filaments, uniseriate, randomly oriented and sparsely branched; cells with a single parietal H-shape or lobed plastid, with one or occasionally two, prominent pyrenoids; monosporangia spherical to ovoid, sessile or on branched stalks; two-caps layered pit plugs, lacking a cap membrane. Isolates from Brazil were recovered in a well-supported clade containing *R. madagascarensis* and *R. hawaiiana*, with interspecific divergence ranging from 10.2% to 5.2%, respectively. Morphologically, the Brazilian species resembles *R. hawaiiana* but differs by the smaller dimensions of intercalary vegetative cells and presence of two pyrenoids. Moreover, they are genetically distinct entities based on *rbcL* sequences. This is the first record of *Rhodachlya* in the Atlantic Ocean, indicating that the genus is more widely distributed than has been reported so far. Acrochaetioid algae are poorly studied, thus an integrative taxonomic approach is a suitable tool to reveal an overlooked diversity in this red algal group. Supported by Fapesp (2016/50370-7), CAPES (23038.001431/2014-75) and CNPq (310672/2016-3, 304963/2014-8).

## PP 190

### Reassessment of taxa with *Polyneura*-type procarp in the tribe Phycodryeae (Delesseriaceae, Rhodophyta)

**Jeong Chan Kang**[*1], Pilar Diaz-Tapia[2], Kathy Ann Miller[3], Showe-Mei Lin[4], Myung Sook Kim[1]

[1] *Department of Biology, Jeju National University, Republic of Korea*
[2] *BioCost Research Group, Universidad de A Coruna, Spain*
[3] *Silva Center for Phycological Documentation, University of California, United States of America*
[4] *Institute of Marine Biology, National Taiwan Ocean University, Taiwan*

Two different procarp developments such as *Phycodrys*-type (1 carpogonial branch + 2 sterile cells group) and *Polyneura*-type (2 carpogonial branches + 1 sterile cells group) have been known among the member of the tribe Phycodryeae. Six genera such as *Erythroglossum, Polyneura, Pseudopolyneura, Sorella, Sorellocolax*, and *Womersleya* are known as having *Polyneura*-type procarp development. Recently, we discovered that molecular phylogeny is not monophyly among the species assigned to six genera from the north western Pacific. To resolve this problem which is mismatched between taxonomic position and phylogenetic relationships of the taxa, we re-examined the taxa by means of morphological observations focused on the cystocarp development and molecular analyses. For the study, we contained three species of *Erythroglossum* and one of Polyneura from Atlantic, three of *Erythroglossum*, two of *Pseudopolynerua* and two of *Sorella* from the north western Pacific, and one of *Polyneura* and *Sorella* from Pacific California. In conclusion, there are five results: 1) *Erythroglossum, Polyneur*a and *Pseudopolyneura* from Pacific should be transferred to Sorella, 2) *Erythroglossum schousboei* and *E. laciniatum* are conspecific, 3) *E. minimum* and *E. pinnatum* are conspecific, 4) *Sorella delicatula* and *S. repens* are conspecific and 5) *Sorella inkyua* sp. nov is newly described.

## PP 191

### *Amphisiphonia* gen. nov. derived from the genus *Polysiphonia* by integrating morphological and molecular analyses

**Byeongseok Kim**[*1], Myung Sook Kim[1]

[1] *Biology, Jeju National University, Republic of Korea*

Although the taxonomic revisions of the genus *Polysiphonia sensu lato* have been conducted for the past ten years, synapomorphic characteristics are still important to recognize the genus or species. In the result of morphology, we found that *Polysiphonia rudis* from New Zealand, *Polysiphonia scopulorum* from Western Australia and *Amphisiphonia diramulia* sp. nov. from Korea are distinguished from the species of *Polysiphonia sensu stricto* by diagnostic characteristics, such as both endogenously and exogenously branching in the apical part of erect branch, the present of vegetative trichoblast or scar cell, the irregular arrangement of tetrasporangia in both straight and spiral series. In the phyogenetic analyses of *rbcL* sequences, they formed the monophyletic clade with *Polysiphonia atlantica* from Spain, *Polysiphonia caespitosa* from Spain, *Polysiphonia scopulorum* var. *villum* from USA and *Polysiphonia subtilissima* from USA and Panama by 100% bootstrap support. The results of integrating morphological and molecular analyses enable the establishment of *Amphisiphonia* gen. nov. as new genus distinguished from the genus *Polysiphonia*. In addition, *Amphisiphonia diramulia* sp. nov. is distinguished from other species in the genus *Amphisiphonia* gen. nov. by unclearly distinguishing the erect branch from prostrate branch and living in subtidal zone, branching subdichotomously in erect branches. *P. rudis* and *P. scopulorum* should be transferred to the genus *Amphisiphonia* gen. nov.

## PP 192

### Cryptic species diversity of *Ulva* and *Umbraulva* (Ulvaceae, Chlorophyta) from subtidal of the Korean coast

**Hyung Woo Lee**[*1], Myung Sook Kim[1]
[1] *Biology, Jeju National University, Republic of Korea*

The cryptic species diversity from subtidal habitats of Ulvaceae has been overlooked because of the intertidal distributions in marine environments all over the world. We conducted the subtidal surveys and provided new discovery of *Ulva* and *Umbraulva* based on molecular analyses of *rbc*L and *tufA* genes; *Ulva adhaerens*, unrecorded in Korean flora and *Umbraulva* sp., a novel species. *Ulva adhaerens* from Korea is pale green, thin and globular thallus exhibiting 0.2% genetic divergence in *rbcL* to *U. adhaerens* from type locality of Japan. The Korean and Japanese specimens of *U. adhaerens* were closely related to *U. rigida* from Ireland with 1.3% divergence in *rbcL*. In tufA, Korean *U. adhaerens* has 6.3% genetic divergence to *U. lobata* from Canada. *Umbraulva* sp. is globular and deep green with greenish fluorescence. In molecular analyses, this species showed 2.9% in *rbcL* and 6.5% in *tufA* to *Um. japonic*a. The tufA gene showed generally wider genetic divergence between the ulvacean specimens than *rbcL*. The continuing surveys of ulvacean taxa in subtidal area can allow a chance to reveal cryptic species diversity of Ulvaceae with the deeper understanding of ulvacean phylogeny.

## PP 193

### Species delimitation of the red algal genus *Scinaia* (Scinaiaceae, Nemaliales) from the northern Pacific based on molecular analyses

**Jong Chul Lee**[*1], Hyung Woo Lee[2], Kathy A. Miller[3], Myung Sook Kim[2]
[1] *Biodiversity Research Institute, Jeju Technopark, Republic of Korea*
[2] *Biology, Jeju National University, Republic of Korea*
[3] *University Herbarium, University of California, United States of America*

The morphological identification of the red algal genus *Scinaia* can give a misinformation to recognize species diversity due to ambiguous diagnostic characteristics, such as thallus constriction, cortical utricles, pigmented hyperdermal layer, surface view, and spermatangial sori. To verify species boundary of *Scinaia*, we applied molecular analyses using the *rbcL* sequences on sixty seven Scinaia specimens distributed from the northern Pacific. There are eight genetic groups and *Scinaia johnstoniae* was confirmed to be divided into three genetic groups; *S. johnstoniae* and *S. articulata* collected from California in USA; *S. tokidae* from Korea and the type locality, Oki Islands in Japan. *S. johnstoniae* exhibited 5.0% and 7.7% interspecific divergences to *S. articulata* from California, the type locality, and *S. tokidae* from the type locality, respectively. These three species are diverged distinctly in spite of few differences on thallus constriction, utricles and hyperdermal layer. In addition, four Scinaia species were confirmed in Korean coasts; *S. japonica, S. latiforns, S. okamurae,* and a cryptic entity. The cryptic species is strongly closed to *S. okamurae* with 6.0–6.1% interspecific divergences. In conclusion, we propose the reinstatement of S. articualta distributed in California, USA and *S. tokidae* in Korea and Japan which are synonyms of *S. johnstoniae*. The molecular investigation of rbcL sequences provides a higher resolution to delimit the species boundary of *Scinaia*.

## PP 194

### Species diversity of the family Sargassaceae (Fucales, Ochrophyta) with distribution at Jeju Island, Korea

**Jeong Chan Kang**[*1], Su Gang Kim[2], Mun Kwan Kim[2], Jong Chul Lee[3]
[1] *Phycology, Manta's Marine Lab., Republic of Korea*
[2] *Ocean and Fisheries Research Institute, Jeju Special Self-Governing Province, Republic of Korea*
[3] *Biodiversity Research Institute, Jeju Technopark, Republic of Korea*

The *Sargassum*-beds are one of the most important components of marine ecosystem in terms of productivity and maintaining marine biodiversity by their large surface area of frond with forming the canopy. Recently, broad and rapid reductions of macroalgal communities including *Sargassum*-beds have been reported in worldwide as well as in Jeju, Korea. There have been recorded 29 species of the family Sargassaceae including 4 of uncertain recorded species in Jeju, Korea. We investigated the species diversity of Sargassaceae around Jeju coast and obtained in situ habit photographs, morphological characteristics and horizontal and vertical distributions. This data provides the information for species identification, morphological variations by habitat and season, their distribution and utilities for human society on various Sargassaceae species. These information are also available to recover the *Sargassum*-beds by transplantation of various species.

## PP 195

### Ultrastructure of the flagellar apparatus in *Rhodomonas salina*

Seung Won Nam[1], Chang Soo Lee[1], Hye-Won Yang[1], **Woongghi Shin**[*2]
[1] *Nakdonggang National Institute of Biological Resources, Sangju, Korea*
[2] *Biology, Chungnam National University, Deajeon Korea.*

Rhodomonas salina Hill & Wetherbee is a photosynthetic marine flagellate that is known to have typical characteristics of the cryptomonads. We examined ultrastructure of R. salina with particular attention to the flagellar apparatus and compared with those of other cryptomonads reported previously. The major components of the flagellar apparatus of R. salina CCMP1419 were rhizostyle (Rhs), striated fibrous root (SR), SR associated microtubular root (SRm), mitochondrion-associated lamella (ML), and 3 types of microtubular roots (9r, 4r, and 2r). The keeled-Rhs originated near the proximal end of the dorsal basal body, passed near the nucleus and dissociated at the posterior of the cell. The SR originated between two basal bodies and laterally extended to the right side of cell. The SRm was associated with the SR and composed of three microtubules. The ML originated between two basal bodies extended to the left side of cell. The 9r overlapped with the Rhs at the basal bodies, picked up additional microtubules and extended toward dorsal anterior lobe of the cell. The 4r originated nearby 9r, extended dorsal lobe with 9r, right away, turned to the right and extended with 2r which originated between two basal bodies. In this study, the flagellar apparatus in R. salina compare with other cryptomonad species, and the ultrastructural differences of the flagellar apparatus among cryptomonad species will be discussed.

## PP 196

### Genetic diversity and distribution of edible brown algae, *Petalonia* and *Scytosiphon*, from Ulleungdo Island, Korea

**Ju Il Lee**[*1], Hyeong Seok Jang[2], Ga Youn Cho[3], Sung Jin Yoon[4] & Sung Min Boo[1,5]
[1] *Institute of Environment and Biology, Chungnam National University, Korea*

[2] National Marine Biodiversity Institute, Korea
[3] National Institute of Biological Resources, Korea
[4] Ulleungdo Dokdo Ocean Science Station, Korean Institute of Ocean Science and Technology, Korea
[5] Biology, Chungnam National University, Korea

Ulleungdo Island embraces rich diversity of marine algae, however, genetic diversity and distribution of edible brown algae in the island remain unstudied. We analyzed mitochondrial cox3 from 86 specimens of *Petalonia* and *Scytosiphon* from Ulleungdo, including additional specimens from the Korean peninsula. Our cox3 phylogeny for the first time confirmed the occurrence of fives species in Ulleungdo Island; *Petalonia* binghamiae, *P. fascia, P. zosterifolia* and two cryptic species of *Scytosiphon lomentaria*. *Petalonia binghamiae* was relatively homogeneous with three haplotypes. *Petalionia fascia* comprised four haplotypes, grouping into two genetic lineages. *Scytosiphon lomentaria* was heterogeneous with nine haplotypes, being segregated into two cryptic species. The two cryptic species overlapped at two locations in Ulleungdo Island: interestingly, one species clustered with haplotypes from cold-temperate locations, considered as a northern species, and the other grouped with haplotypes from warm-temperate locations, being a southern species. Low genetic diversity in *Petalonia binghamiae* while high genetic diversity in *Scytosiphon lomentaria* from Ulleungdo Island are comparable to genetic diversity patterns of those species in Korean peninsula. Ulleungdo Island, being small in size but harboring diverse haplotypes, is an ideal field laboratory to investigate genetic diversity and distributions of other economic marine algae.

## PP 197

### Morphological identification and diversity of late holocene diatoms from reservoir Gonggeomji, Korea

**Sang Deuk Lee**[*1], Suk Min Yun[1], Hoil Lee[2], Jin-Young Lee[2], Pyo Yun Cho[1], Jaesoo Lim[2], Seung Won Nam[1], Chang Soo Lee[1], Z-Hun Kim[1], and Mirye Park[1]

[1] Nakdonggang National Institute of Biological Resources , Korea
[2] Korea Institute of Geoscience and Mineral Resources , Korea

Sangju Gonggeomji, one of the three oldest artificial reservoirs, is an ancient reservoir which is known to have been constructed during the Samhan era. Gonggeomji is generally believed to have been artificially constructed for the supply of agricultural water, and the exact construction time is unknown. Usually it is considered to have been built in the same time as Eurimji, Susanje, and Byokgolje. Diatoms are a major group of eukaryotic unicellular microalgae and one of the most common organic matters in aquatic ecosystem. They play an important role as the primary producers in freshwater and marine environments, and they contribute to approximately one fifth of the photosynthesis activity on Earth. Furthermore, diatoms have been used as biological indicators of water quality in several countries. Fossil diatoms are a widely used proxy for past surface water conditions because of their high diversity and abundance, combined with their sensitivity to environmental conditions and relatively good preservation in sediment thanks to their siliceous frustules. The fossil diatom record in core sediment revealed well-defined hydrological changes and paleoenvironmental conditions. In this study, the fossil diatoms were identified from four sediment cores: GG01 (in depth of 105 cm, 125 cm, 150 cm, 175 cm, 200 cm, 225 cm, 250 cm, 275 cm, 300 cm, 325 cm, 350 cm, 375 cm), GG02 (in depth of 135 cm, 150 cm, 175 cm, 205 cm, 225 cm, 250 cm, 275 cm, 305 cm, 325 cm), GG03 (in depth of 165 cm, 175 cm, 200 cm, 225 cm, 250 cm, 275 cm, 300 cm, 325 cm), and 04 (in depth of 125 cm, 150 cm, 175 cm, 195 cm, 200 cm, 225 cm, 250 cm, 275 cm, 300 cm). The dominant species selected in the fossil diatom samples appeared in high percentages (>5%) in the core sediment samples. In total, 52 diatom species belonging to 27 genera were selected and photographed from Holocene sediment cores of Gonggeomji. Fourteen newly recorded species were found in Korea as below, *Caloneis wardii, Encyonema vulgare, Eunotia myrmica, Fallacia californica, Gomphonema asiaticum, Gomphonema neoapiculatum, Gomphonema insigniturris, Gomphonema tumens, Pinnularia fusana, Pinnularia parvulissima, Punctastriata lancettula, Sellaphora moesta, Sellaphora capitate, Staurosira dimorpha*. This study provides an annotated list of the most commonly identified diatom species and references to further literature. All taxa are documented by high quality FE-SEM photomicrographs.

## PP 198

### Physiological and genetic characterization of cryo-preserved *Anabaena variabilis* isolated from Nakdong River

Mirye Park[1], **Chang Soo Lee**[*1]

[1] Microbial Research, Nakdonggang National Institute of Biological Resources, Korea

Microalgae are usually maintained by traditional subcultures on fresh media. However, the algal subculture is time-consuming and labor-intensive. Continuous subcultures also pose potential risks of genetic or phenotypic variations and may increase the possibility of contamination with other microorganisms such as bacteria and fungi. For these reasons, a cryopreservation is considered as an alternative way to maintain algal cultures in safety. In this study, we have performed a cryopreservation of *Anabaena variabilis* and optimized the concentration of dimethyl sulfoxide (DMSO). Chlorophyll-a and lipid contents moreover expression level of *mreB* gene were analyzed for the evaluation of physiological and genetic effects on the cyanobacterial cells before and after cryopreservation respectively. The results showed that the maximum viability after the cryopreservation was about 13.3% under 10% DMSO, where chlorophyll-a and lipid contents were slightly decreased and the expression level of *mreB* gene expression was down regulated.

## PP 199

### The molecular-assisted alpha taxonomy of marine green algal family Cladophaceae on the coasts of Chinese sea

Huang Bingxin[1,2], Teng Linhong[1,2], Dai Yue[1], **Ding Lanping**[*1,2]

[1] Collage of Life Sciences, Tianjin Normal University, China
[2] Institute of Oceanology, Chinese Academy of Sciences , China

The marine green algae on the family Cladophoraceae (Cladophorales, Chlorophyta) are commonly distributed along the coasts of Chinese sea. They generally hold simple structure and easily are affected morphologically by environmental conditions. At present, it is difficult to be identified based on the morphology. In order to solve this problem, authors collected more 52 samples belonging to the family respectively in Oct. 2009 to Oct. 2010 and Dec. 2016 to Aug. 2017 at the coasts of Chinese sea, and carried out the study on their taxonomy and phylongenetic analysis. The results are as follows: 1) based on the morphological features, more 52 samples were identified as 3 genera 22 species (*Rhizoclonium implexum, R. riparium, Chaetomorpha aerea, Ch. antennina, Ch. brachygona, Ch. liaodongensis, Ch. linum, Ch. pachynema, Ch. valida, Cladophora albida , Cl. Aokii, Cl. catenata, Cl. Cymopoliae, Cl. expansa, Cl. fascicularis,*

*Cl. gracilis, Cl. hutchinsioides, Cl. laetevirens, Cl. oligoclada, Cl. opaca, Cl. perpusilla, Cl. stimpsonii*) and 6 pending species. 2) using ITS, SSU and/or LSU sequences, the phylongenetic analysis of more 52 samples were carried out. 44, 42 and 14 (20 samples) products of PCR amplification were respectively consistent to three sequences. Following these sequences, the NJ and ML trees were constructed, and anchoring to 19 species and 1 variant, i.e. *R. riparium, R. riparium var. implexum, Ch. aerea, Ch. antennina, Ch. brachygona, Ch. crassa, Ch. liaodongensis, Ch. linum, Ch. valida, Cl. albida, Cl. aokii, Cl. expansa, Cl. fascicularis, Cl. gracilis, Cl. hutchinsiae, Cl. hutchinsioides, Cl. laetevirens, Cl. oligocladoidea, Cl. opaca, Cl. stimpsonii*. 3) combination between morphological and molecular data analysis, above 52 samples were verified as 20 species and 1 variant, i.e. *R. riparium, R. riparium var. implexum, Ch. aerea, Ch. antennina, Ch. brachygona, Ch. liaodongensis, Ch. linum, Ch. pachynema, Ch. valida, Cl. albida, Cl. aokii, Cl. cymopoliae, Cl. expansa, Cl. fascicularis, Cl. gracilis, Cl. hutchinsioides, Cl. laetevirens, Cl. oligoclada, Cl. opaca, Cl. perpusilla, Cl. stimpsonii.* 4) based on the phylongenetic trees, three genera (*Rhizoclonium, Chaetomorpha, Cladophora*) of family Cladophoraceae are hybrid evolved and not monophyletic origin. The divisions of the genera status don't conform to their evolutionary. Thus authors recommend merging the three genera into one genus, i.e. earliest established genus, *Rhizoclonium* Kützing.

## PA 02

### Dieckol; an algal polyphenol attenuates urban fine dust-induced inflammation in RAW 264.7 cells via the activation of Anti-inflammatory and antioxidant signaling pathways

**KK Asanka Sanjeewa**[*1], Thilina U. Jayawardena[1], Seo-young Kim[1], You-Jin Jeon[1]

[1] *Marine life sciences, Jeju National University, Republic of Korea*

Fine dust associated complications related to human health is one of the major issues in East-Asia region. Specifically, fine dust associated complications such as asthma, airway inflammation, and skin irritations found to increase with the level of fine dust in the atmospheres. Therefore, the compounds with anti-inflammatory properties and antioxidant properties have a great potential to develop as functional materials to reduced fine dust-induced complications. In the present study, we evaluated anti-inflammatory and antioxidant properties of dieckol (31.3 ~125 μg/mL) in fine dust-stimulated RAW 264.7 macrophage cells using ELISA, western blots, and RT-qPCR. The result showed that the exposure of macrophages to fine dust (125 μg/mL), induced the productions of nitric oxide (NO) and prostaglandin E2 (PGE2), and the mRNA expression levels of inflammatory mediators such as inducible NO synthase (iNOS) and cyclooxygenase (COX)-2 whereas it was significantly attenuated by the treatment of dieckol. In addition, fine dust-increased the pro-inflammatory cytokines such as interleukin (IL)-1β, IL-6, and tumor necrosis factor (TNF)-α were down-regulated by dieckol. Interestingly, dieckol protected macrophages against cell damages via reducing the fine dust-caused intracellular reactive oxygen species (ROS) generation via induction of superoxide dismutase production as well as the HO-1/Nrf2 signaling activation. In conclusions, dieckol protects RAW 264.7 cells against fine dust-induced inflammation and oxidative stress via inducing anti-inflammatory and antioxidant mechanisms. Thus, dieckol is a potential candidate to develop as a functional ingredient in commercial products like cosmeceuticals.

## PA 03

### A study on a species of littoral brown algae *Leathesia difformis* extract on melanogenesis by regulating the gene expressions in B16F10 melanoma cells

**Ah-hyun Park**[*1], Won-Hwi Lee[2,3], Yuna Ha[1,3], Do Yeon Seo[3], Jae Woo Jeong[1,3], Young-Eun Choi[2,3], Young Jin Kim[2,3], Oh Wook Kwon[3], Mira Park[3], Youn-Jung Kim[1,2,3]

[1] *Department of Cosmetic Science & Management, Graduate School Incheon National University, Republic of Korea*
[2] *Department of Marine Sciences, Incheon National University, Republic of Korea*
[3] *Researsh Institute of Basic Sciences, Incheon National University, Republic of Korea*

*Leathesia difformis (L. difformis)* is a species of littoral brown algae in the class Phaeophyceae. Brown algae live in marine environments, where they play an important role both as food and as habitat. In this study, to identify the functional cosmetics material and natural cosmeceutical ingredients which have whitening function of *L. difformis* extract. Firtst of all, prior to whole of the test, the cellulotoxic evaluation against B16F10 cell, and as the *in vitro* cellulotoxicity relies on activation of mitochondria of cell, the *in vitro* cellulotoxicity was measured with MTT reaction solution to determine the survival of cell. The result indicated that the concentration without cellulotoxicity was set to perform the main test. To evaluate the melanin synthesis inhibitory effect of *L. difformis*-extracted fractions, tyrosinase activities, melanin contents assay and the expression of melanin biosynthesis related genes, such as tyrosinase (*Tyr*), tyrosinase-related protein-1 (*TRP-1*), Dopachrome tautomerase (*DCT*), Melanocortin 1 receptor (*Mc1r*) and microphthalmia-associated transcription factor (*MITF*) in B16F10 melanoma cells by real time PCR. *L. difformis* extracts showed inhibitory effects of melanin contents and tyrosinase activity in α-MSH-stimulated B16F10 melanoma cells. The effects of *L. difformis* extracts increased concentration-dependently. *L. difformis* extracts also suppressed genes expressed of the melanin synthesis enzymes, such as *MITF, TRP-1* and *Tyr*. These results indicate that the inhibitory activity of EtoAc fraction from *L. difformis* on melanin synthesis process is linked to the downregulation of tyrosinase expression signaling pathways. Results suggest that *L. difformis* may be a potential anti-melanogenic factor and has the potential as a whitening functional cosmetic material by inhibiting the expression of the melanogenic genes.

## PA 04

### Melanogenesis regulation of extracts from *Polyopes affinis* in α-MSH-Stimulated B16F10 melanoma cells

**Won-Hwi Lee**[*1], Ah-Hyun Park[2,3], Yuna Ha[2,3], Do Yeon Seo[3], Jae Woo Jeong[2,3], Young-Eun Choi[1,3], Young Jin Kim[1,3], Oh Wook Kwon[3], Mira Park[3], Youn-Jung Kim[1,2,3]

[1] *Department of Marine Sciences, Incheon National University, Republic of Korea*
[2] *Department of Cosmetic Science & Management, Incheon National University, Republic of Korea*
[3] *Researsh Institute of Basic Sciences, Incheon National University, Republic of Korea*

*Polyopes affinis (P. affinis)*, a type of red algae, is known to be distributed in along the intertidal zone. *P. affinis* extracts have effects such as anti-inflammation, antioxidant and light protection. The purpose of this study is to investigate anti-melanogenesis effect of the extract of *P. affinis* on α-Melanocyte Stimulating Hormone(α-MSH)-stimulated B16F10 melanoma cells. *P. affinis* was extracted with 70% methanol and 80% ethanol for 24 hours at room temperature. After the filtration, *P. affinis* extract was concentrated, fraction extracts for each solvent such as BuOH and Aqua were concentrated and then lyophilized as a powder. *P. affinis* was extracted with 70% methanol (70-MPA) and further fractionated with butanol (MPA-Bu), aqua (MPA-A). Also, *P. affinis* was extracted with 80% ethanol (80-EPA) and further fractionated with butanol (EPA-Bu), aqua (EPA-A). 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay was used to measure the cytotoxicity of the extracts of *P. affinis* on α-MSH-stimulated B16F10 cells. Cellular tyrosinase assay was performed to investigate the inhibition of tyrosinase, which is involved in melanin synthesis. The inhibition of melanin production was confirmed by the melanin contents assay. Expression of melanin synthesis-related genes such as Melanocortin 1 Receptor (*Mc1r*) and Tyrosinase (*Tyr*) was examined by real time RT-PCR. Especially MPA-Bu showed an inhibitory effect on melanin synthesis in B16F10 cells. MPA-Bu decreased the production of melanin, and the tyrosinase inhibitory activity in melanocytes was effective in the α-MSH stimulated B16F10 cell. The effect of *P. affinis* extract increased dose-dependently. The expression of melanogenesis related genes was reduced by the extract of *P. affinis*. These results suggest that the extract of *P. affinis* melanin synthesis downregulates the expression of melanogenesis related genes, thereby reducing melanogenesis and reducing other expression genes. In conclusion, MPA-Bu shows a whitening effect and is considered to be a natural component of whitening functional cosmetics.

## PA 05

## Effects of seaweed extracts on the determination of chemokine in human keratinocyte cell line

**Jae Woo Jeong**[*1], Yuna Ha[1,2], Ah-Hyun Park[1,2], Won-Hwi Lee[3,2], Do Yeon Seo[2], Young-Eun Choi[3,2], Young Jin Kim[3,2], Oh Wook Kwon[2], Mira Park[2], Youn-Jung Kim[1,3,2]

[1] *Department of Cosmetic Science & Management, Incheon National University, Republic of Korea*
[2] *Researsh Institute of Basic Sciences, Incheon National University, Republic of Korea*
[3] *Department of Marine Sciences, Incheon National University, Republic of Korea*

Algal as a source of materials has various bioactive materials, such as strong antioxidant properties. In this study, we investigate the anti-atopic dermatitis effect of *Polyopes affinis* and *Ulva compressa* and *Sargassum thunbergii* on HaCaT cells. Respectively, seaweeds are red algae, brown algae, and green algae. We measured thymus and activation-regulated chemokine (TARC/CCL17) and macrophage-derived chemokine (MDC/CCL22) gene expression level using real time PCR. Protein expression was performed to examine effects of the marine seaweed extract on the Th2-type chemokines by ELISA. HaCaT cells incubated with interferon-gamma (10 ng/ml) and TNF-alpha (10 ng/ml) in the presence or absence of three each different concentration of marine seaweed extracts, respectively. Responses of Th2-type chemokine genes depend on the concentration of extract. In conclusion, this research indicated that the anti-atopic activity of *Polyopes affinis, Ulva compressa, Sargassum thunbergii* extract was appeared on the cellular and molecular levels. Also, Th2 cells into skin lesions and lessen the skin inflammation as is seen in AD. This result suggests that marine seaweed extract suppresses the IFN-γ and TNF-α induced expression of TARC and MDC in HaCaT cells. Through further study, can be comparison between each seaweed components and the precise mechanism will be elucidated by analyzing of the inflammation induction in this cell model.

# PA 06

## Constructing ethanol derived bioactive extracts using the brown seaweed *Zonaria tournefortii* performed with timatic extractor by means of Response Surface Methodology (RSM)

**Nuno Nunes**[*1], Sofia Valente[2], Sónia Ferraz[1], Maria Carmo Barreto[3], M.A.A. Pinheiro de Carvalho[1,4]

[1] *ISOPlexis - Faculdade de Ciências da Vida, University of Madeira, Portugal*
[2] *R&D, Unidade de Bioquímica Lda (UBQ II), Portugal*
[3] *CE3C–Centre for Ecology, Evolution and Environmental Changes / Azorean Biodiversity Group and Faculty of Sciences and Technology, University of Azores, Portugal*
[4] *ICAAM, University of Évora, Portugal*

The understanding of the biochemical and antioxidant composition and capacity of target biomass is the first step to its selectivity as functional food. These can promote health benefits, such as reducing the risk of chronic diseases and enhancing the ability to promote health. The main purpose was to employ Response Surface Methodology (RSM) to determine the effect of the independent variables, % of ethanol (50 – 96%), time of sonication (0 -20min) and number of extraction cycles (6 – 18 cycles) in the primary extract of brown seaweed *Zonaria tournefortii* and study the yield variation of some bioactive compounds. The extractions were performed employing "Green Chemistry" technics, executed with the Timatic extractor, which employed pressurized ethanol solution at a maximum pressure of 8.5 bar, through the milled dehydrated biomass in the extraction vessel. Several parameters were assessed in the primary bioactive extract which included extract yield (11,56 – 28,49%,), total chlorophyll content (TChlC) ( 0,14 – 1,42%), total carotenoid content (TCC) ( 0,35 – 0,80%), total fucoxanthin content (TFxC) (0,04 – 0,13%), total phenolic content (TPC) (3,58 – 5,84%), total flavonoid content (TFC) (0,22 – 4,70%), DPPH (56,05 – 76,45%) and reducing activity (RA) (3,83 – 6,04%). Biocompound yield were introduced in RSM and analyzed for its predictability, extract yield (R2=0,99), TChlC (R2=0,97), TCC (R2=0,91), TFxC (R2=0,88), TPC (R2=0,96), TFC (R2=0,88), DPPH (R2=0,90) and RA (R2=0,95). Also, a PCA plot was performed to determine how parameters and samples were interconnected, having PC1 68,88% and PC2 20,67% of the explanatory variability. A secondary objective was implemented to the residue, to determine its usability for subsequent extraction of valuable compounds such as fucoidan, which yield varied from 4,87 to 6,59% and cellulose yield varied between 18,88 to 20,27%, implementing the first step to a biorefinary strategy using a cascade approach.

# PA 08

## Indole derivatives isolated from brown alga *Sargassum thunbergii* Inhibit Adipogenesis through AMPK activation in 3T3-L1 preadipocytes

**KK Asanka Sanjeewa**[*1], Min-Cheol Kang[1], You-Jin Jeon[1]

[1] *Marine life sciences, Jeju National University, Republic of Korea*

Seaweed, a popular and abundant food ingredient mainly consumed in Asian countries, and are also known as good source of bioactive compounds with anti-obesity effects. However, the anti-obesity effects of *Sargassum thunbergii* have not yet been established. In this study, we isolated six indole derivatives (STCs)-indole-2-carboxaldehyde (STC-1), indole-3-carboxaldehyde (STC-2), indole-4-carboxaldehyde (STC-3), indole-5-carboxaldehyde (STC-4), indole-6-carboxaldehyde (STC-5), and indole-7-carboxaldehyde (STC-6)-from S. thunbergii and evaluated their inhibitory effects on adipocyte differentiation in 3T3-L1 cells. We found that STC-1 and STC-5 resulted in non-toxic inhibition of the differentiation of 3T3-L1 adipocytes and thus selected these compounds for further study. STC-1 and STC-5 significantly inhibited lipid accumulation and downregulated the expression of peroxisome proliferator-activated receptor- (PPAR), CCAAT/enhancer-binding protein (C/EBP), and sterol regulatory element-binding protein 1c (SREBP-1c) in a dose-dependent manner. The specific mechanism mediating the effects of STC-1 and STC-5 was shown to be AMP-activated protein kinase (AMPK) activation. Our results demonstrated the inhibitory effect of STC-1 and STC-5 on adipogenesis through the activation of the AMPK signal pathway. Together, these findings suggested that STC-1 and STC-5 may be effective candidates for the prevention of obesity or obesity-related diseases.

# PA 09

## Inhibition of adipogenesis by diphlorethohydroxycarmalol (DPHC) through AMPK activation in adipocytes

**Lei Wang**[*1], Min-Cheol Kang[1,2], You-Jin Jeon[1]

[1] *Department of Marine Life Sciences, Jeju National University, Republic of Korea*
[2] *Korea Food Research Institute, Korea Food Research Institute, Republic of Korea*

Chronic obesity is one of the most detrimental health issue and a major social problem in the 21st century. In 2017, nearly two billion individuals were reported of being overweight, of which 671 million were obese. The purpose of this study was to investigate the anti-obesity effect and the mechanism of action of diphlorethohydroxycarmalol (DPHC) isolated from *Ishige okamurae* in 3T3-L1 cells. The anti-obesity effects were examined by

evaluating intracellular fat accumulation in Oil-Red O stained adipocytes and Western blot assay. The results indicate that DPHC dose-dependently inhibited the lipid accumulation in 3T3-L1 adipocytes. Furthermore, DPHC significantly inhibited adipocyte-specific proteins such as SREBP-1c, PPARγ, C/EBP α, and adiponectin, as well as adipogenic enzymes, including perilipin, FAS, FABP4, and leptin in adipocytes. These results indicated that DPHC primarily acts by regulating adipogenic-specific proteins through inhibiting fat accumulation and fatty acid synthesis in adipocytes. In addition, DPHC treatment significantly increased both AMPK and ACC phosphorylation in adipocytes. These results indicate that DPHC inhibits the fat accumulation by activating AMPK and ACC in 3T3-L1 cells. In a conclusion, these results suggest that DPHC can be used as a potential therapeutic agent against obesity.

## PA 10

### Purification of fucoidan from *Turbinaria ornata;* attenuation of LPS-induced Inflammatory responces in In-vitro and In-vivo models

**Thiliṇa U. Jayawardena**[*1], K.K. Asanka Sanjeewa[1], Hyun-Soo Kim[1], You-Jin Jeon[1]

[1] *Marine BioMedical sciences, Jeju National University, Republic of Korea*

Fucoidan is a fucose containing sulfated polysaccharide (FCSP) present in the brown algae cell wall that is reported to exhibit potential anti-inflammatory activity. In the present study, the fucoidans are purified from *Turbinaria ornata* (TO) from the Maldives. The method mainly uses enzyme assisted extraction and is modified to improve the effectiveness and purity of the final product. Purified, active fucoidan fraction was identified as F10, and its chemical properties were verified via FTIR, 1H NMR, and monosaccharide analysis. Selected inflammatory mediators were studied to evaluate the anti-inflammatory potential using RAW 264.7 macrophages involving bioassay techniques such as ELISA and western blotting. F10 successfully inhibited NO production (IC50 = 30.83 ± 1.02 µg mL-1). iNOS, COX-2 levels as well as proinflammatory cytokines including PGE2 were dose-dependently downregulated by F10. The in vivo experiments were assisted by zebrafish embryo model. This exhibited a reduction in ROS and NO expression levels. To the best of our knowledge, this is the first report to illustrate the potential anti-inflammatory activity of FCSPs' extracted from the brown algae *T. ornata*. Concisely, the results suggest that fucoidan purified from *T. ornata* increases the macrophage cellular and zebrafish embryo resistance against LPS-induced inflammation. Based on the observations, the fucoidans are promising candidates to be used in the pharmaceutical and cosmeceutical sectors.

## PA 11

### *Sargassum horneri* ethanol extract inhibits fine dust induced inflammation via Nrf2/HO-1 signaling pathway in RAW 264.7 macrophages

**Thiliṇa U. Jayawardena**[*1], K.K. Asanka Sanjeewa[1], Seo-Young Kim[1], You-Jin Jeon[1]

[1] *Marine BioMedical sciences, Jeju National University, Republic of Korea*

Among different kinds of pollutions, air pollution continue to increase all around the globe. East Asia is considered as a main affecter. This study investigates the fine dust (FD) particles (CRM No. 28) against macrophage cells as a model for alveolar lung cells. Research focus on inflammation and oxidative stress induced by FD, and *Sargassum horneri* (Turner) C. Agardh ethanol extract (SHE) as a potential treatment method. MTT, Griess, ELISA and western blot analysis including mRNA expression analysis using PCR techniques were used in the study. FD particles stimulated the inflammatory mediator production (iNOS, COX-2) as well as pro-inflammatory cytokines (PGE2, IL1β, IL-6, and TNF-α) and lead to NO production. These mediators dose-dependently downregulated through the treatment of SHE. Between, IL-6 and TNF-α were identified as biomarkers for FD. SHE treatment induced HO-1 and Nrf2 activity in a dose-dependent manner against FD stimulation. This conferred the cytoprotective effect against oxidative stress-induced via FD. Furthermore, treatment of the cells with a p38 MAPK inhibitor (SB202190) induced FD-stimulated NO production against SHE conduct. Concisely, the results suggest that SHE increases the macrophage cellular resistance against FD-induced inflammation, oxidative stress, via the p38 MAPK pathway Nrf2/HO-1 expression.

## PA 12

### Effects of ishophloroglucin a isolated from *Ishige okamurae* on high glucose-induced angiogenesis

**K.H.N. Fernando**[*1], Hye-Won Yang[1], Yunfei Jiang[1], BoMi Ryu[1], You-Jin Jeon[1]

[1] *Marine Life Science, Jeju National University, Republic of Korea*

Diabetes mellitus can cause excessive angiogenesis result in serious pathologies such as diabetic retinopathy and nephropathy. Ishophloroglucin A (IPA) isolated from *Ishige okamurae* is known to possess α-glucosidase inhibitory activity. In the present study, anti-angiogenic effect of IPA was evaluated against high glucose induced angiogenesis *in vitro* and *in vivo*. The effect of IPA was evaluated on human vascular endothelial cell line, EA.hy926 induced by high glucose (30 mM). The zebrafish transgenic (*flk*:EGFP) embryo were treated with IPA and studied for the vessel formation against high glucose-induced angiogenesis. IPA treatment suppressed high glucose induced cell proliferation, migration and capillary formation in EA.hy926 cells. The vascular endothelial growth factor receptor 2 (VEGFR 2) expression and downstream signaling molecules including extracellular signal-regulated kinase (ERK), protein kinase B (AKT), c-Jun N-terminal kinase (JNK), and endothelial nitric oxide synthase (eNOS) were down regulated with IPA treatment. High glucose-induced vessel formation in retina and whole body was suppressed by IPA in zebrafish embryo. These findings suggest that IPA can be used as a potential pharmaceutical agent against the angiogenesis associated with diabetes.

## PA 14

### Anti-inflammation effect of diphlorethohydroxy-carmalol from a brown alga *Ishige okamurae* by treatment of urban fine dust particles in keratinocytes and macrophages

**Yulin Dai**[*1], Hyo Geun Lee[1], BoMi Ryu[1], You Jin Jeon[1]

[1] *Marine life science, Jeju National University, Republic of Korea*

Fine dust (FD) particles have become a major contributor to air pollution causing detrimental effects on the respiratory system and skin. Although some studies have investigated the effects of FD on the respiratory system, their possible effects on the skin remain under explored. We investigated the FD mediated inflammatory responses in keratinocytes,

present in the outer layers of skin tissues and the transfer of inflammatory potential to macrophages. We further evaluated the anti-inflammatory effects of the polyphenolic derivative,diphlorethohydroxycarmalol (DPHC) isolated from *Ishige okamurae* against FD induced inflammation. Size distribution of FD particles was analyzed by scanning electron microscopy. FD particles induced the production of cyclooxygenase-2, prostaglandin E2 (PGE2), interleukin (IL)-1β, and IL-6 in HaCaT keratinocytes and the expression of nitric oxide (NO), inducible nitric oxide synthases (iNOS), PGE2, tumor necrosis factor-α expression in RAW 264.7 macrophages. Further, we evaluated the inflammatory potential of the culture medium of inflammation-induced HaCaT cells in RAW 264.7 macrophages and observed a marked increase in the expression of NO, iNOS,PGE2, and proinflammatory cytokines. DPHC treatment markedly attenuated the inflammatory responses, indicating its effectiveness in suppressing a broad range of inflammatory responses. It showed anti-inflammatory potential in in-vivo experiments using FD-stimulated zebrafish embryos by decreasing NO and reactive oxygen species production, while evening cell death caused by inflammation.

## PA 15

### Evaluation of anti-obesity effect of *Grateloupia elliptica* ethanol extract on 3T3 preadipocytes and high fat diet induced obese mice

**Hyo Geun Lee**[*1], Min-Cheol Kang[2], Jeong Jun Lee[3], Tae hee Kim[3], Hye-Min Kim[3], Seon hye Yoon[3], Hyun Soo Kim[1], You Jin Jeon[1]

[1] *Marine life science, Jeju national university, Republic of Korea*
[2] *Research Group of Process Engineering, Korea Food Research Institute, Republic of Korea*
[3] *R&D planning team, Naturetech, Republic of Korea*

Obesity is medical condition of in which excess body fat has accumulated in the body that induce a negative effect on health. In recent reports, the red seaweed extract have antiobesity effect on 3T3-L1 preadipocytes. Thus we investigate the anti-obesity effect of red seaweeds *Grateloupia elliptica* ethanol extract (GEE) on 3T3-L1 preadipocyte and high fat diet (HFD) induced obese mice. To determine the antiobesity effect of GEE we measured the lipid accumulation in 3T3-L1 cells using oil red o (ORO) staining dye. In the cell study, the 3T3-L1 cells were treated sample 4 times and ORO stain was performed for determination of lipid accumulation. In addition, we evaluate the antiobesity effect of GEE on HFD induced obese mice. The animal study was carry out for 8 weeks and GEE was treated for 8 weeks. During the animal study, the body weight were measured on every 7thday and 56thday animals were sacrificed and serum lipid profile, organ weight, histological analysis was conducted. In present study, GEE have highest inhibitory effect on lipogenesis through down regulation of adipospecific protein expression in 3T3 cells. Furthermore oral administration of GEE lower triglyceride and total cholesterol contents and significantly decrease body weight and amount of fat tissue weight on HFD obese mice. These results indicated that GEE down regulate the expression of adipospecific protein, which contribute to reducing lipid accumulation and that can be useful as an antiobesity agent in medical industries.

## PA 16

### Anti-obesity effects of seaweeds collected in Jeju Island on 3T3-L1 preadipocytes and obese mice

**Jun-Geon Je**[*1], Hyun-Soo Kim[1], Jae-Young Oh[1], Min-Cheol Kang[2], You-Jin Jeon[1]

[1] *Marine life science department, Jeju National University, Republic of Korea*
[2] *Research Group of Process Engineering, Korea Food Research Institute, Republic of Korea*

In the present study, we investigated anti-obesity effects of ethanol extracts from seaweeds by testing their effects on adipogenic differentiation in 3T3- L1 cells. The results displayed that the ethanol extract of *Plocamium telfairiae* extract (PTE) showed the highest inhibitory effect on lipogenesis in adipocytes compared to the other algal extracts. Thus, PTE was selected as a potential anti-obesity agent for further study. The marine algae collected from the coast of Jeju Island were extracted three times with 70% ethanol. The anti-obesity activities were measured in 3T3-L1 cells and in C57BL/6 mice fed with high fat diet (HFD).
The results indicated that PTE significantly decreased the expressions of the adipogenic-specific proteins peroxisome proliferator-activated receptor-ɣ, CCAAT/enhancer-binding protein-α, sterol regulatory element-binding protein 1, and fatty acid-binding protein 4 in 3T3-L1 cells compared with PTE untreated cells. In addition, PTE inhibited high-fat diet (HFD)-induced obesity in C57BL/6 mice. Oral administration of PTE significantly reduced the body weight, fatty liver, amount of white adipose tissue, and levels of triglyceride and glucose in the tested animals. In conclusion, these data demonstrate that PTE possesses strong anti-obesity activity and cloud be developed as a therapeutic agent for obesity.

## PA 17

### Nutraceutical assessment of the red seaweeds *Solieria filiformis* and *Gracilaria cornea* pigments by light quality modulation in culture

**Enrique Zepeda**[*1], Daniel Robledo[1], Yolanda Freile-Pelegrin[1]

[1] *Marine Resources, CINVESTAV, Mexico*

Seaweeds have the ability to produce certain pigments under specific light, salinity, and nutrients culture conditions. These pigments have important biological activities, which has been verified in numerous experimental designs, thus they have been considered of nutraceutical importance. *Solieria filiformis* and *Gracilaria cornea* (Rhodophyta) have been studied for their ability to produce pigments, polysaccharides, and other nutraceuticals with antioxidant activity. These species are currently cultivated by our group under an environmentally friendly Integrated Multi-trophic Aquaculture (IMTA) system. In the present study, the ability of these seaweeds to synthesize carotenoid and phycobiliproteins by light quality modulation in laboratory cultures was determined. A one-factor experimental design with four color Light Emitting Diods (LEDs) (blue, red, green and white) and five replicates per treatment were implemented. Seaweeds were kept in 800 mL polyethylene photobioreactors with Provasoli´s enriched seawater at 25 ºC for 14 days. The cultures were irradiated between 150-200 µmol photons m-2 s-1 with a 12:12 light:dark cycle. Growth parameters, pigment content, antioxidant capacity and C:N ratio were determined. Growth rate and chlorophyll a increased when the seaweeds were subjected to green light. As for phycobiliproteins, blue light resulted in the highest synthesis of phycocyanin, while phycoerythrin under red light. The synthesis of carotenoids and antioxidant activity increased with exposure to white light. Combination of intensity and quality light can promote the synthesis of certain compounds in red macroalgae, understanding these variables would be an advantage in order to control their nutraceutical quality. As a second step, the combination of color LEDs will be tested to understand their effect in algae physiology. Financial support CONACYT 2015-01-118 and CONACYT2015-01-575.

## PA 18

### Anti-obesity effects of *Plocamium telfairiae* ethanol extracts in the 3T3-L1 cell line and obese mice fed a high-fat diet

**Yu An Lu**[*1], Hyo Geun Lee[1], Xining Li[1], Tae hee Kim[2], Seon hye Yoon[2], Hye-Min Kim[2], Min Cheol Kang[3], Jeong Jun Lee[2], You-Jin Jeon[1]

[1] *Marine life science, Jeju National University, Republic of Korea*
[2] *Naturetech, Naturetech, Republic of Korea*
[3] *Research Group of Process Engineering, Korea Food Research Institute, Republic of Korea*

*Plocamium Telfairiae* was collected from the coast of Jeju Island, South Korea. The ethanol extracts from *P. telfairiae* as potential anti-obesity agents by testing their effect on adipogenic differentiation in 3T3-L1 cells and C57BL/6 mice. Among the different concentrations ethanol extracts (0-100% ethanol) tested, the inhibitory effect of the *P. telfairiae* extract (PTE) on lipogenesis in adipocytes were evaluated. Moreover, the different dried method of extracts (Natural, Freezed, Vaccum, Hot air dried processed) were investigated. The male C57BL/6 mice was divided into control, high fat diet(HFD), positive control (Oristat and Garcinia Cambogia) and HFD+PTE group (100mg/kg, 165mg/kg, 300mg/kg). The contents of triglyceride, total cholesterol, adiponectin and insulin were investigated from mice adipose tissue. Further, adipose tissue and liver were stained with haematoxylin and eosin(H&E) In 3T3-L1 cell line anti-lipogensis testing, the PTE showed the inhibitory effect on lipogenesis in adipocytes. The highest anti-obesity effect extract method (natural dried and 40% ethanol extract) was found. In the animal assay, the results showed oral administration of HFD+PTE groups significantly reduced body weight, fatty liver, size of white adipose tissue and also decreased the contents of triglyceride, total cholesterol, adiponectin and insulin. PTE has potent anti-obesity activity both *in vitro* and *in vivo*. Therefore, it could be developed as a therapeutic agent for anti-obesity.

## PA 19

### Natural pigments from Indonesian red seaweeds: extraction and characterization

**Hakiki Melanie**[*1], Ambo Tuwo[2], Marcos A. Neves[1,3], Mitsutoshi Nakajima[1,3]

[1] *Tsukuba Life Science Innovation (T-LSI), University of Tsukuba, Japan*
[2] *Faculty of Marine Science and Fisheries, Hasanuddin University, Indonesia*
[3] *Life and Environmental Sciences, University of Tsukuba, Japan*

The market trend and consumers growing interest in natural and healthy products have forced research and industry to develop novel products with positive health effects. Seaweed pigments such as chlorophylls and phycobiliproteins have great potential in food industry as functional ingredients. Indonesia is the largest producer for red seaweed with total production of 11 million ton in 2015. This study aimed to investigate the potential of seaweed pigments from Indonesian red seaweed. Samples of *Euchema cottonii* and *Gracilaria* sp. were collected from Jeneponto, South Sulawesi. The collected seaweeds were extracted using combined solvent at different temperatures. For the quantification of chlorophylls and carotenoid, dried seaweeds were homogenized with mixture of ethanol and hexane each at different ratios (25:75, 50:50, 75:25), while for phycobiliproteins were extracted with ethanol and distilled water at the same ratio as previous. Quantitative analysis of pigment and its antioxidant activity were analyzed by UV-Visible spectrophotometry. The chemical characteristics of seaweed pigments were structurally verified by Fourier Transform Infrared Spectroscopy (FTIR). In overall, *Gracilaria* extract has higher content of chlorophylls, carotene and phycobiliproteins than *E. cottonii.* Chlorophylls in both *E. cottonii* and *Gracilaria* extracts were slightly increased at 50 °C, ranged from 14.12 ± 0.03 to 45.97 ± 0.79 µg/100 g and 16.91 ± 1.64 to 52.49 ± 0.30 µg/100 g, respectively. This may be due to the increasing of solubility of the solute in liquid, which is enhanced the molecular diffusion as temperature increases. However, the phycobiliproteins were comparatively more stable at room temperature and their concentrations slightly decreased at 50°C. By increasing the temperature, protein denaturation occurs which decrease the amount of alpha helix causing a loss of pigment stability. The FTIR spectra showed respective bands assigned to the structure of chlorophylls and phycobiliproteins.

## PA 20

### Ca2+-dependent beneficial effect of Diphlorethohydroxycarmalol on induced glucose uptake in C2C12 cells and zebrafish model

**Hye-Won Yang**[*1], You-Jin Jeon[1], Bo Mi Ryu[1]

[1] *Marine Life Science, Jeju National University, Republic of Korea*

Diphlorethohydroxycarmalol (DPHC) a type of phlorotannin, isolated from Ishige Okamurae, has been shown to have inhibitory effects against α-glucosidase and α-amylase. However, DPHC has not been fully evaluated for its anti-diabetes mechanism of action.
This study aimed to investigate the biological activity of DPHC and the responsible molecules for this activity. To achieve this, we measured the intracellular calcium levels of muscle in in-vitro and in-vivo models and evaluated the effect of blood glucose level on alloxan induced no-insulin secretion in zebrafish model. Furthermore, using an intracellular Ca2+ chelator, we demonstrated that the effect of DPHC on the regulation of glucose uptake in muscle is through increasing the intracellular calcium levels.

## PA 21

### Anti-melanogenesis effects of Ishophloroglucin A isolated from *Ishige okamurae* in α-MSH- stimulated murine melanoma cells

**Yunfei Jiang**[*1], Hye-Won Yang[1], Xining Li[1], K.H.N Fernando[1], Bo Mi Ryu[1], You-Jin Jeon[1]

[1] *Marine Life of Science, Jeju National University, Republic of Korea*

Seaweeds are composed of bioactive compounds which are rich in pharmaceutical, cosmeceutical and nutraceutical values. *Ishige okamurae* is edible brown algae in the coastal area of Jeju Island and it possesses several bioactivities including anti-inflammation, anti-diabetes and anti-oxidant. The aim of the present study is to investigate the anti-melanogenesis activity of *Ishige okamurae* and its compound, Ishophloroglucin A (IPA) The 50% ethanol extraction of *Ishige okamurae* was fractionated with hexane, ethyl acetate and butanol and ethyl acetate fraction was further purified to obtain IPA. The chemical structure of IPA was confirmed by UHPLC-Q-ToF LC/MS, proton and carbon NMR. The ethanolic crude extract of *Ishige okamurae* and IPA were tested for their potential to use as anti-melanogenesis agents by mean of their abilities to inhibit melanogenesis and cellular tyrosinase activity in B16F10 murine melanoma cells. The effect of IPA was checked for the expression of microphthalmia-associated transcription factor (MITF), phosphatidylinositol 3-kinase (P13K), Protein Kinase B (Akt) and mitogen-

activated protein kinases (MAPK) signaling pathways were checked. *Ishige okamurae* extract and IPA showed a significant inhibitory effect on melanogenesis and cellular tyrosinase activity. In terms of Melanogenesis signaling pathways, *Ishige okamurae* extract and IPA downregulated the α-MSH-induced expression of MITF by regulating P13K/Akt and MAPK signaling pathway. We identified that IPA significantly reduces melanogenesis and inhibits cellular tyrosinase activity, resulting in reduced expression of MITF. These data suggest that *Ishige okamurae* may be useful for treating hyperpigmentation and as a skin-whitening agent in the cosmetics industry.

## PA 22

### 5-bromo-3,4-dihydroxybenzaldehyde from *Polysiphonia morrowii* suppress the IgE-mediated allergic response in mast cell and passive cutaneous anaphylaxis animal mouse model

**Eui Jeong Han**[*1], Soo-Jin Heo[2], Eun-A Kim[2], Eun-Ji Shin[2], Min Ju Kim[1,3], Disanayaka Mudiyanselage Dinesh Madusanka[1], Mawalle Kankanamge Hasitha Madhawa Dias[1], Ginnae Ahn[1,4]

[1] *Department of Food Technology and Nutrition, Chonnam National University, Republic of Korea*
[2] *Jeju International Marine Science Center for Research & Education, Korea Institute of Ocean Science & Technology (KIOST), Republic of Korea*
[3] *Department of R&D, Nantapizza 5000, Republic of Korea*
[4] *Department of Marine Bio-Food Sciences, Chonnam National University, Republic of Korea*

In this study, we investigated the anti-allergic effect of 5-bromo-3,4-dihydroxybenzaldehyde (PS6-1) isolated from *Polysiphonia morrowii* on IgE-mediated mast cell activation. The result showed that PS6-1 did not indicate any cytotoxic effects at used all concentration (15.6, 31.3 and 62.5 μg/ml) in bone marrow-derived cultured-mast cells (BMCMCs). And then, PS6-1 markedly suppress the degranulation of BMCMCs by reducing the release of β-hexosaminidase and histamine in dose dependently manner. Also, PS6-1 decreased the IgE binding on as well as the expression of FcεRI on mast cell, compared to the only IgE-stimulated mast cells. In addition, PS6-1 reduced the mRNA expression levels and the secretion of pro inflammatory cytokines (IL-1β, IL-4, IL-5, IL-6, L-10, IL-13, IFN-γ and/or TNF-α) by suppressing the nuclear factor (NF)-κB signaling. In further study, after the injection of IgE, the application of PS6-1 significantly reduced the passive cutaneous anaphylaxis (PCA) reaction known as a type I allergy in mice ear. Taken together, these results suggested that treatment with PS6-1 has the anti-allergic effect and might be a natural material for the remedy of allergy. This work (Grants No. 2018016523) was supported by National Research Foundation of Korea in 2018.

## PA 23

### Fucoidan isolated from *Undaria pinnatifida* sporophylls using enzyme assistant extraction inhibits oxidative stress in zebrafish model

**Jae-Young Oh**[*1], Hyun-Soo Kim[1], You-Jin Jeon[1]

[1] *Marine life science, Jeju national university, Republic of Korea*

Fucoidan is a sulfated polysaccharide, found mainly in various species of brown algae and is interesting due to its various biological activities. Mainly, fucoidan is extracted using hot water and organic solvents of acid water but these extraction methods is low products quality, high energy input and toxicity. Therefore, in this study, we examined fucoidan isolated from the celluclast enzyme extract of *Undaria pinnatifida* sporophylls (FUSC) because of gaining more efficient, safety, nontoxicity and high quality yield and carry out measurement of antioxidant activities in in vitro and in vivo zebrafish model. FUSC was containing 30.4% of sulfate content and 52.3% of fucose. CUSF showed evidenced remarkable scavenging ROS (Reactive oxygen species) production against AAPH (2,2´-Azobis (2-methylpropionamidine) dihydrochloride) in vero cells. In particular, CUSF remarkably decreased cell death, ROS and lipid peroxidation production in zebrafish in vivo model. These findings indicate that fucose-sulfate-rich-fucoidan of FUSC could be used as a beneficial antioxidant agent or food and functional ingredient.

## PA 24

### *Sargassum horneri* methanol extracts protect human keratinocytes against UVB-induced cellular damages via the activation of Nrf2/HO-1 signaling

**Eui Jeong Han**[*1], Eun-Ji Shin[2], Min Ju Kim[1,2], Disanayaka Mudiyanselage Dinesh Madusanka[1], Mawalle Kankanamge Hasitha Madhawa Dias[1], Kyounghoon Lee[3], Ginnae Ahn[1,4]

[1] *Department of Food Technology and Nutrition, Chonnam National University, Republic of Korea*
[2] *Department of R&D, Nantapizza 5000, Republic of Korea*
[3] *Department of Marine Production Management, Chonnam National University, Republic of Korea*
[4] *Department of Marine Bio-Food Sciences, Chonnam National University, Republic of Korea*

In this study, we evaluated the protective activity of *Sargassum horneri* methanol extract (SHM) against UVB-induced cellular damages in HaCaT cells, a human keratinocyte. The results showed that SHM improved the cell viability in UVB-irradiated HaCaT cells by reducing the intracellular reactive oxygen species (ROS) generation. In addition, SHM inhibited apoptosis via thr reduction in sub-G1 cell population and apoptotic body by the modulating of Bax/Bcl-2 expressions known as apoptosis-related molecules in UVB-irradiated HaCaT cells. Furthermore, SHM suppressed the NF-κB signaling by regulating the phosphorylation of IκB-α and NF-κB as well as the activation of nuclear factor (NF)-κB p65. Interestingly, the pre-treatment with SHM led to the activation of Nrf2/HO-1 signaling with the increased heme oxygenase 1 (HO-1) and the nuclear factor erythroid 2-related factor 2 (Nrf2) expressions. The protective capacities of SHM against UVB-caused cellular damages were blocked by the inhibition of HO-1 singaling. Taken together, this study suggests that SHM may be used as a potential protector against damage caused by UVB irradiation. This work (Grants No. M01201820180359) was supported by Korea Institute of Marine Science & Technology Promotion (KIMST).

## PA 25

### *Pyropia yezoensis* extract inhibits TNF-α and IFN-γ-induced TARC and MDC expression via down-regulation of NF-κB activation in HaCaT cells

**Yuna Ha**[*1], Ah-Hyun Park[1,2], Jae Woo Jeong[1,2], Won-Hwi Lee[3,2], Do Yeon Seo[1,2], Young-Eun Choi[3,2], Young Jin Kim[3,2], Mira Park[2], Oh Wook Kwon[2], Youn-Jung Kim[1,3,2]

[1] *Department of cosmetic science and management, Incheon National University, Republic of Korea*
[2] *Researsh Institute of Basic Sciences, Incheon National University, Republic of Korea*
[3] *Department of Marine Sciences, Incheon National University, Republic of Korea*

Seaweed is known to afford protective effects against skin diseases including dermatitis and includes many bioactive compounds, such as carotenoids compound, xanthophyll is promising candidate for useful cosmetic resources. This study researches the immunological effect of pepsin extract of *Pyropia yezoensis* on Human keratinocytes. Generally, chronic AD patients have increased IL-5, IL-12, and interferon-gamma mRNA-expression levels. These show that AD is Th-2 type immune response. Furthermore, AD causes the skin barrier dysfunction. In this study, we investigated the anti-atopic dermatitis effect of these seaweed extracts on pro-inflammatory chemokines such as thymus and activation-regulated chemokine (TARC/CCL17) and macrophage-derived chemokine (MDC/CCL22) mRNA and on protein levels in HaCaT cells. Cells were incubated with 10 ng/mL interferon-gamma (IFN-γ) or 10 ng/mL tumor necrosis factor-alpha (TNF-α) in the presence or absence 40 μg/ml, 200 μg/ml, and 1000 μg/ml of *P. yezoensis* extracts, respectively. Responses of Th2-type chemokine genes and protein levels were suppressed depending on the concentration of extract. And also, *P. yezoensis*extract regulate both IFN-γ and TNF-α-stimulated the activation of NF-κB in parallel with the production of TARC and MDC. We determined IFN-γ or TNF-α-induced cell model nuclear translocation of NF-kB-p65 was significantly inhibited. Therefore, our result suggest that NF-kB protein is a crucial and specific regulator of IFN-γ and TNF-a signaling that controls the transcription of target genes, including MDC and TARC.

## PA 26

### Antifouling ability of calcium sulfide crystal found in coralline algae

**Jimin Choi**[*1], Ekavianty Prajatelistia[2], Sang mok Jung[3], Hyun Woung Shin[3], Dong Soo Hwang[1]

[1] *IBB, postech, Republic of Korea*
[2] *Materials Science and Engineering, Institut Teknologi Bandung, Indonesia*
[3] *Department of Biological Science & Biotechnology, Soonchunhyang University, Republic of Korea*

Nonspecific fouling of algae on marine substrate is a serious problem that cause huge economic loss in the maritime industries, but an affordable, environmentally friendly solution has been developed yet. In this study, we have pursued an antifouling compound from a crustose coralline algae *Lithophyllum yessoense*, which cause the disappearance of the macroalgal communities on the marine substratum. Calcium sulfide (CaS) crystal was identified for the first time in the live *L. yessoense* which retain an antifouling activities, whilst the dead *L. yessoense* has no CaS. CaS containing silica pellet was formulated to confirm the antifouling activity of CaS. Interestingly the settlement, germination and chlorophyll concentrations of *Ulva* spores inhibited on CaS containing substrate. These results demonstrate that naturally occurring CaS in *L. yessoense* is effective for inhibiting the alga spore settlement, and represent a promising candidate for the practical antifouling coating.

## PA 27

### Content of *Sargassum* sp. from ekas gulf lombok Indonesia

**Nunik Cokrowati**[*1], Nuri Muahiddah[2], Nanda Diniarti[2], Yenny Risjani[3], Diana Arfiati[3], Dewi N.S[2]

[1] *Post Graduate Program, Fisheries and Marine Science Faculty, Brawijaya University, Indonesia*
[2] *Mataram University, Indonesia*
[3] *Brawijaya University, Indonesia*

*Sargassum* sp. as brown algae used for food material, fertilizer, alginate, growth stimulant and fucoidan. Fucoidan which is anti-tumor drug and immunostimulant. This objective of this study was to determine content nutrient of *Sargassum* sp. from Ekas Gulf, Lombok Timur district, Nusa Tenggara Province, Indonesia. The research method used is analytical methods in the laboratory by analyzing water content, ash content, protein, fat, carbohydrates, Calsium (Ca), Ferum (Fe) and alginate. The results showed that water content, ash content, Fe, Ca were 12.79; 28.89; 0.12 and 3.34 %. Fat and Carbohydrate were 8.41 dan 59.51%. The contents of this nutrient has the potential to be used as food material, fertilizer and medicinal ingredient.

## PA 28

### Application of magma seawater to the cultivation of seaweed: effects of nutrients addition on *Ecklonia cava* growth

**Sun Kyeong Choi**[*1], Kyeonglim Moon[1], Byeong Su Song[1], Tae Hyeon Kim[1], Su Ji Lee[1], Yun Hee Kang[2], Sang Rul Park[1]

[1] *Department of Marine Life Sciences, Jeju National University, Republic of Korea*
[2] *Department of Earth and Marine Sciences, Jeju National University, Republic of Korea*

Magma seawater is a kind of underground seawater in volcanic island such as Jeju Island. It includes various minerals and has purity and safety of the water resource. Temperature (17°C) and salinity (34 PSU) of magma seawater are constant all the year round. Thus, magma seawater has been widely used for fish aquaculture in Jeju Island. In this study, we evaluated the potential use of Jeju magma seawater for the cultivation of macroalgae by analysis of growth (weight and area) and photosynthetic pigments of kelp, *Ecklonia cava* in surface seawater (SW) and magma seawater (MS). Moreover, nutrients addition experiments (ammonium 100μμM, nitrate 100μM or ammonium 50μM + nitrate 50μM to MS) were conducted to investigate the effect of nutrients addition on growth of *E. cava*. All experiments were performed seasonally. At the end of the experiment (10 days), the weight and area of the MS-cultured blades were 48.8% and 60.1% higher than those of the SW-cultured blades without additional nutrients, respectively. The growth of *E. cava* cultured in the medium with nutrients addition was significantly higher than that in control medium. Surprising, *E. cava* grown in the medium with nitrate addition showed the highest growth (area and weight) compared with other media. Its area and weight increased 25.9% and 31.7%, respectively for 10 days. Photosynthetic pigments (Chlorophyll a and Fucoxanthin) of cultured blades showed a similar to the results of growth. Nitrate reductase activity of *E. cava* was dependent on ammonium availability in the medium, even though nitrate concentration in the medium was high. These studies suggest that magma seawater has a high potential for cultivation of macroalgae without additional nutrients. Nevertheless, the additional supply of nutrients (N and P) is still needed to enhance the production of macroalgae.

## PA 29

### An investigation of the nutritional composition of *Saccharina latissima, Alaria esculenta* and *Laminaria digitata* and commercial open-ocean cultivation in the Faroe Islands

**Urd Grandorf Bak**[*1], Ólavur Gregersen[2], Charlotte Jacobsen[1], Susan Lovstad Holdt[1]

[1] *The National Food Institute, Technical University of Denmark, Denmark*
[2] *R&D, Ocean Rainforest Sp/F, FaroeIslands*

A global need for sustainable produced biomass has kick-started the development of a European macroalgal cultivation industry. In contrast to the nearshore cultivation in Asia, a Faroese company has successfully developed a low-cost MacroAlgal Cultivation Rig (MACR) that is suitable for oceanic conditions. The design has proven itself scalable and 10 MACR's have been in operation since 2010. Still, the challenge is to reduce the cost of production to be competitive within the global market. The aquaculture output (yield/ha/year) were optimised through in situ experiments of e.g. multiple partial harvesting. Growth and yield were monitored through a three-year period at two sites, and biochemical composition of monthly biomass samples was determined. Analyses of all compounds incl. antioxidant activity and vitamins were made to understand seasonal, site and depth variations. Finally, innovative seeding trials were carried out to reduce cost e.g. by using direct seeding methods. The aquaculture output was increased from two harvests per year in three years without re-seeding, resulting in an 85% lower capital expenditure. The MACR capacity was increased by 300% by e.g. having a smaller distance between vertical lines. The biochemical composition confirmed a large difference between species. In general, a seasonal variation was observed for most compounds (exclusive lipid and protein), but no variation in composition between sites, depths and year of cultivation. Direct seeding reduced the cost of seeding with ~25% compared to twine-around-rope seeding. The improved understanding of the nutritional composition has allowed further value-creation and is crucial for future bio-refinery processes. Cultivation in open-ocean and the use of multiple partial harvesting have proven a high aquaculture output for European macroalgal industry. This work has thus demonstrated that kelp cultivation is possible in the Faroe Islands using the MACR and has highlighted the need for further innovation to lower the cost even more.

## PA 30

### Factors affecting survival and cell division during protoplast culture of *Undaria pinnatifida* sporophyte

**Jose Avila Peltroche**[*1], Boo Yeon Won[1], Tae Oh Cho[1]

[1] *Natural Science, Chosun University, Republic of Korea*

Protoplast regeneration is indispensable when developing protoplast systems. Although sporophyte regeneration from protoplasts of the commercial brown algae *Undaria pinnatifida* has been accomplished (Matsumura et al. 2001), factors affecting its regeneration process has not been extensively explored. In this study, we examined the effect of six regeneration media, two regeneration protocols (three-step reduction and Matsumura's protocol), and three antibiotic formulations at two temperatures (16°C and 20°C) on protoplast survival and division from *U. pinnatifida*. After 2 weeks in culture, protoplasts survived only in PES medium supplemented with NaCl and $CaCl_2$ or sugars (sucrose + glucose). Protoplast survival was similar among the regeneration protocols tested. After one month in culture, more than 70% of protoplasts survived in treatments containing a penicillin-streptomycin-chloramphenicol (PSC) antibiotic mixture although percentage of cells in division was superior (14%) at 16°C than 3°C at 20°C. After two months in culture, only protoplasts at 16°C continued cell division until formation of easily distinguished callus-like masses. Our results suggest that protoplasts survival and division are influenced by the regeneration media used, antibiotic formulations and temperature. A simple regeneration protocol (three-step reduction using PES medium plus NaCl, $CaCl_2$ and PSC mixture at 16°C) can be used for culturing protoplasts from *U. pinnatifida*.

## PA 31

### Use of AMPEP K+ and coconut water in the micropropagation of red seaweed *Kappaphycus alvarezii* var. *tambalang* (Doty)

**Che Khairun Aisyah Che Khazahari**[*1], Noor Mutmainnah Johar[2], Ming Herng Gan[2], Christine Abellana Orosco[2], Anicia Hurtado[3]

[1] *School of Fisheries and Aquaculture Sciences, Universiti Malaysia Terengganu, Malaysia*
[2] *School of Marine and Environmental Sciences, Universiti Malaysia Terengganu, Malaysia*
[3] *Integrated Services for the Development of Aquaculture and Fisheries, ISDA, The Philippines*

*Kappaphycus* is economically importance in producing carrageenan as raw material for various industries. Commercial cultivation of *Kappaphycus* still using conventional methods in Southeast Asia countries to continue supply the high demand of the market. However, conventional methods remained problems in producing good quality seedling, further decrements of growth rate and susceptibility to diseases. Implement technique for micropropagation of carrageenophyte was aimed to produce high survival, fast growth rate and inexpensive method for *K. alvarezii* var. *tambalang* plantlets. Provasoli's enriched seawater combination with various concentration of Arcadian Marine Plant Extract Powder (AMPEP K+) and coconut water (CW) as culture medium. 72 culture media with 30 segments each medium were cultured using microwave container in static condition without aeration under 13:11hrs L:D cycle, temperature 19-29°C, salinity 34-37psu and 10-15µmol of photons m-2s-1. From the observation, AMPEP K+ (0.5-10mg L-1) induced callus cell released faster in week 1 and later in week 2 for CW (0.5-1%) and 10 out of 15 combinations of AMPEP K++CW; callus formation in week 3-4 for most of the AMPEP K++CW combination excepted AMPEP K+ (0.5, 1, 10mg L-1) and 0.1% CW+AMPEP K+ (0.1, 0.5, 1, 10mg L-1) were died; 1% CW and all combination with AMPEP K+ generated 1st shoot primordium in week 5-6; 1% CW and combination with AMPEP K+ (0.5, 5mg L-1) only produced secondary branching in week 11 and 14, respectively. Treatment 5mg L-1 AMPEP K++ 1% CW showed highest survival rate with 66.67%. Meanwhile, treatment 0.5mg L-1 AMPEP K++ 1% CW gave highest growth rate with 6.55% day-1. Culture media with 1% CW were reduced the infestation by contaminant like filamentous cyanobacteria in the end of culture period (week 18). In conclusion, the combination of AMPEP K+ and 1% CW promoted higher survival and better growth rate of *K. alvarezii* var. *tambalang* plantlets.

## PA 32

### Scaling-up estimation of $CO_2$ regulation and mitigation capacity of *Pyropia* aquaculture beds

**Hanbi Moon**[*1], Sukyeon Lee[1], Ju-Hyoung Kim[2]

[1] *Department of Marine Life and Aquaculture, Kunsan National University, Republic of Korea*
[2] *Faculty of Marine Applied Biosciences, Kunsan National University, Republic of Korea*

Dense seaweed aquaculture beds (SABs) play important roles for climate regulation and mitigation due to active uptake of inorganic carbon by photosynthesis. In this study, $CO_2$ removal efficiency of *Pyropia* SABs were

estimated with photosynthetic measurement of algal tissue. The thallus of *Pyropia* species were collected from three different *Pyropia* SABs for measuring photosynthetic rate from South and West coast of Korea from December 2016 to March 2017. The maximum $CO_2$ uptake of *Pyropia* spp. ranged from 2.27~7.48 mg $CO_2$ $g^{-1}$ ww $h^{-1}$ and light saturated at 78 to 105 µmol photons $m^{-2}$ $s^{-1}$. Estimated total $CO_2$ removal efficiency of scaling-up using total biomass and in situ light data exhibit range from 103.86±6.16 g $CO_2$ $m^{-2}d^{-1}$ on March 2017 to 272.42±1.76 g $CO_2$ $m^{-2}$ $d^{-1}$ on December 2016. These results representing that *Pyropia* SABs showed significantly high removal efficiency of $CO_2$ by active photosynthesis, and it can be acts as a potential $CO_2$ sink from the atmospheric $CO_2$.

## PA 32-1

### Seeding method and salinity effects on the growth of edible *Caulerpa okamurae*

**Jiha Shin**[*1], Song Hyun Lee[1], Dae Sung An[2], Seo Kyoung Park[1], Han Gil Choi[1]

[1] *Biological Science, Wonkwang University, Republic of Korea*
[2] *Biological Science, Institute of Eco and Environmental Incorporation, Republic of Korea*

To increase production of edible *Caulerpa okamurae* fronds, optimal seeding method and salinity concentration were examined using three seeding methods (erect, stolon, erect+stolon frond) and six salinity levels (20, 25, 30, 35, 40, 45 psu). They were cultured for 12 days and relative growth rates (RGRs) were also calculated for frond wet weight. In addition, we tested whether erect frond of *C. okamurae* has polarized growth pattern, after cutting erect fronds into apical and basal parts. The apical and basal frond parts of *C. okamurae* were cultured for eight days and production of frond and rhizoid were observed. RGRs of *C. okamurae* were between 2.18~3.32% $day^{-1}$ with maximal growth in stolon treatment and minimal in erect frond one. In the salinity experiment, RGRs of *C. okamurae* were from -0.66 to 2.82 % $day^{-1}$ with maximal growth in 30psu and the growth of *C. okamurae* fronds was retarded in lower salinity levels of 20 and 25 psu, and higher ones (35, 40 psu). In particular, *C. okamurae* showed minus growth in the culture medium with 45 psu. All *C. okamurae* segments produced rhizoids from the basal cut surface but a clear polarized growth pattern was not observed. In conclusion, *Caulerpa okamurae* grew in erect and stolon fronds and production was maximal in stolon treatment forming many new erect fronds. Also, we confirmed this species was euryhaline growing wide range of salinity from 20 to 40 psu.

## PA 33

### The effect of ocean acidification on the expected thermal niche of *Chattonella marina*

**Myeong Hwan Lim**[*1], Kwang Young Kim[1]

[1] *Oceanography, Chonnam national university, Republic of Korea*

A harmful raphidophyte, *Chattonella marina*, usually shows an increased abundance during high temperature periods in Korean coastal waters. This pattern of blooms is expected to change with climate change. The growth rate of *C. marina* was measured at five temperatures (13, 20, 26, 30, and 34 °C) in both ambient (300-450 ppm) and elevated $CO_2$ level (800-1200 ppm). The thermal growth model was used to fit the data to estimate the minimum ($T_{min}$), maximum ($T_{max}$), and optimum temperature ($_{Topt}$) for the growth of *C. marina*. The $_{Topt}$ is estimated at 29.7°C in both ambient and elevated $CO_2$ levels. Compared to the ambient $CO_2$ condition, the Tmin shows a lower quantity, while the Tmax shows a higher quantity in the elevated $CO_2$ level. *C. marina* has expanded its thermal niche, especially under the acidification condition. Therefore, its known range of distribution will continue to grow in the future.

## PA 35

### Induced oxidative stress and DNA damage of red sea bream exposed to red tide caused by *Karenia mikimotoi*

**Young Jin Kim**[*1], Do Yeon Seo[2], Young-Eun Choi[1,2], Yuna Ha[2,3], Ah-Hyun Park[2,3], Jae Woo Jeong[2,3], Won-Hwi Lee[1,2], Mira Park[2], Oh Wook Kwon[2], Youn-Jung Kim[1,2,3]

[1] *Department of Marine Sciences, Incheon National University, Republic of Korea*
[2] *Research Institute of Basic Sciences, Incheon National University, Republic of Korea*
[3] *Department of Cosmetic Science and Management, Graduate school, Incheon National University, Republic of Korea*

The death of aquatic organisms during red tide is known to be caused by dyspnea due to mucus components secreted by red tide creatures, but the detailed mechanism has not yet been elucidated. The red sea bream (*Pagrus major*) is a major aquaculture species in the Korean coast, and is also a high value-added aquatic organism. The death of this species causes economic loss to aquaculture. A total of 15 fish were exposed for 0, 3, 24 h and depurated for 3 h for each concentration of *Karenia mikimotoi* (1000, 3000, 5000 cell/mL). Oxidative stress related enzymes (SOD, CAT, GR, GPx, and GST) were observed to be activated by *K. mikimotoi* in gill tissue of red sea bream. We also confirmed that DNA damage was induced by comet assay using blood samples of red sea bream. It was confirmed that gills and blood sample of fish can be used as biomarkers to detect the degree of antioxidant stress. In particular, blood samples can be obtained faster than using gill tissue and the possibility of application is confirmed. These results suggest that this study may provide additional information on the signs of aquatic organisms caused by red tide and may be useful for red tide management.

## PA 36

### Could ocean acidification influence epiphytism? a comparison of carbon-use strategies between *Fucus vesiculosus* and its epiphytes in the Baltic Sea

**Gerli Albert**[*1], Christopher D. Hepburn[2], Georg Martin[1], Liina Pajusalu[1], Daniel W. Pritchard[3]

[1] *Estonian Marine Institute, University of Tartu, Estonia*
[2] *Department of Marine Science, University of Otago, New Zealand*
[3] *Te Ao Tūroa, Te Rūnanga o Ngāi Tahu, Nicaragua*

Reduced seawater pH due to elevated $CO_2$, a process known as Ocean Acidification (OA), is a globally significant environmental issue. OA is predicted to influence a range of ecosystem processes but little is known about how changing seawater carbon chemistry could influence the extent and impacts of epiphytism. In the brackish Baltic Sea, increased epiphytism is associated with coastal eutrophication and the potential for OA to interact with this relationship remains unclear. This study focuses on slow-growing perennial algae *Fucus vesiculosus* – which is one of the most important habitat-forming species in the Baltic Sea – and two of its most dominant fast-growing filamentous epiphytes *Ceramium tenuicorne* and *Pylaiella littoralis*. Material for this study was collected from Küdema Bay in West Estonian Archipelago Sea, northern Baltic Sea. The first step of the research was to determine which carbon acquisition strategies these species possess, which could indicate how they respond

to predicted changes in seawater chemistry due to elevated $CO_2$,. Carbon use strategies in macroalgae were determined by analyzing the natural abundances of carbon isotopes (δ13C), pH drift and photosynthesis vs. dissolved inorganic carbon (DIC) curves. Our preliminary results showed that *F. vesiculosus* and its filamentous epiphytes have similar inorganic acquisition strategies and that could be related to their shared environment. The next step will be to carry out experiments to determine the effect of elevated $CO_2$, and interactions with nutrient concentration on the photosynthesis and growth of *F. vesiculosus* alone and cohabitation with its epiphytes.

## PA 37

### The effect of climate change on growth rate and chain-forming capacity of the *Alexandrium pacificum*

**Chung Hyeon Lee**[*1], Jun Yeong Jang[1], Kwang Young Kim[1]
[1] *Oceanography, Chonnam National University, Republic of Korea*

The dinoflagellate *Alexandrium* species are widely spread throughout the world, and they cause economic loss in the fishery industry by producing paralytic shellfish poisoning (PSP). The purpose of this study is to investigate the effects of ocean acidification on the thermal growth and predict the adaptability of *A. pacificum* in future environments. The experimental conditions have temperatures of 10 to 35°C under the ambient (ca. 380 ppm) and future $CO_2$ condition (ca. 1,000 ppm). The future adaptability of the *A. pacificum* was evaluated by growth rate and chain-formation index(CI). The results show that *A. pacificum* has extended its thermal niche and increased its growth rate, but decreased in CI value in the elevated $CO_2$ condition. This indicates that *A. pacificum* would successfully adapt to future climate change.

## PA 38

### Invasion potential of subtropical seaweed *Caulerpa sertularioides* (Ulvophyceae) into temperate ocean with ecophysiolgical acclimation under future climate conditions

**Sukyeon Lee**[*1], Juhyun Kang[1], Hanbi Moon[1], Nahyun Kim[1], Kwang Young Kim[2], Eun Ju Kang[3], Ju-Hyoung Kim[1]
[1] *Department of Marine Life and Aquaculture, Kunsan National University, Republic of Korea*
[2] *Department of Oceanography, Chonnam National University, Republic of Korea*
[3] *Research Institute for Basic Science, Chonnam National University, Republic of Korea*

*Caulerpa sertularioides* is introduced into the aquariums in Korea, it is necessary to evaluate the possibility of invading this species to the native macroalgal habitat because this genus is notorious worldwide taxonomic group as an invasive seaweed. here, photosynthesis and growth of *C. sertularioides* were investigated under various climate conditions. mesocosm experiment was designed to examine invasion risk of non-native seaweed *C. sertularioides*. three experimental conditions were simulated as future climate treatments (acidification: 900 µatm $CO_2$ & 20°C; warming: 450 µatm $CO_2$ & 25°C; greenhouse; 900 µatm $CO_2$ & 25°C) compared to ambient (450 µatm $CO_2$ & mean SST during the summer 20°C). results representing that acidification and warming conditions are positively affecting on photosynthesis and growth of *C. sertularioides*. moreover, photosynthesis and growth were more synergistically increased under greenhouse condition than acidification and warming. consequently, establishment of this species will be promoted by elevated $CO_2$ and temperature compared to ambient condition, thus management plan is quite required for preventing to invasion of *C. sertularioides* to the Korea coastal ocean.

## PA 38-1

### Interactive effects of ocean acidification and warming on photosynthesis and growth of crustose coralline algae

**Nahyeon Kim**[*1], So Young Jeong[2], Kwang Young Kim[3], Ju-Hyoung Kim[4]
[1] *Department of Marine Life and Aquaculture, Kunsan National University, Republic of Korea*
[2] *Department of Life Science, Chosun University, Republic of Korea*
[3] *Department of Oceanography, Chonnam National University, Republic of Korea*
[4] *Faculty of Marine Applied Biosciences, Kunsan National University, Republic of Korea*

Crustose coralline algae (CCA), which are inhabited on intertidal and subtidal rocky subtracts, play a fundamental role in inorganic and organic carbon dynamics in coastal ecosystem driven by photosynthesis and calcification. Dramatic increases of anthropogenic $CO_2$ and global temperature since industrial revolution are inducing alteration of relative fraction of carbonate chemistry, leading to significant changes of rocky shore habitat with metabolic change of most marine organisms. Especially, there is much interest in the fate of CCA in a recent year because CCA could utilize all component of carbonate chemistries via photosynthesis and calcification. Thus, indoor mesocosm experiment was conducted to evaluate photosynthesis and growth of CCA under future climate conditions (Acidification, Warming, and Greenhouse) compared to ambient condition. After 47 days acclimation, photosynthesis and growth were obtained by diffusive boundary layers measurement using oxygen microelectrode and by coverage calculation with image analysis, respectively. Photosynthesis was lowest under acidification, and highest respiration exhibited under greenhouse treatment. The coverage of CCA also reduced under acidification treatments, but negative response under high $CO_2$ conditions was offset by elevated temperature (greenhouse). Moreover, the increased coverage of CCA was strongly correlated with the saturation state of aragonite and calcite in seawater. Together, seawater carbonate chemistry in seawater induced by climate change is most important factor for regulating distribution of coverage of CCA, and elevated temperature create more suitable conditions for growth of CCA even acidification depress photosynthesis and growth.

## PA 39

### Ecology of an edible seaweed *Eucheuma serra* (J. Agardh) J. Agardh in the northeast coast of Taiwan

**Boryuan Chen**[*1], Pohsiung Huang[2], Mingjun Lee[2], Daisuke Fujita[1]
[1] *Laboratory of Applied Phycology, Tokyo University of Marine Science and Technology, Japan*
[2] *Course Director, Association of Project AWARE, Taiwan*

*Eucheuma serra* (J. Agardh) J. Agardh is an edible red alga growing in subtropical to tropical waters in Indo-Pacific, which is distributed most to the north in the genus *Eucheuma*. In northeast coast of Taiwan, the wild resources are collected by skin diving, boiled lightly, mixed with finely chopped cayenne peppers, garlic and sesame oil, and eaten as a "Liang Ban Wu Gong Cai" (vegetables with dressing). In spite of its commercial

importance, however, the ecology of this species has never been studied in Taiwan. In the present study, twenty-one stands of *E. serra* were tagged to monitor the thallus length and conditions (bite marks and epiphytes) and 10-50 wild thalli were collected randomly every month to measure the weight and generation proportion in Shen-Ao Bay, Rui-fang District, New Taipei City, in May 2017. Thallus length reached maximum in June 2017 and decreased from August. The thalli regrew from December and reached maximum again in June 2018. Cystocarp was present on female thalli except the period from December 2017 to March 2018. Bite marks and epiphytic filamentous algae were common on the thalli through the study period. Gametophytes and tetrasporophytes accounted for more than 50 % of total collected thalli in May and July, respectively; only immature thalli were found from December to March. Among the eleven species of herbivores tested in feeding experiments, *Tripneustes gratilla* and *Acanthrus dussumieri* were the most voracious. In addition, it was found that *E. serra* is harvested by local residents who have no fishery rights. Thus, management of the densities of the above herbivores and the establishment of harvest rules are needed to maintain the wild resources along this coast.

## PA 40

### Seasonal dynamics and mixotrophy of the toxic benthic dinoflagellate *Ostreopsis*

**Bora Lee**[*1], Myung Gil Park[1]

[1] *Department of Oceanography, Chonnam National University, Republic of Korea*

Phagotrophy of the harmful benthic dinoflagellates of the genus *Ostreopsis* has long been inferred based on observations of food particles present inside the cell, but the prey was not identified yet. This study aimed to investigate seasonal dynamics of the benthic dinoflagellates *Ostreopsis* spp. in temperate Korean coastal sites, with special emphasis on their phagotrophy. To further identify the prey, the ingested food particles were extracted from single *Ostreopsis* cells and their rbcL and psaA genes sequences were determined. High concentration of *Ostreopsis* cells was observed between June and October at all sites, when water temperatures were higher than 19°C, exhibiting a marke d temporal seasonality. The percentage of *Ostreopsis* cells containing the ingested food particles exhibited the large spatial and temporal variations among sampling sites, ranging from undetectable level to 29.5%, and was not always associated with *Ostreopsis* cell abundance. Phylogenetic analyses using both plastid-encoded rbcL and psaA genes revealed that all sequences obtained from the ingested food particles of *Ostreopsis* cells grouped within the class Florideophyceae, rhodophyta. Our result clearly demonstrates that *Ostreopsis* species consume various macroalgae from the rhodophyta, not protists which have long been thought to be potential prey. The result from this study provides a basis for better understanding mixotrophic behavior and nutritional ecology of the benthic harmful dinoflagellate *Ostreopsis* species.

## PA 41

### Effects of predation risk on urchin grazing behavior on *Sargassum patens* C. Agardh

**Dominic Belleza**[*1], Yuuki Kawabata[2], Gregory Nishihara[3]

[1] *Graduate School of Fisheries and Environmental Science, Nagasaki University, Japan*
[2] *Graduate School of Fisheries and Environmental Science (Faculty of Fisheries), Nagasaki University, Japan*
[3] *Organization for Marine Science and Technology, Nagasaki University, Japan*

Trophic interactions in temperate shallow-water ecosystems depend on a delicate balance between the grazing activity of herbivores and grazer removal by predators. Loss of either bottom-up or top-down control may lead to an alternative state. A good example of this phenomenon is the uncontrolled grazing of urchins which cause a decline of foliose seaweed forests and a transition into barrens dominated by crustose coralline species. However, grazers can be influenced through trait-mediated indirect interactions (TMII) by altering their behavior through a perceived act of predation without actual grazer mortality. To test this, purple urchin (*Heliocidaris crassispina*) behaviors were observed in laboratory experiments using time-lapse video in response to the presence of food cues (*Sargassum patens*), predation-risk cues (dead urchin) or a combination of both, relative to controls (no chemosensory cues). Behaviors were quantified by recording the time spent by each urchin performing a particular behavior (i.e. none, idle, halt, approach, escape, pass, interaction, food haul, outside) and comparing the frequency and duration of each behavior type on different urchin conditions (starved or fed urchins). Results show urchin interactions with the algal food patch was interrupted in the presence of the dead urchin in both fed and starved urchins, with escape responses ensuing not long after. An interesting behavior exhibited only by some starved urchins was food hauling, which seems to indicate an attempt to feed while fleeing away from danger. The experiment reveals that TMII have an important effect in the maintenance of seaweed bed biomass against herbivory by overriding hunger response and disrupting foraging and feeding behavior by purple urchins.

## PA 42

### Phenology of diatoms attached on *Sargassum macrocarpum* and *Zostera marina* in Arikawa Bay, Goto Islands, Nagasaki, Japan

**Hoshimi Kamisaki**[*1], Kenjiro Hinode[1], Yukio Inoue[1], Yuhei Matsuda[2], Gregory Nishihara[3]

[1] *Graduate School of Fisheries and Environmental Sciences, Nagasaki University, Japan*
[2] *Faculty of Fisheries, Nagasaki University, Japan*
[3] *Organization for Marine Science and Technology, Nagasaki University, Japan*

Seaweed beds are highly productive habitats that are the spawning ground and nursery habitat for many aquatic organisms. Recently, studies have shown that the high primary productivity of microalgae, including attached diatoms, can be a valuable food source for grazers because of their high dietary value, which is particularly rich in proteins. However, there are few studies regarding species composition and the quantitative evaluation of attached diatoms. The purpose of this study was to investigate species composition, population, and document the seasonal change of diatoms attached to seaweeds and seagrasses. Monthly surveys were done from April 2017 to October 2018 in a *Sargassum macrocarpum* forest and *Zostera marina* meadow in Arikawa Bay. Epifauna and epiflora samples were removed from the collected *S. macrocarpum* thalli and *Z. marina* leaves. After separating attached diatoms and attached animals using a net (5 µm), animals were examined using a stereomicroscope while diatoms were examined using a light microscope (LM) and a scanning electron microscope (SEM). On *S. macrocarpum*, the diatom assemblage consisted of 51 genera and 72 species while, the diatom assemblage on *Z. marina* consisted of 44 genera and 80 species. The cell density of diatoms per dry weight of seaweed and seagrass ranged from $4.7\times10^3$ ~$1.2\times10^6$ on *S. macrocarpum* and $7.4\times10^2$~ $1.4\times10^6$ on *Z. marina.* In both species, peaks in diatom cell density were observed in September and December of 2017 and August of 2018. Dominant species were

different for each of the months and appeared to be correlated to the changes in the population of attached animals, especially amphipods.

## PA 43

### Conditioning of seaweed dominated environments by hydrodynamics

**Thomas Burel**[*1], Jacques Grall[2], Gauthier Schaal[1], Erwan Ar Gall[1]

[1] *Lemar, University of Brest - IUEM, France*
[2] *Observatoire du Domaine Côtier, University of Brest - IUEM, France*

The development and composition of rocky shores communities are ruled by several abiotic factors including hydrodynamics. An exposure gradient is observed between sheltered shores, where macroalgal canopies are well developed, and exposed shores, where sessile animals (barnacles, mussels) and limpets dominate the substrate. Hydrodynamics include several components such as wave height, orbital velocity, swell or shear stress but also currents with flow velocity. Based either on in situ monitoring or on geographic data, proxies are usually used to assess hydrodynamical profiles, each showing (dis)advantages depending on the spatial and/or temporal scale. We present here a study on the effect of hydrodynamics, evaluated by several proxies, on the extent and structure of macroalgal communities. In that prospect we developed several complementary approaches combining pressure probe measurements, wave height models and geographical proxies. In parallel, we propose a biological sampling method taking into account the macroalgal specific richness, the cover of macroalgae strata, allowing a accurate description of the structure and development of macroalgal communities. The analysis aims at describing which proxy explains the most the variation of these communities. To obtain a larger, latitudinal view of this approach, a collaborative project is in progress in Europe (Galicia, Ireland, Norway). To achieve an overall assessment of hydrodynamical conditioning of seaweed dominated coastal environments, current measurement was initiated in order to compare effects of wave and currents on macroalgal species distribution and cover. Initial results will be shown in the communication.

## PA 44

### Using reflectance to estimate condition of giant kelp (*Macrocystis pyrifera*) and its relationship to environmental variability between California and Alaska

**Wendel Raymond**[*1], Tom Bell[2,3]

[1] *College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, United States of America*
[2] *Department of Natural Sciences, University of Alaska Southeast, United States of America*
[3] *Earth Research Institute, University of California Santa Barbra, United States of America*

Giant kelp (*Macrocystis pyrifera*) is a globally distributed canopy forming species that serves as the foundation to an ecologically and economically important ecosystem. The physiological condition of giant kelp is largely a function of nutrient and light availability. Nutrients, such as nitrate, are negatively related to temperature in the coastal eastern Pacific, creating gradients of nitrate availability and potentially kelp condition. Recent research in California found that the Chl:C ratio, a proxy for physiological condition, can be estimated by measuring the difference in reflectance between two spectral bands along the edge of the chlorophyll a absorption feature. This Chl:C varies as a function of ambient light and seawater nutrients and is closely associated with the nitrogen content of blades. Our aim was to use kelp blade reflectance data measured in the field to (1) validate the existing Chl:C reflectance algorithm by integrating data from Alaska and (2) relate our estimates of kelp condition across temperature/nutrient gradients at the regional and basin scale. We hypothesized that kelp blade condition would differ both within and between regions. To test this we measured the reflectance of mature kelp canopy blades off the coast of Santa Barbara, California and Prince of Wales Island, Alaska. Since each region spanned < 1 degree of latitude, we assumed similar canopy light conditions for sites within a region. However, small scale temperature variability may expose kelps to a gradient of nutrient conditions. We found that the spectral algorithm accurately estimated kelp blade condition in both regions and kelp condition varied as a function of their surrounding environmental conditions. This study has not only improved our ability to measure and understand kelp condition in the field but provides a glimpse into seawater nitrate conditions that would otherwise be impractical to measure in remote regions like Prince of Wales Island.

## PA 45

### The growth and survival of *Sargassum macrocarpum* C. Agardh juveniles in vegetated and barren ecosystems

**Yuhei Matsuda**[*1], Kenjiro Hinode[2], Yukio Inoue[2], Koichi Osaki[2], Hoshimi Kamisaki[2], Dominic Belleza[2], Azusa Kawate[1], Nao Hatata[1], Gregory Nishihara[3]

[1] *Fisheries and environmental science, Nagasaki university, Japan*
[2] *Graduate School of Fisheries and Environmental Sciences, Nagasaki university, Japan*
[3] *Organization for Marine Science and Technology, Nagasaki university, Japan*

Vegetated shallow water ecosystems are known for high primary production and biodiversity. However, barren ecosystems characterized by the complete loss of foliose seaweeds have been increasing in frequency throughout temperate coastal waters around the world. Many reports have observed that barren ecosystems tend to form when grazing pressure by herbivores exceed seaweed production. Grazing pressure can lead to low growth rates and survival. However, variables such as nutrients, water temperature, and light also affect the growth rates and survival of macroalgae juveniles. We carried out a one season experiment in two locations, one where a previously vegetated ecosystem transformed into a barren state, and another which remains vegetated. Both sites are located in Nakadori Island, Nagasaki, Japan. From February 2018 to December 2018, a total of 887 juveniles attached to ropes were placed in the barren ecosystem, while 697 juveniles were placed in a vegetated ecosystem. The number of surviving juveniles and their total width was measured every two months. Ambient nutrient concentration, underwater irradiance, and temperature was measured monthly. Environmental parameters were analyzed using principal component analysis (PCA), and the effects of the first component was used to analyze growth and survival rate. Survival rates were 5.88% and 0.45% at the vegetated site and the barren site, respectively. Mean width of the juveniles were 3.70 cm and 2.78 cm at the vegetated site and the barren site, respectively. PCA revealed a negatively correlated light-nutrient gradient. Survival rates were highest under low nutrient and high light conditions, although these conditions promoted growth rates. Furthermore, environmental conditions between the sites were observed to be similar during summer, and dissimilar during the start and end of the experiment. We suggest that *S. macrocarpum* juveniles may require different environmental conditions during different stages of its growth history.

## PA 46

### Application of RF and VF index to the analysis of growth and maturation pattern of *Sargassum macrocarpum* C. Agardh in Jeju Island, Korea

**Shin Ja Ko**[*1], Eun Kyoung Hwang[2], Seung Wan Hong[3], Young Don Lee[4]

[1] *Department of Marine Life Sciences, Jeju National University, Republic of Korea*
[2] *Seaweed Research Center, National Institute of Fisheries Science, Republic of Korea*
[3] *Ocean and Fisheries Research Institute, Republic of Korea*
[4] *Marine Science Institute, Jeju National University, Republic of Korea*

*Sargassum macrocarpum* is an ecologically and commercially valuable species in Jeju Island because the alga is a canopy forming perennial kelp and contains a variety of functional substances. However, the growth and maturation period of this useful alga is not reported yet, so it is difficult to apply to mass cultivation. This study was conducted from May 2018 to December 2018 to reveal the growth and reproductive pattern of *S. macrocarpum* population in Jeju coast. In order to quantify the reproductive characteristics of *S. macrocarpum*, reproductive and vegetative fronds were separated and their density, length, biomass, RFI (Reproductive Fronds Index; reproductive fronds weight/total weight x 100) and VFI (Vegetative Fronds Index; vegetative fronds weight/ total weight x 100) were investigated. The mean seawater temperature (MST) during the experimental period was 20.70°C. At this experimental period, MST was the highest in August (25.02°C) and the lowest in December (16.79°C). The mean annual density of *S. macrocarpum* was 3.88 individuals $m^{-2}$, the maximum length of thallus was 134.94 cm in June and the minimum length was 53.10 cm in October. The maximum biomass was 6.30 kg wet-wt.$m^{-2}$ in May and the minimum was 1.58 kg wet wt.$m^{-2}$ in September. Maturation peak of *S. macrocarpum* showed in July when RFI was 69.85. In this period MST was 22.9°C and photoperiod was 14L:10D. After that, biomass of reproductive fronds was decreased rapidly in August (25.02°C) when RFI value was 29.55. VFI was increased from October (20.74°C, 11L:13D) to December (16.79°C, 10L:14D). RFI and VFI of *S. macrocarpum* have been changed by effect of photoperiod and MST. Therefore, these RFI and VFI could be useful indicators to understand the growth and maturation pattern of Vaughaniella stage.

## PA 47

### Effects of degree of bleaching and herbivore exclusion on coral-algal community dynamics

**Jatdilok Titioatchasai**[*1], Jaruwan Mayakun[1], Anchana Prathep[1]

[1] *Biology, Prince of Songkla University, Thailand*

The coral bleaching and overfishing have been occurred and reported worldwide. These are main causes that can affect coral reefs and benthic communities, shifting from coral dominated reefs to algal dominated communities. However, their impacts might vary spatially and temporally and the combine effects of bleaching and herbivore are not well understood. The objective of this study was to investigate the effect of degree of coral bleaching and herbivore exclusion on coral-algal community dynamics. Three different degrees of bleaching were selected; healthy coral patches (100 percentage cover of coral), natural patches (10 percentage cover of live coral), and cleared dead coral patches. To test effect of herbivory, cages (fully caged, partial caged and uncaged patches) were used to exclude herbivore. The results showed that red turf algae were dominant group in all treatments while *Padina* sp., *Lobophora variegata* (J.V.Lamouroux) Womersley ex E.C.Oliveira, and *Cladophora* sp. had very low coverage. It might be because this turf can reproduce throughout a year with a fast growing ability in contrast with other species that have slow growth rates. After bleaching, turf algae occupied space rapidly while coral did not recruit and the recovery was low. Herbivory had effect on coral-algal abundances and coral recovery. Herbivore significantly influence Padina cover and morphology, having the highest percentage cover with fan-shaped blade when herbivory was excluded while *Vaughaniella* stage appeared in the presence of herbivores. For coral cover, the cover decreased in the absence of herbivores. Our results indicated that the bleaching and herbivore exclusion influence the benthic communities and the recovery of coral. The benthic community can change rapidly if bleaching and overfishing are occurred.

## PA 48

### The composition and structure of marine benthic community in Terra Nova Bay, Antarctica: responses of benthic assemblage to anthropogenic impact

**Kyeonglim Moon**[*1], Yun Hee Kang[2], Sun Kyeong Choi[1], Sang Rul Park[1]

[1] *Department of Marine Life Sciences, Jeju National University, Republic of Korea*
[2] *Department of Earth and Marine Sciences, Jeju National University, Republic of Korea*

The community structure and assemblages of marine benthic organisms were investigated in coastal areas near the Jang Bogo Antarctic Research Station in Terra Nova Bay during the 2012–2018 summer seasons. We also examined the recovery pattern of marine benthic organisms following the disturbance due to the Jang Bogo Station's construction. A total of 29 macro-benthic species were identified in the study area during the experimental period. Species number and diversity indices (richness index, evenness index and diversity index) showed relatively low levels. *Sphaerotylus antarcticus, Clavularia frankliniana, Hydractinia* sp., *Iridaea cordata,* Diatoms, *Alcyonium antarcticum* and *Dexiospira* sp. were main dominant species in this area. Diatoms were the most abundant species at the study area. This indicates that they still would play a key role in maintaining marine benthic community and controlling biogeochemical cycling. Under the construction of the Jang Bogo Station, the increase of sediment coverage and decline of diatoms were observed due to the release of sediment into a coastal area. In 2014, the coverage of diatoms was dramatically increased and thereby, species number, richness index and diversity index steadily enhanced from 2015 to 2018. However, non-metric multidimensional scaling ordination analysis of species similarities among sampling times showed that community structure did not completely recover in 2018. Thus, long-term monitoring research is required to elucidate post-disturbance settlement mechanisms of marine benthic organisms at the study area in Terra Nova Bay.

## PA 49

### Difference in cold tolerance of a native and an invasive *Undaria pinnatifida* population

**Jessica Schiller**[*1], Shaojun Pang[2], Kai Bischof[1]

[1] *Bremen Marine Ecology (BreMarE), Marine Botany, University of Bremen, Germany*
[2] *Key Laboratory of Experimental Marine Biology, Institute of Oceanology, Chinese Academy of Sciences, China*

The kelp *Undaria pinnatifida* is of high economic importance in its native range but critically observed as an invasive species worldwide. Its northern distributional limit in continental Europe is currently at Sylt, Germany at 54°47′ latitude. In contrast to ephemeric, seasonal growth in aquaculture,

the population in Northern Germany persists almost year round, likely due to the differences in temperature regime. To characterize this population and assess its potential for further northward migration, sporophytes were bred by self-crossing gametophyte cultures of the German population and a Chinese cultivar from Qingdao, respectively. The juvenile plants were exposed to a range of experimental temperature (4, 8, 12, 16°C) for the duration of 12 days. At the beginning and end biomass, size and appearance were recorded, and material was preserved for biochemical analysis. Both German and Chinese sporophytes performed best at 8 to 12°C. Both isolates grew much less at 4°C and disintegrated at 16°C before the end of the experiment. While the Chinese culture had a slightly higher increase in biomass and length at 8-16°C, the German s porophytes grew more than twice as fast than the Chinese at 4°C. The results indicate that the German population is already better adapted to colder temperatures than the Chinese cultivar it was compared to. This could support its future spread to colder regions in northern Europe. Furthermore, the German strain might be of economic interest for breeding of cold tolerant cultivars.

## PA 50

### The cross-kingdom interaction: morphogenetic factors as drivers of morphogenesis in the marine green macroalgae *Ulva* spp.

**Fatemeh Ghaderiardakani**[*1], Juliet Coates[1], Thomas Wichard[2]

[1] *Biosciences, University of Birmingham, United Kingdom*
[2] *Inorganic and Analytical Chemistry, Friedrich Schiller University, Germany*

*Ulva* spp. is a genus of multicellular green macroalga, growing predominantly in intertidal zones worldwide. *Ulva* is a key parameter in coastal ecosystem management, due to its ability to form nuisance blooms ("green tides") in shallow marine ecosystems and attachment to surfaces of marine machinery (as a biofouler). Growth and morphological development of *Ulva* is dependent on the interaction with particular associated bacteria and compounds they produce. In the absence of bacteria, gametes develop into undifferentiated colonies with abnormal cell walls. A breakthrough in understanding how bacteria control *Ulva* development was the establishment of a standardised tripartite community consisting of *Ulva mutabilis* (Føyn) and just two isolated bacterial strains, *Roseovarius* sp. and *Maribacter* sp. Employing this standardised tripartite model system, our research aims to (i) determine for the first time the specificity of bacteria-induced morphogenesis of *Ulva* by cross-testing of two very well investigated *Ulva* species, *U. mutabilis* and the *U. intestinalis,* (ii) elucidate the algal growth- and morphogenesis-promoting factors in an integrated multitrophic aquaculture system (IMTA) of fish and macroalgae (located at the coastal lagoon Ria de Aveiro, Portugal). Specifically, the survey revealed that pairs of bacterial strains isolated from species other than *U. mutabilis* and *U. intestinalis* can completely recover morphogenesis of *U. mutabilis* or *U. intestinalis* gametes under axenic conditions. It means that different compositions of bacterial guilds with similar functional characteristics can enable complete algal development and thus supports the "competitive lottery" theory for how symbiotic bacteria colonise ecological niches such as algal surfaces.

## PA 51

### NADPH oxidase-mediated oxidative burst plays a key role in resistance to pathogen attacks in red alga *Pyropia tenera*

**Dajeong Lee**[*1], Tatyana A. Klochkova[1], Gwang Hoon Kim[1]

[1] *Department of biological sciences, Kongju National University, Republic of Korea*

The marine red alga *Pyropia* is an important marine crop with a market currently worth over nearly $ 0.95 billion. As with land crops, cultivated *Pyropia* are affected by various pathogen, which may downgrade the value of the final product. The three most serious diseases are *Olpidiopsis*-blight and red-rot disease caused by oomycete pathogens and green-spot disease caused by PyroV1 virus. Respiratory burst oxidase homologues (Rbohs) belong to NADPH oxidase super-families and generate the initial and reactive oxygen species (ROS) in response to pathogen attacks in plants. However, the functional characteristics of Rboh in *Pyropia* are currently undisclosed. In this study, we identified *Pyropia tenera* 6 Rbohs (PtRbohs) and studied their contribution to defense to pathogen attacks. Transcript analysis revealed that expression of 6 PtRboh genes were specifically induced following inoculation of three pathogens. Histochemical staining showed that large amount of ROS accumulated in *P. tenera* blade infected with each pathogen. Inhibition of Ptrboh proteins using diphenyleneiodonium resulted in increased infection rate to oomycete pathogens and reduced ROS levels during initial infection. These results suggest that *P. tenera* may have signal transduction pathway regulated by Rboh in response to pathogens and uses oxidative burst to inhibit the spread of oomycete disease.

## PA 52

### Effect of salinity and desiccated on antioxidant defense responses in a *Pyropia yezoensis*

**Bao Le**[*1], Seung Hwan Yang[1], Sangmi Sun[1]

[1] *Department of Biotechnology, Chonnam National University, Republic of Korea*

*Pyropia yezoensis* belongs to red seaweeds and is the important economical species. The aim of this study was to evaluate the effects of salinity and desiccation on biochemical and molecular mechanisms underlying the adaptive mechanism of *P. yezoensis*. The desiccation-rehydration experiment was conducted to expose the thallus to air during short (4 h) and long (8 h). To determine the salinity stress effects, the thallus was cultured in 14, 28, 42, 70 ‰ salinity. The results showed that the changes in antioxidant enzyme activities including ascorbate peroxidase (APX), catalase (CAT), glutathione peroxidase (GPx), and superoxide dismutase (SOD) were different according to increasing salinity and during desiccation. A real-time polymerase chain reaction (RT-PCR) showed that the enzymes were upregulated under 70 ‰ salinity. Moreover, the cyclic electron flow around photosystem I (PSI) increased significantly during desiccation. To conclude, the inducible mechanisms responsible for ascorbate oxidation and the reduction of oxidized glutathione contribute to salt tolerance in *P. yezoensis*.

## PA 53

### DinoRsour: a comprehensive dinoflagellate RNA sequence database and bioinformatics resources

**Hyun-Hee Hong**[*1], Sung-Gwon Lee[1,2], Hyun-Gwan Lee[2,3], Seongmin Cheon[1,2], Jooseong Oh[1,2], Hyemi Kim[2,3], Kwang Young Kim[2,3], Chungoo Park[1,2]

[1] *School of Biological Sciences and Technology, Chonnam National University, Republic of Korea*
[2] *Marine Ecological Disturbing and Harmful Organisms Research Center, Chonnam National University, Republic of Korea*
[3] *Department of Oceanography, Chonnam National University, Chonnam National*

*University, Republic of Korea*

The dinoflagellates are heterogeneous group with ecological and physiological differences wondering their genetic basement and working mechanism. The symbiosis with coral, secretion of various toxin materials, harmful algal blooming and complex life cycle have been researched for their importance to marine-ecosystem. Nowadays, we have fancy and easy tools, next generation sequencing (NGS) that sequence and analyze the whole genome sequences to know functional features and evolutionary histories. These will also helpful to research and unveil dinoflagellates conundrum. However, only four genomes of dinoflagellates had been sequenced due to the large genome-size ranging about 1Gb to 270 Gb (Hong et al. 2016). The transcriptome-wide mining is alternative to reveal their evolutionary history, unveiling mechanisms for response to environment and life stages, and identification of useful genes related to biochemical component and toxicity (Lowe et al. 2011; Zhang et al. 2014; Deng et al. 2017; Janouskovec et al. 2017; Lauritano et al. 2017). So far, there are available 283 RNA-seq data of 40 dinoflagellates species registered in NCBI SRA by Aug. 2018. However, they are not well suited for understanding dinoflagellates evolution and physiology. In this study, we integrated the dispersed RNA-seq data through unified analysis method including de novo assembly, quantification of expression and annotation of the genes for meaningful comparisons. In addition, five newly sequenced dinoflagellates transcriptomes (*Alexandrium affine, Alexandrium pacificum, Gambierdiscus yasmoto, Symbiodinium voratum and Pfiesteria piscicida*) were added. Up to date, A total of 45 million transcripts with 2.5 million annotated coding sequences have been generated and an expression level of each transcript was estimated by TPM (transcripts per million). We profiled extraordinary features of dinoflagellates which cannot observed in other eukaryotes or taking unique actions: (i) absence or presence of histone proteins; (ii) a trans-splicing exon that is a concatenated exon from two different primary mRNAs; (iii) DNA methyltransferases that are involved in self-methylation of retro-transcribed DNA by retrotransposon. Furthermore, to infer phylogenetic their relationships, transcriptome based-phylogeny of dinoflagellates was constructed using 192 single copy genes with three outgroup species (*Perkinsus marinus, Plasmodium falciparum, Tetrahymena thermophila*). The newly constructed phylogenetic tree was consistent with previous studies (Janouskovec et al. 2017; Price and Bhattacharya 2017). The Dinoflagellate RNA resource (DinoRsour) will resolve many genetic and epigenetic features specific to dinoflagellates and provide useful set of resources to research dinoflagellates. All of these data are available in the DinoRsour web site (www.compsysbio.re.kr).

## PA 54

### Quantitative proteomic profiling of the brown seaweed *Sargassum filipendula*: insights into UV radiation stress

**Luz Karime Polo**[*1], André Luis Wendt dos Santos Wendt dos Santos[1], Eny Floh[1], Fungyi Chow[1]

[1] *Botany, University of São Paulo, Brazil*

Discovering the functions of genes whose expression responds to the stress caused by the effects of UV radiation is essential for understanding the molecular bases that determine the main characteristics of the dynamic responses of stress-responsive genes. However, it is important to correlate and confirm the information through systematic integrated data sets on transcription studies of all messenger RNA (transcriptomic) with those that address the protein translation (proteomic). Therefore, our objective was to evaluate the proteome changes of sub-tropical seaweed *Sargassum filipendula* exposed to PAR (Photosynthetically Active Radiation-control), PAR+UVA and PAR+ UVB treatments by the analysis of differential abundance of proteins. Protein extraction was performed using the phenol method from approximately 10 g of fresh frozen sample, with n = 3 per treatment. Following protein digestion with trypsin, the peptide mixture was analyzed by LC-MS/MS on a LTQ-Orbitrap Velos ETD coupled with Easy nanoLC II. Analysis of the results was performed in MaxQuant using the Andromeda search engine. MS spectra were searched against Ectocarpales database, and identified proteins classified according to its metabolic function. 767 proteins were identified and 34 proteins were differentially abundant. Proteins were classified according to its metabolism function: energy metabolism (18%); photosynthesis (18%); carbohydrate metabolism (15%); transport and catabolism (6%); ROS scavenging defense and stress related (3%); and genetic information processing (3%). Our results have giving so far insights into UV stress responses in *S. filipendula*, which suggests that this stressor in higher doses may have a severe effect on proteins by the inhibition of its proper functions. Additionally, this analysis could provide target proteins that could improve the ability of *S. filipendula* to adapt to UV exposure. Therefore, proteome studies may lead to identify the proteins involved in stress responses and contribute significantly in our understanding of the molecular mechanisms underlying stress tolerance.

## PA 55

### Identifying the key features that distinguish proteins for DNA and RNA binding

**Jooseong Oh**[*1], Seongmin Cheon[1], Chungoo Park[1]

[1] *School of Biological Sciences and Biotechnology, Chonnam National University, Republic of Korea*

Proteins binding either DNA or RNA play key roles within gene regulations such as transcription, alternative splicing and RNA editing [1,2,3]. In order to discover and annotate these proteins, various methods including experimental and computational approaches are attempted. However, the experimental approach is inefficient in large-scale identification of DNA or RNA binding proteins because of massive time and cost consuming. For time and cost decreased, computational methods are used to finding candidates of proteins binding either DNA or RNA utilizing information of domain or specificities of a protein. Nevertheless, domain-based and protein specificities-based methods are limited for identifying novel proteins due to their prediction is dependent to information of well-known domains or predicting accurately result because of using partly specificities [1]. To overcome these limitation, we identified new features for proteins binding either DNA or RNA and used large-scale feature for protein specificities. Total 20 features: (protein length, proportion of amino acid, proportion of amino acid group, ECnum, signal peptide sequence, PEST sequence, gene ontology terms, PTM, secondary structure, transmembrane helices, subcellular localization, essential or non-essential genes, protein abundant, protein surface accessibility, protein conservative, protein stability, repeat sequence pattern, k-mer pattern, protein-protein interaction, cofactor-protein interaction) were listed up by comprehensive literature-survey [4,5,6]. The features were validated to assign whether they can represent each binding protein or not, and then classified to each category. Result of partly analysis, protein length is not significantly differed between DNA(or RNA) binding proteins and DNA(or RNA) not binding proteins. On the other hands, proportion of amino acid and amino acid group are definitely differed DNA(or RNA) binding proteins and the others. In the future, we are designed for analysis remained feature and then construct machine learning model which can predict proteins binding to DNA and RNA using these features.

## PA 56

### *De novo* assembly of transcriptome from the green macroalgae *Ulva pertusa* and identification of heavy metal stress response related gene

**Young-Eun Choi**[*1], Do Yeon Seo[2], Yuna Ha[2,3], Ah-Hyun Park[2,3], Jae Woo Jeong[2,3], Won-Hwi Lee[1,2], Young Jin Kim[1,2], Mira Park[2], Oh Wook Kwon[2], Youn-Jung Kim[1,2,3]

[1] *Department of Marine Science, Incheon National University, Republic of Korea*
[2] *Research Institute of Basic Sciences, Incheon National University, Republic of Korea*
[3] *Department of Cosmetic Science and Management, Graduate School Incheon National University, Republic of Korea*

The problem of water pollution from industrial and domestic water has long been a concern for environmental issues in the marine ecosystem. *Ulva pertusa* is a dominant species of marine ecosystem in Korea and plays an important ecological role in coastal ecosystems. Currently, studies on the effects of heavy metal in *U. pertusa* have been conducted mainly at the physiological and ecological level, and genetic studies are lacking. Therefore, in this study, transcriptome analysis of *U. pertusa* exposed to heavy metals was performed by NGS. Transcriptome profiles were analyzed in *U. pertusa* compared to the control group (Con) and the treated group with the concentrations of heavy metals corresponding to marine protection standards (Eco-type). In addition, the transcriptome of *U. pertusa* exposed to highly enriched copper (Eco-Cu) and cadmium (Eco-Cd) was compared and compared with that of Eco-type. Each sample was compared and found 53 (Con vs. Eco-type), 27 (Eco-type vs. Eco-Cd), and 725 (Eco-type vs. Eco-Cu) differentially expressed genes (DEGs). Most of the DEGs were related to metabolic pathway such as fatty acid and pyrimidine metabolism, and some of them were related to peroxisome and DNA-repair. These results extend our understanding for possible effect of heavy metal stress to green algae such as *U. pertusa*.

## PA 57

### Transcriptional profiling of *Polyopes affinis* extract in Human keratinocyte cell line identifies specific patterns of gene expression

**Yuna Ha**[*1], Ah-Hyun Park[1,2], Jae Woo Jeong[1,2], Won-Hwi Lee[1,2], Do Yeon Seo[2], Young-Eun Choi[1,2], Young Jin Kim[1,2], Mira Park[2], Oh Wook Kwon[2], Youn-Jung Kim[1,3,2]

[1] *Department of Cosmetic Science & Management, Incheon National University, Republic of Korea*
[2] *Researsh Institute of Basic Sciences, Incheon National University, Republic of Korea*
[3] *Department of Marine Sciences, Incheon National University, Republic of Korea*

The skin inflammation potential of ingredients is mainly assessed using animal methods, such as the murine local lymph node assay. Recently, an in vitro assay based on a mRNA expression signature in the HaCaT keratinocyte cell line was proposed as an alternative to these animal methods. Here, cells were incubated with 10 ng/mL interferon-gamma (IFN-γ) and 10 ng/mL tumor necrosis factor-alpha (TNF-α) in the presence or absence 10 μg/ml, 30 μg/ml, and 60 μg/ml of *Polyopes affinis* extracts, respectively. Especially, we have been used 80 % EtOH *Polyopes affinis* extract was divided into butanol fraction. The GO analysis of these *Polyopes affinis*-characterized genes showed the diverse cellular and biological processes such as cell adhesion, immune response, inflammatory response, chemokine-mediated pathway. Those significantly regulated genes were transcriptional profiling of *Polyopes affinis* extract in Human keratinocyte cell line identifies specific patterns of gene expression. We observed in vitro, suggesting that the molecular processes that drive expression of inflammation related genes were identified as potential biomarker of these gene patterns for *Polyopes affinis* extracts treated associating an insight into molecular mechanism for TNF-α and IFN-γ-induced human keratinocyte cell line.

## PA 58

### Marine algae checklist of South China Sea focussing on Malaysia region

**Ming Herng Gan**[*1], Nurul Ain Abdullah[1], Christine Abellana Orosco[1]

[1] *School of Marine and Environmental Sciences, Universiti Malaysia Terengganu, Malaysia*

The reported diversity of marine algae especially seaweed which is specifically focussing in the Malaysia region are always in good progressing through time. The increasing in the number of taxa of marine algae or new records of species in the region of South China Sea is reported by local phycologists. This paper is documented the number of macroalgal taxa in particular six states which are Kelantan, Terengganu, Pahang and Johor in the Peninsular, Sarawak and Sabah in the east Malaysia. The checklist of species was comprised from the databases of Marine Algal Reference Collection (MARC), UMT Herbaria. The specimens' identification and checklist compilation of all recorded species was done up to 2016. However, some species were only referred to other publications without further verification on the algal taxonomy identification. A total of 533 taxa was recorded which comprised of 43 taxa of Cynobacteria, 136 taxa of Chlorophyta, 88 taxa of Ochrophyta and 267 taxa of Rhodophyta. In Peninsular Malaysia, Terengganu showed the highest number of taxa which was 327 species of marine algae while the lowest diversity was found in Kelantan which only yielded 22 taxa. Meanwhile, for the east Malaysia, Sarawak gained higher diversity of marine algae with a total of 129 taxa if compared to Sabah which on identified 95 taxa. Based on the checklist of marine algae, the seaweed resources and its locality are well documented. At present, 80 species out of 532 taxa were new records in Malaysian SCS region. Off that, 16 taxa of Cyanobacteria, 21 taxa of Chlorophyta, 10 taxa of Ochrophyta and 33 taxa of Rhodophyta were newly listed in the checklist. The importance of marine algae checklist is fundamental for the future phycological approaches in the economic and ecological applications.

## PA 59

### A new crustose brown algal species, *Diplura koreana* sp. nov. (Ishigeales, Phaeophyceae) from Korea

**Antony Oteng'o**[*1], Boo Yeon Won[1], Tae Oh Cho[1]

[1] *Life Sciences, Chosun University, Republic of Korea*

*Diplura* is a crustose brown algal genus that is widely distributed in warm and cold marine waters. Since it was erected by Hollenberg (1969), this genus has been composed of two species, *Diplura simplex* J. Tanaka & Chihara from Japan and *D. simulans* Hollenberg from California. *Diplura* samples were collected along the coastal line of Korea from 2017 to 2018, and morphological and molecular studies about them were performed. Our *Diplura* samples are distinguished from *D. simplex* by having branched vegetative filaments, some plurangial reproductive organs stand in single rows on erect filaments and unilocular sporangia sessile or on one stalk cell whereas from *D. simulans* by less broad and thinner thalli, tightly adjoined vegetative filaments and some plurangial reproductive organs stand in branched single rows on erect filaments. Phylogenetic analyses

based on *rbcL* gene also revealed that our samples nested within *Diplura* and in a distinct clade from congeners. In this study, we propose this to be a new species *Diplura koreana* sp. nov. based on morphological and molecular data.

## PA 60

### DNA-assisted identification of species diversity of the calcareous macroalgae *Halimeda* (Bryopsidales, Chlorophyta) in Taiwan including Spratly Island and Dongsha atoll from South China Sea

**Sinjai Phetcharat**[*1], Jaruwan Mayakun[1], Shao Lun Liu[2], Pin Chen Chen[2]
[1] *Biology, Prince of Songkla University, Thailand*
[2] *Life Science, Tunghai University, Taiwan*

The calcified green algal genus *Halimeda* is one of the most ecologically important but morphologically diverse seaweeds in sub- and tropical waters around world. Due to its high morphological plasticity, the species identification is challenging solely based on morphological characters without the assistance of molecular analyses. DNA-assisted identification of species diversity of *Halimeda* remain unexplored in Taiwan. To fill this taxonomic knowledge gap in this area, this study was set out to systematically examine the species diversity of *Halimeda* in Taiwan including Spratly Island and Dongsha atoll from South China Sea using DNA sequence data (plastid *tufA* gene) and morphological data. Our DNA-assisted analyses revealed that ten *Halimeda* species; (*Halimeda borneensis, H. cuneata, H. cylindracea, H. discoidea, H. distorta, H. macroloba, H.minima, H. opuntia, H. renschii, and H. velasquezii*) were found from Taiwan, Spratly Island, and Dongsha Atoll. With the DNA-guided identifications, majorities of them were readily distinguished by their morphological and anatomical characters despite of *H. minima* and *H. renschii*. We herein provide a taxonomic key to facilitate the species identification of *Halimeda* in Taiwan. Environmental factors that might drive their occurrence and latitudinal distribution were discussed in this study.

## PA 61

### DNA assisted diversity assessment of the green algal genus *Caulerpa* J.V. Lamouroux (Chlorophyta) in Thailand

**Kattika Pattarach**[*1], Jaruwan Mayakun[1], Stefano G.A. Draisma[2]
[1] *Biology, Prince of Songkla University, Thailand*
[2] *CBIPT, Biology, Prince of Songkla University, Thailand*

The multinucleate siphonaceous green algal genus *Caulerpa* is widely distributed in the intertidal and subtidal zones of tropical and subtropical seas. Some species show a complex external morphology and high morphological plasticity hampers the taxonomy of this genus. The present study explored the *Caulerpa* diversity in Thailand for the first time using DNA sequence data (chloroplast-encoded *tufA* gene and nuclear ITS rDNA sequences) in combination with morphological data. The results confirm the presence of eight *Caulerpa* species in Thai waters, i.e., *C. chemnitzia, C. lentillifera, C. macrodisca, C. racemosa, C. serrulata, C. sertularioides, C. taxifolia* and *C. verticillata. Caulerpa* diversity on the Andaman coast (8 spp.) was higher than in the Gulf of Thailand (7 spp.). Specimens from mangrove channels on the Andaman coast that were previously identified as *C. corynephora* (with turbinate ramuli) and *C. ashmeadii* (with terete ramuli) were found to be conspecific with *C. macrodisca* (with large peltate ramuli, only found in the Gulf of Thailand). *C. racemosa* is represented by two distinct morphologies in Thailand; a typical *C. racemosa* morphology (with vesiculate ramuli) and a *C. chemnitzia*-like morphology (with peltate ramuli). The peltate form of *C. racemosa* occurred in sympatry with *C. chemnitzia* and could not be distinguished from it by morphology. It is concluded that *Caulerpa* species identification cannot rely on morphology alone. Five *Caulerpa* species that were previously recorded for Thailand (i.e., *C. ambigua, C. cupressoides, C. fastigiata, C. manorensis*, and *C. mexicana*) were not found during our survey (2016-2018) and their identity could not be confirmed with DNA sequence data obtained from herbarium specimens.

## PA 62

### Algal composition and structural complexity of different Mediterranean rhodolith beds found off the Campania Coast (Italy)

**Francesco Rendina**[*1], Giovanni Fulvio Russo[1], Roberto Sandulli[1], Valentina Roviello[2], Sara Kaleb[3], Annalisa Falace[1]
[1] *Science and Technology, University of Naples, Italy*
[2] *Advanced Metrologic Service Center (CeSMA), University of Naples "Federico II", Italy*
[3] *Life Sciences, University of Trieste, Italy*

Mediterranean rodolith beds (RBs) are coastal to offshore habitats mainly occurring at about 40-60 m of depth. They are characterized by a high diversity of algal species and can be structured by a combination of different rhodolith morphotypes, classified as boxworks, pralines, unattached branches (also known as maerl), and coated grains. The importance and vulnerability of these habitats has been recently recognized in various European and international frameworks (i.e. Marine Strategy Framework Directive), through the adoption of a range of protection instruments. Despite their important role in marine ecosystems, there is only few information about the distribution and description of Mediterranean RBs. In the present study, we report preliminary results in terms of vitality, structural complexity, rhodoliths and associated macroalgae taxa composition of different RBs found off the Campania Coast in the Tyrrhenian Sea (Italy).

## PA 63

### The consideration of ambiguity in species Identification with DNA barcodes on a public database

**Soyeong Jin**[*1], Chungoo Park[1]
[1] *School of Biology Science and Technology, Chonnam University, Republic of Korea*

The National Center for Biotechnology Information (NCBI, http://www.ncbi.nlm.nih.gov) provides analysis and resources for various biological data through the NCBI web site (NCBI Resource Coordinators., 2013). The non-redundant nucleotide (nt) database which is one of resources maintained by NCBI is used universally when researchers need to identify certain species by DNA barcode sequence. However, there are multitude inconsistencies such as different sequence lengths, bases and regions, although they represent same genetic element. Because their registers are derived from various and different laboratory works with a range of technologies and assumptions without any assessment process (Chen et al., 2016). To assign this problem, we designed to explore how many DNA barcode sequences within the database show high identity each other even though those are different species. Firstly, in the database,

each barcode sequence was sorted in descending order by the number of those. And total four barcode sequences (Cytochrome c oxidase subunit I, Internal transcribed spacer, Ribulose-bisphosphate carboxylase, Elongation factor Tu 1) which are representatives in each subcellular organelle (i.e. nucleus, mitochondria and chloroplast) were selected. Second, each reciprocal BLAST search would be proceeded within each barcode sequence group. Then the number of case of identical barcode sequences but different species would be counted in each BLAST result. We expect that there may be instances of indicating as same species for different species by same barcode region. If those cases would be existed, we can argue that we need to have cautions with species identification using public database.

## PA 64

### Variations in the thallus morphological and pigmentation in four *Ulva* spp.

**Geonhee Kim**[*1], Jihae Park[2], Soyeon Choi[1], Hojun Lee[1], Taejun Han[1,3]

[1] *Marine science, Incheon National University, Republic of Korea*
[2] *Department of Enviromental Technology, Food Technology and Molecular Biotechnology, Ghent University Global Campus, Republic of Korea*
[3] *Ghent University Global Campus, Republic of Korea*

The chlorophyte *Ulva* is perceived as a simple and uniform algal morphology, and is rarely functional within a thallus. In our study, we compared the cell size, number of cell per a given area and thickness in different thallus regions of four species of the *Ulva* (*Ulva pertusa, U. fasciata, U. taeniata, U. compressa*). *U. pertusa* showed a significant difference in cell size, cell number and thickness depending different thallus area. Only cell thickness differed in *U. fasciata* with basal part being greater. Both *U. taeniata* and *U. compressa* exhibited greater cell size in basal parts than in middle and marginal parts while cell number is greater in marginal part than in middle and basal parts. There were no differences in thickness of *U. taeniata* and *U. compressa* regardless different thallus parts. Thallus dependent difference in pigmentation was noted only in *U. pertusa* and *U. taeniata*.

## PA 65

### Learning from communities: can historical indigenous uses of seaweeds inform a sustainable Australian seaweed industry

**Zoe Brittain**[*1], Alecia Bellgrove[4], David S. Jones[2], Ruth Thurstan[3], Elizabeth Cameron[4]

[1] *Life and Environmental Sciences, Deakin University, Australia*
[2] *Architecture and Built Environment, Deakin University, Australia*
[3] *Centre for Ecology and Conservation,University of Exeter, UK*
[4] *Institute for Koorie Education, Deakin University, Australia*
[5] *School of Life and Environmental Sciences, Deakin University Australia*

Seaweed production has grown exponentially over the past decade, driven in part by the growing appreciation of the health and nutritional benefits of eating seaweeds and by the potential of seaweed for climate-change mitigation. There is also a growing acknowledgement of the role seaweed has played in the lives of Indigenous communities around the world, who have rich, traditional knowledge around utilizing their local seaweed resources. This research uncovered a rich history of seaweed use by Australian Salt Water Peoples and explored related knowledge held within their Oral Histories and traditions. Traditional knowledge is especially pertinent in Australia, where a commercial seaweed industry is still developing, and where additional collaboration the communities of Salt Water Peoples has great potential to guide that development is a sustainable manner.

## PA 66

### DNA barcoding of South African Rhodophyta

**Jamie Du Plessis**[*1], Rouvay Roodt-Wilding[1], Maggie Reddy[2], John Bolton[2], Robert Anderson[2]

[1] *Genetics, Stellenbosch University, South Africa*
[2] *Biological Sciences, University of Cape Town, South Africa*

Red macro-algae (Rhodophyta) dominate the seaweed flora of South Africa and represent approximately two-thirds of the seaweed diversity. Traditional systems for species identification and taxonomic classification in marine macro-algae, especially Rhodophyta, is very difficult and inconsistent due to simple morphology and anatomy, and phenotypic plasticity. Accordingly, algal systematics has become more reliant on molecular tools such as DNA barcoding to investigate species identification, the discovery of cryptic species, species distribution limits and new records of macro-algae globally. This approach is utilized in the current study to increase foundational biodiversity knowledge in the form of DNA barcodes and species occurrence records for specifically red macro-algae occurring in the species-rich Port Alfred region on the south coast of South Africa. This region has the highest number of seaweed species and the highest number of endemic species, in the only major marine biome which is geographically confined to South Africa (the Agulhas region). In this study 132, red macro-algae specimens were collected representing 51 genera. DNA sequence data for several loci (LSU, COI-5P, rbcL) have been generated for each specimen. Sequencing success was the highest for LSU followed by COI-5P and rbcL, ranging from 64% and 44% respectively.

## PA 67

### Survey on the composition, function and application of seaweed in cosmetics in the European market

**Lu Zhou**[*1]

[1] *MA Fashion Entrepreneurship & Innovation, University of the Arts London, United Kingdom*

It has been long discovered that seaweed can be used for beauty products. Particularly, Europeans were the first who discovered that seaweed is a rich source of amino acids, vitamins and trace minerals. Seaweed along with sea water and sea salt is also used in cosmetics. Over centuries, as the demand for natural and environment-friendly cosmetics is increasing among customers, the world's major brands are focusing on developing new ingredients and researching on their implications to compete for their positions in the market. This paper aims to investigate the seaweed composition, functions and implications of existing cosmetic products of European brands as well as how the products work with the supply chains and the European standard for the market admission. The results can be used for further analysis of the trend of innovative development of seaweed cosmetics and the consumption prospects. According to the data results, the paper also provides a discussion of marketing strategy with the support of new media and the importance of launching a platform to coordinate seaweed cosmetic companies and supply chains, so that more attentions can be drawn on the concept of

marine ingredients in promoting health across the globe. At the same time, it hopes to engage more people in developing and discovering the value of seaweed products.

# Author Index

*Ecklonia cava*

# Participants List

## Australia

| | | | |
|---|---|---|---|
| Bellgrove | Alecia | Deakin University | alecia@deakin.edu.au |
| Borowitzka | Michael | Murdoch University | m.borowitzka@murdoch.edu.au |
| Brittain | Zoe | Deakin University | zoe-ellen-brittain@hotmail.com |
| Britton | Damon | University of Tasmania | damon.britton@utas.edu.au |
| Butler | Hugh | Marine Algae | hugh.butler@marinealgaeproducts.com |
| Chan | Cheong Xin | University of Queensland | c.chan1@uq.edu.au |
| Cole | Andrew | James Cook University | andrew.cole3@jcu.edu.au |
| Coleman | Melinda | NSW Department of Primary Industries | melinda.coleman@gmail.com |
| De Nys | Rocky | James Cook University | rocky.denys@jcu.edu.au |
| Egan | Suhelen | UNSW Sydney | s.egan@unsw.edu.au |
| Garrott | Paul | Marinova Pty Ltd | paul.garrott@marinova.com.au |
| Hewitt | Chad | Murdoch University | chad.hewitt@murdoch.edu.au |
| Jameson | Ian | CSIRO | ian.jameson@csiro.au |
| Kelly | Jo | Australian Seaweed Institute | jo.kelly@australianseaweedinstitute.com.au |
| Kelly | Nick | Australian Seaweed Institute | nickandjoey@hotmail.com |
| Kumar | Manoj | University of Technology Sydney (UTS) | manoj.kumar@uts.edu.au |
| Lane | Jo | Sea Health Products | kelp@seahealthproducts.com.au |
| Layton | Cayne | University of Tasmania | cayne.layton@utas.edu.au |
| Park | Ahyoung | Marinova | ahyoungpark79@gmail.com |
| Sanderson | John Craig | Tassal P/L | craig.sanderson@iinet.net.au |
| Stringer | Damien | Marinova Pty Ltd | damien.stringer@marinova.com.au |
| Verges | Adriana | UNSW Sydney | a.verges@unsw.edu.au |
| Wernberg | Thomas | University of Western Australia | thomas.wernberg@uwa.edu.au |
| Zhang | Wei | Flinders University | wei.zhang@flinders.edu.au |

## Belgium

| | | | |
|---|---|---|---|
| De Clerck | Olivier | Ghent University | olivier.declerck@ugent.be |
| Groenendaal | Bert | SIOEN Industries | bert.groenendaal@sioen.com |

## Brazil

| | | | |
|---|---|---|---|
| Bernardi Vasconcelos | Juliane | Universidade Federal de Pernambuco | bernardijuliane@gmail.com |
| Canuto De Souza | Jonatas | Instituto de Botânica | mjrcanuto@gmail.com |
| Chow | Fungyi | University of Sao Paulo | fchow@ib.usp.br |
| Fujii | Mutue | Instituto de Botânica | mutue.fujii@gmail.com |
| Hayashi | Leila | Federal University of Santa Catarina | leilahayashi@hotmail.com |
| Oliveira | Mariana C. | University of Sao Paulo | mcdolive@ib.usp.br |
| Polo | Luz Karime | University of São Paulo | luzkapolo@gmail.com |
| Setoguchi | Jun | Agargel Ind Com Ltda. | jun@agargel.com.br |
| Yokoya | Nair | Institute of Botany | nyokoya@hotmail.com |

## Canada

| | | | |
|---|---|---|---|
| Cronin | Holly | McGill University | holly.cronin@mail.mcgill.ca |
| Deveau | Jean-Paul | Acadian Seaplants Limited | pab@acadian.ca |
| Garbary | David | St. Francis Xavier University | dgarbary@gmail.com |
| Hafting | Jeff | Acadian Seaplants Limited | jhafting@acadian.ca |

| | | | |
|---|---|---|---|
| Lee | Jae-Hyeok | University of British Columbia | jae-hyeok.lee@botany.ubc.ca |
| Nagabhatla | Nidhi | United Nations University (UNU INWEH) | nidhi.nagabhatla@unu.edu |
| Subramanian | Sowmyalakshmi | McGill University | sowmyalakshmi.subramanian@mail.mcgill.ca |
| Tamigneaux | Éric | Merinov-Cégep de la Gaspésie et des Îles | etamigneaux@cegepgim.ca |
| Ugarte | Raul | Acadian Seaplants Limited | rugarte@acadian.ca |

## Chile

| | | | |
|---|---|---|---|
| Ayala | Pablo | SECO S.A. | payala@secosa.cl |
| Bañados | Claudio | Alimex S.A. | cbanados@alimex.cl |
| Buschmann | Alejandro | Universidad de Los Lagos | abuschma@ulagos.cl |
| Calderon | Martha S. | University of Magallanes | marthacalderonrios@gmail.com |
| Camus | Carolina | Universidad de Los Lagos | carolina.camus@ulagos.cl |
| Contreras-Porcia | Loretto | Universidad Andrés Bello | lorettocontreras@unab.cl |
| De La Piedra | Pablo | Alimex S.A. | pdelapiedra@alimex.cl |
| Fernandez | Pamela | Universidad de Los Lagos | fernandez.pam@hotmail.com |
| Gallego Nuñez | Alejandra | Universidad Andres Bello | gnunez.alejandra@gmail.com |
| Gonzalez | Alejandra | Universidad de Chile | apgonzalez@uchile.cl |
| Guillemin | Marie-Laure | Universidad Austral de Chile | marielaure.guillemin@gmail.com |
| Landeta | Catalina | Universidad de Chile | cmlandeta@uc.cl |
| Leyton | Allison | Universidad de La Frontera | leytonallison@gmail.com |
| Macaya | Erasmo | Universidad de Concepción | emacaya@oceanografia.udec.cl |
| Mansilla | Andres | Universidad de Magallanes | andres.mansilla@umag.cl |
| Mayorga | Carmelo | Carmelo Mayorga | algaschillan@gmail.com |
| Mayorga | Pablo | Dried Seaweeds Chile SpA | pmayorga@dswchile.cl |
| Mercado | Emilio | Alimex S.A. | emercado@alimex.cl |
| Meynard | Andrés | Universidad Andres Bello | meynardster@gmail.com |
| Morales | Antonio | Bioseaweeds S.P.A. | bio_seaweeds@hotmail.com |
| Oyarzo | Carolina | Universidad Andres Bello | karo.oyarzo@gmail.com |
| Padilla Latorre | Nicolás | Universidad Andres Bello | nlatorrepadilla@gmail.com |
| Piantini | Rene | PRODALMAR S.A. | rpiantini@prodalmar.cl |
| Vasquez | Julio | Universidad a Católica del Norte | jvasquez@ucn.cl |
| Westermeier | Renato | Universidad Austral de Chile Sede Puerto Montt | westermeier@gmail.com |
| Yang | Diane | Alimex S.A. | dyang@alimex.cl |
| Zamorano | Jaime | Gelymar SA | jzamorano@gelymar.com |

## China

| | | | |
|---|---|---|---|
| Bao | Shixiang | Chinese Academy of Tropical Agricultural Sciences | bsxitbb@163.com |
| Cao | Min | Ocean University of China | caominjiayou@163.com |
| Chen | Haimin | Ningbo University | chenhaimin@nbu.edu.cn |
| Chen | Huaxin | Institute of Oceanology, Chinese Academy of Sciences | chhx@qdio.ac.cn |
| Chen | Juanjuan | Ningbo University | chenjuanjuan@nbu.edu.cn |
| Chen | Shiyun | Shanghai Brilliant Gum | wang@sh-blg.com |
| Chen | Xi | HIGH HOPE FOODS (NANJING) CO., LTD. | info@highhopefoods.cn |
| Cho | Warren | Green Fresh (Fujian) Foodstuff Co.,ltd. | lei@greenfreshfood.com |
| Ding | Hong-Chang | Shanghai Ocean University | dhongchang@126.com |
| Ding | Lanping | Tianjin Normal University | skydlp@tjnu.edu.cn |

| | | | |
|---|---|---|---|
| Du | Guoying | Ocean University of China | duguo923@163.com |
| Duan | Delin | Institute of Oceanology, Chinese Academy of Sciences | dlduan@qdio.ac.cn |
| Fu | Xiaoting | Ocean University of China | xiaotingfu@ouc.edu.cn |
| Gong | Qingli | Ocean University of China | qingli@vip.sina.com |
| Guo | Jeffrey | Qingdao CoDo International Limited | jeffreyguo@chinacodo.com |
| He | Peimin | Shanghai Ocean University | pmhe@shou.edu.cn |
| Hu | Chaoyang | Ningbo University | huchaoyang@nbu.edu.cn |
| Hu | Qiang | Institute of Hydrobiology, Chinese Academy of Sciences | huqiang@ihb.ac.cn |
| Hu | Yiyi | Ocean University of China | pycyiyi@126.com |
| Hu | Zi-Min | Institute of Oceanology, Chinese Academy of Sciences | huzm@qdio.ac.cn |
| Huang | Lin-Bin | Shanghai Ocean University | lbhuang@shou.edu.cn |
| Ji | Dehua | Jimei University | dhji@jmu.edu.cn |
| Jiang | Peng | Institute of Oceanology, Chinese Academy of Sciences | jiangpeng@qdio.ac.cn |
| Kong | Fanna | Ocean University of China | fnkong@ouc.edu.cn |
| Li | Huiru | Fisheries College, Ocean University of China, Qingdao, China | lihuiru@stu.ouc.edu.cn |
| Li | Jing | Institute of Oceanology, Chinese Academy of Sciences | jingli@qdio.ac.cn |
| Li | Jingjing | Hohai University | lijingjing@hhu.edu.cn |
| Li | Jingyu | Ocean University of China | qdlijingyu@ouc.edu.cn |
| Li | Xiancui | Institute of Oceanology, Chinese Academy of Sciences | lixiancui@hotmail.com |
| Li | Yahe | Ningbo University | liyahe@nbu.edu.cn |
| Liu | Chunxiang | Huaibei Normal University | xiaoguo6655@126.com |
| Liu | Fuli | Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences | liufl@ysfri.ac.cn |
| Liu | Tao | Ocean University of China | liutao@ouc.edu.cn |
| Liu | Yan | Ocean University of China | qd_liuyan@ouc.edu.cn |
| Luo | Hongtian | Jinan University | lhtcoffee@163.com |
| Mao | Yun-Xiang | Ocean University of China | yxmao@ouc.edu.cn |
| Ngan | Tim | Green Fresh (Fujian) Foodstuff Co.,ltd. | lizzuo@greenfreshfood.com |
| Pang | Shaojun | Institute of Oceanology, Chinese Academy of Sciences | sjpang@qdio.ac.cn |
| Qi | Zizhong | Ocean University of China | zizhongqi@ouc.edu.cn |
| Qin | Song | Yantai Institute of Coastal Zone Research, CAS | sqin@yic.ac.cn |
| Qin | Yimin | QingDao Bright Moon Seaweed Group Co.,LTD | spl@bmsg.com |
| Shan | Tifeng | Institute of Oceanology, Chinese Academy of Sciences | shantifeng@qdio.ac.cn |
| Shao | Zhanru | Institute of Oceanology, CAS | zrshao@qdio.ac.cn |
| Song | Lirong | Institute of Hydrobiology, the Chinese Academy of Sciences | lrsong@ihb.ac.cn |
| Su | Li | Institute of Oceanology, Chinese Academy of Sciences | suli@qdio.ac.cn |
| Sun | Siqi | Ningbo University | 15728041077@163.com |
| Sun | Xue | Ningbo University | sunxue@nbu.edu.cn |
| Sun | Zhongmin | Institute of Oceanology, Chinese Academy of Sciences | zhmsun@hotmail.com |
| Tang | Lei | Ocean Univesity of China | tanglei@stu.ouc.edu.cn |
| Wang | Danli | Ningbo University | wangdanli@nbu.edu.cn |
| Wang | Dongmei | Ocean University of China | wangdm@ouc.edu.cn |
| Wang | Gaoge | Ocean University of China | gaogewang@hotmail.com |
| Wang | Qiaohan | Ocean University of China | 340315630@qq.com |
| Wang | Qing | Jinan University | wq2010@jnu.edu.cn |
| Wang | Wenlei | Jimei University | wenleiboy1@126.com |
| Wang | Xiuliang | Institute of Oceanology, Chinese Academy of Sciences | xlwang@qdio.ac.cn |
| Wu | Chunhui | Institute of Oceanology, Chinese Academy of Sciences | wu_chunhui88@163.com |
| Wu | Shipeng | QINGDAO GATHER GREAT OCEAN ALGAE INDUSTRY GROUP CO.,LTD | zhangzhenji@judayang.com |
| Xia | Jianrong | Guangzhou University | jrxia@gzhu.edu.cn |
| Xie | Chaotian | Jimei University | ctxie@jmu.edu.cn |
| Xu | Di | Ocean University of China | dixu@ouc.edu.cn |

| | | | |
|---|---|---|---|
| Xu | Kuipeng | Ocean University of China | xuluzhou1990@163.com |
| Xu | Nianjun | Ningbo University | xunianjun@nbu.edu.cn |
| Xu | Shanliang | Ningbo University | xushanliang@nbu.edu.cn |
| Yan | Xing-Hong | Shanghai Ocean University | xhyan@shou.edu.cn |
| Yang | Yufeng | Jinan University | tyyf@jnu.edu.cn |
| Yu | Xinzi | Ocean University of China | yxz3181@stu.ouc.edu.cn |
| Yu | Yahui | Ocean University of China | mgbl_16@ouc.edu.cn |
| Yuan | Yi | INSTITUTE OF OCEANOLOGY, CHINESE ACADEMY OF SCIENCES | yuanyi@qdio.ac.cn |
| Zang | Xiaonan | Ocean University of China | xnzang@ouc.edu.cn |
| Zhang | Jianheng | Shanghai Ocean University | jh-zhang@shou.edu.cn |
| Zhang | Jie | Institute of Oceanology, Chinese Academy of Sciences | zhangjie0616@126.com |
| Zhang | Jing | Qi Lu University of Technology (Shandong Academy of Sciences) | hellenzhangj@163.com |
| Zhang | Quanbin | Institute of Oceanology, Chinese Academy of Sciences | qbzhang@qdio.ac.cn |
| Zhang | Xiaoqian | Ningbo University | zhangxiaoqian@nbu.edu.cn |
| Zhou | Zhi-Gang | Shanghai Ocean University | zgzhou@shou.edu.cn |
| Zhu | Jun | Chinese Academy of Tropical Agricultural Sciences | zhujun@itbb.org.cn |

## Costa Rica

| | | | |
|---|---|---|---|
| Radulovich | Ricardo | University of Costa Rica | ricardo.radulovic@gmail.com |

## Denmark

| | | | |
|---|---|---|---|
| Bak Grandorf | Urd | Technical University of Denmark | ugba@food.dtu.dk |
| Bladt | Trine Sofie | Danish Technological Institute | trbl@teknologisk.dk |
| Boderskov | Teis | Aarhus University | tebo@bios.au.dk |
| Bruhn | Annette | Aarhus University | anbr@bios.au.dk |
| Dalsgaard | Trine Kastrup | Aarhus University | trine.dalsgaard@food.au.dk |
| Eriksen | Mikael | Eurogum A/S | me@eurogum.dk |
| Holdt Løvstad | Susan | Technical University of Denmark | suho@food.dtu.dk |
| Mikkelsen | Sigrid | Aarhus University | sem@bios.au.dk |
| Nielsen Møller | Mette | Technical University of Denmark | menie@aqua.dtu.dk |
| Ottesen | Kristian | Nordisk Tang | kristian@nordisktang.dk |
| Pedersen | Louise Juul | Aarhus University | louisejuulp@food.au.dk |
| Rasmussen | Michael Bo | Aaruns university | mir@bios.au.dk |
| Rhein-Knudsen | Nanna | Technical University of Denmark | nark@dtu.dk |
| Thomsen | Marianne | Aarhus University | mth@envs.au.dk |
| Zhang | Xueqian | Aarhus University | xqzh@envs.au.dk |

## Estonia

| | | | |
|---|---|---|---|
| Albert | Gerli | Estonian Marine Institude | gerli.albert@ut.ee |
| Pajusalu | Liina | Estonian Marine Institute, University of Tartu | liina.pajusalu@ut.ee |
| Robal | Marju | Tallinn University | marju.robal@gmail.com |
| Saluri | Kadri | Tallinn University | kadrisaluri@gmail.com |
| Saluri | Mihkel | Tallinn University | mihkel.saluri@tlu.ee |
| Tuvikene | Rando | Tallinn University | rtu@akvaarium.com |

## Faroe Islands

| | | | |
|---|---|---|---|
| Gregersen | Olavur | Ocean Rainforest | olavur@oceanrainforest.com |

## France

| | | | |
|---|---|---|---|
| Abdul malik | Shareen A. | University of South Brittany | seaqueen_cheri@yahoo.co.in |
| Brebion | Jeremy | ALGAIA | jeremy.brebion@algaia.com |
| Burel | Thomas | University of Brest - IUEM | thomas.burel@univ-brest.fr |
| Cascella | Kevin | CNRS | kevin.cascella@sb-roscoff.fr |
| Cock | J. Mark | Station Biologique de Roscoff | cock@sb-roscoff.fr |
| Dittami | Simon | CNRS / Station Biologique de Roscoff | simon.dittami@gmail.com |
| Dumay | Justine | University of Nantes | justine.dumay@univ-nantes.fr |
| Gager | Leslie | LEMAR/IUEM/UBO | leslie.gager@univ-brest.fr |
| Grimaldi | Aurelia | CARGILL | aurelia_grimaldi@cargill.com |
| Jan | Sebastien | CARGILL | sebastien_jan@cargill.com |
| Lalegerie | Fanny | Institut Universitaire Européen de la Mer | fanny.lalegerie@univ-brest.fr |
| Le Gélébart | Erwan | BiotechMarine-SEPPIC | erwan.legelebart@airliquide.com |
| Le Guillard | Cécile | Agro Innovation International | cecile.leguillard@roullier.com |
| Leblanc | Catherine | CNRS / Station Biologique de Roscoff | catherine.leblanc@sb-roscoff.fr |
| Loaëc | Aurélie | CARGILL | aurelie_loaec@cargill.com |
| Nehr | Zofia | CNRS | zofia.nehr@sb-roscoff.fr |
| Pierre | Ronan | CEVA | algue@ceva.fr |
| Potin | Philippe | CNRS | potin@sb-roscoff.fr |
| Queguineur | Benoit | ALGAIA | benoit.queguineur@algaia.com |
| Richier | Sophie | CEVA | elisabeth.deboise@ceva.fr |
| Zubia | Mayalen | Université de Polynésie française | mayalen.zubia@upf.pf |

## Germany

| | | | |
|---|---|---|---|
| Bischof | Kai | University of Bremen | kbischof@uni-bremen.de |
| Friedl | Thomas | Georg-August-University of Göttingen | tfriedl@uni-goettingen.de |
| Hees | Bettina | MTS Marine Therapy Solutions GmbH | info@marine-therapy.com |
| Hees | Ulrich | maBitec GmbH | uh@mabitec.de |
| Kruse | Olaf | Bielefeld University | olaf.kruse@uni-bielefeld.de |
| Liesner | Daniel | Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research | daniel.liesner@awi.de |
| Monteiro | Catia | University of Bremen | monteiro@uni-bremen.de |
| Piek | Alexander | GEA Westfalia Separator Group GmbH | alexander.piek@gea.com |
| Schiller | Jessica | University of Bremen | j.schiller@uni-bremen.de |
| Valetin | Klaus | AWI | valentin@awi.de |
| Weinberger | Florian | GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel | fweinberger@geomar.de |
| Wichard | Thomas | Friedrich Schiller University Jena | thomas.wichard@uni-jena.de |

## Guam

| | | | |
|---|---|---|---|
| Schils | Tom | University of Guam | tom.schils@reef.earth |

## Hong Kong

| | | | |
|---|---|---|---|
| Ang | Put Jr. | Chinese University of Hong Kong | aput96229@gmail.com |

## India

| | | | |
|---|---|---|---|
| Balendiran | Sowmya Lakshmi | Sea6 Energy | sowmya@sea6energy.com |
| Chatterjee | Srideep | Sea6 Energy | srideep@sea6energy.com |
| Debbarma | Jesmi | ICAR-CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY | jessmi.cife@gmail.com |
| Munisamy | Shanmugam | AquAgri Processing (P) Ltd. | m.shanmugam@aquagri.in |

| | | | |
|---|---|---|---|
| Natarajan Ganapathy | Chakravarthy | Sahayamatha Salterns Private Limited | gn_c@yahoo.com |
| Nori | Sri Sailaja | Sea6 Energy | sailaja@sea6energy.com |
| Ravirajan | Mangaiyarkarasi | Sri Balaji Vidyapeeth deemed University | mangai33@yahoo.co.in |
| Singh | Vijetna | Indira Gandhi National Tribal University | vijetnasingh1211@gmail.com |
| Suryanarayan | Shrikumar | Sea6 Energy | shri@sea6energy.com |
| Tr | Girish | Sea6Energy Private Limited | girish@sea6energy.com |
| Tripathi | Bhumi Nath | Indira Gandhi National Tribal University | bhuminathtripathi@hotmail.com |
| V V | Hemanth Giri Rao | Sea6 Energy | hemanth@sea6energy.com |
| Vadassery | Nelson | Sea6 Energy | nelson@sea6energy.com |

## Indonesia

| | | | |
|---|---|---|---|
| Agustina | Media | Hydrocolloid Indonesia | media.agustina@hydrocolloid-indonesia.com |
| Akrim | Djusdil | Universitas Negeri Makassar | djusdil.karim@bosowa.co.id |
| Arif Madjid | Nurlita Pertiwi | Universitas Negeri Makassar | nurlita.pertiwi@yahoo.com |
| Azis | Safari | Indonesian Seaweed Association | bataracelebes@yahoo.com |
| Cokrowati | Nunik | Mataram University | nunikcokrowati@unram.ac.id |
| Dewi | Eko Nurcahya | Diponegoro University | nurdewisatsmoko@yahoo.com |
| Dirawan | Gufran Darma | Universitas Negeri Makassar | gufrandarma@unm.ac.id |
| Kusnowirjono | Soerianto | Agarindo Bogatama (ASTRULI) | agarindo.bogatama@gmail.com |
| Kusumanegara | Melania | Surya Indoalgas | nia@indoalgas.co.id |
| Marsuki | Asdar | CV. Persada Semesta (Member of ARLI) | asdar_m@pupuk.or.id |
| Merdekawati | Windu | UGM | winz.merdekawati18@gmail.com |
| Nagasan | Mc Donny Watad | Indonesia Seaweed Industry Association (ASTRULI) | chairman@astruli.org |
| Neish | Iain | Sea6 Energy Indonesia | ineish@sea6energy.com |
| Prasedya | Eka | University of Mataram | ekaprasedya@gmail.com |
| Puspita | Maya | Indonesian Seaweed Association | maya.puspita@hotmail.co.id |
| Ribek | Ni Nyoman | Rahmat Bahari | saumia82@gmail.com |
| Risjani | Yenny | Universitas Brawijaya | risjani@ub.ac.id |
| Santoso | Gunawan Edy | PT Surya Indoalgas | gunawan@indoalgas.co.id |
| Saputra | Surya | Amarta | surya_saputra@amarta-group.com |
| Simbik | I Made | Rahmat Bahari | saumia@rahmatbahari.com |
| Sulistiani | Erina | SEAMEO BIOTROP | esulistiani@biotrop.org |
| Sunjoto | Budhi Sugiharto | Hydrocolloid Indonesia | budhis@hydrocolloid-indonesia.com |
| Tandra | Alfred | Cahaya Cemerlang | cc_shellbtn@yahoo.com |
| Yunianta | Yunianta | University of Brawijaya | yunianta_ub@yahoo.com |

## Ireland

| | | | |
|---|---|---|---|
| Monagail Mac | Michéal | The National University of Ireland, Galway | michealmacmonagail2@gmail.com |
| Gonzalez Blanco | Silvia | Bantry Marine Research Station | sblanco@bmrs.ie |
| Kraan | Stefan | The Seaweed Company | kraanska@hotmail.com |
| Zanolla | Marianela | National University of Ireland, Galway | marianela.zanolla@nuigalway.ie |

## Israel

| | | | |
|---|---|---|---|
| Golberg | Alexander | Tel Aviv University | agolberg@gmail.com |
| Israel | Alvaro | Israel Oceanographic Institute | alvaro@ocean.org.il |

## Italy

| | | | |
|---|---|---|---|
| Giacchetti | Cinzia | Valagro S.p.A. | c.giacchetti@valagro.com |
| Rendina | Francesco | University of Naples "Parthenope" | rendina.francesco.91@gmail.com |

## Japan

| | | | |
|---|---|---|---|
| Arimoto | Asuka | Okinawa Institute of Science and Technology Graduate University | asuka.arimoto@oist.jp |
| Aruga | Yusho | Tokyo University of Fisheries | arugay@mx4.ttcn.ne.jp |
| Belleza | Dominic | Nagasaki University | dfcbelleza@gmail.com |
| Chen | Boryuan | Tokyo University of Marine Science and Technology | boryuan0527@gmail.com |
| Fujita | Daisuke | Tokyo University of Marine Science and Technology | d-fujita@kaiyodai.ac.jp |
| Hamada | Toshiyuki | Kagoshima University | thamada@sci.kagoshima-u.ac.jp |
| Hamid Sahul | Shahlizah | Keio University | shahlizah@gmail.com |
| Hiraoka | Masanori | Kochi University | mhiraoka@kochi-u.ac.jp |
| Inoue | Yukio | Nagasaki university | yukio.yoga12@gmail.com |
| Iwamoto | Katsuaki | Marine Science Co., Ltd | iwagen@marine-science.co.jp |
| Kakita | Hirotaka | Nihon University | kakita.hirotaka@nihon-u.ac.jp |
| Kamisaki | Hoshimi | Nagasaki University | kamitsure0109@gmail.com |
| Kato | Aki | Hiroshima University | katoa@hiroshima-u.ac.jp |
| Kawai | Hiroshi | Kobe University | kawai@kobe-u.ac.jp |
| Kurashima | Akira | Mie University | kurasima@bio.mie-u.ac.jp |
| Liao | Lawrence | Hiroshima University | lliao@hiroshima-u.ac.jp |
| Matsuda | Yuhei | Nagasaki University | fishboyumintyu@gmail.com |
| Mehjabin | Jakia Jerin | Hokkaido University | jakia@ees.hokudai.ac.jp |
| Melanie | Hakiki | University of Tsukuba | melanie.hakiki@gmail.com |
| Niihara | Kinuko | Tokyo City University | kniihara@tcu.ac.jp |
| Nishihara | Gregory (Naoki) | Nagasaki University | gnishihara@gmail.com |
| Nishimura | Mitsumasa | Mitsu co.,ltd | bank@mitsucorp.co.jp |
| Nishitsuji | Koki | Okinawa institute of Science and Technology Graduate University | koki.nishitsuji@oist.jp |
| Niwa | Kyosuke | Tokyo University of Marine Science and Technology | kniwa00@kaiyodai.ac.jp |
| Punchai | Peeraporn | Nagasaki University | bb53513002@ms.nagasaki-u.ac.jp |
| Sato | Yuko | Tokyo Health Care University | yu-sato@thcu.ac.jp |
| Shoguchi | Eiichi | OIST | eiichi@oist.jp |
| Taga | Masaki | Wayo Women's University | m-taga@wayo.ac.jp |
| Takano | Shiori | Wayo Women's University Graduate School | t.instinc.shio@gmail.com |
| Taniguchi Yamada | Akiko | Tokyo University of Agriculture | akiko@nodai.ac.jp |
| Terada | Ryuta | Kagoshima University | terada@fish.kagoshima-u.ac.jp |
| Uchida | Motoharu | Fisheries Research and Education Agency | uchida@affrc.go.jp |
| Yatsuya | Kosuke | Japan Fisheries Research and Education Agency | yatsuya@affrc.go.jp |
| Yoshizumi | Kazuma | Kaneryo Seavegetable Corporation | yoshizumi@kaneryo.co.jp |
| Yotsukura | Norishige | Hokkaido University | yotsukur@fsc.hokudai.ac.jp |

## Madagascar

| | | | |
|---|---|---|---|
| Meraud | Olivier | OCEAN FARMERS | omeraud@copefrito.com |
| Pascal | Frédéric | OCEAN FARMERS | fred@ocean-farmers.com |

## Malaysia

| | | | |
|---|---|---|---|
| Balasubramaniam | Vimala | Institute for Medical Research | balavimala@hotmail.com |
| Davis | Simon | Seadling | sd@seadling.com |
| Gan | Ming Herng | Universiti Malaysia Terengganu | mh_gan@yahoo.com |
| Khazahari Che | Che Khairun Aisyah | Universiti Malaysia Terengganu | khaiyoungche@yahoo.com |
| Lim | Phaik Eem | University of Malaya | phaikeem@um.edu.my |
| Matanjun | Patricia | Universiti Malaysia Sabah | patsy@ums.edu.my |
| Mustar | Suraiami | Institute for Medical Research | fatinnura@yahoo.co.uk |
| Nor | Adibi | University of Malaya | adibi.m.nor@gmail.com |

| | | | |
|---|---|---|---|
| Poong | Sze-Wan | University of Malaya | szewan@um.edu.my |
| Vairappan | Charles Santhanaraju | Universiti Malaysia Sabah | csv@ums.edu.my |
| Yow | Yoon Yen | Sunway University | yoonyeny@sunway.edu.my |

## Mexico

| | | | |
|---|---|---|---|
| Cruz-Suarez | Lucia Elizabeth | Universidad Autonoma de Nuevo Leon | lucia.cruzsr@uanl.edu.mx |
| Freile-Pelegrín | Yolanda | CINVESTAV | yolanda.freile@cinvestav.mx |
| Hernández-Carmona | Gustavo | Instituto Politécnico Nacional | gcarmona2007@gmail.com |
| Marcos | Roberto | Algas Marinas, S.A. de C.V. | rmarcos@grupoalgamar.com |
| Marie Ricque | Denis | UANL Monterrey | denisricque@hotmail.com |
| Revilla-Lovano | Stephanie | Instituto de Investigaciones Oceanológicas, University of Baja California | srevilla@uabc.edu.mx |
| Robledo | Daniel | CINVESTAV | daniel.robledo@cinvestav.mx |
| Zepeda | Enrique | CINVESTAV | enrique.zepeda@cinvestav.mx |

## Morocco

| | | | |
|---|---|---|---|
| Lebbar | Rachid | SETEXAM | rlebbar@setexam.com |
| Lebbar | Salim | SETEXAM | slebbar@setexam.com |

## Netherlands

| | | | |
|---|---|---|---|
| Brouwers | Eef | North Sea Farm | eefbrouwers@noordzeeboerderij.nl |
| Draisma | Marlies | North Sea Farm | marlies@noordzeeboerderij.nl |
| Ebbing | Alexander | NIOZ | alexander.ebbing@nioz.nl |
| Harmsen | Paulien | Wageningen Food and Biobased Research | paulien.harmsen@wur.nl |
| Heldens | Jos | Hortimare B.V. | jos.heldens@hortimare.com |
| Mulder | Monique | Erasmus University Medical Center | m.t.mulder@erasmusmc.nl |
| Schipper | Job | Hortimare B.V. | job.schipper@hortimare.com |
| Van Den Broek | Lambertus | Wageningen UR | ben.vandenbroek@wur.nl |
| Van Den Burg | Sander | Wageningen University and Research | sander.vandenburg@wur.nl |
| Van Der Meer | Ingrid | Wageningen University & Research | ingrid.vandermeer@wur.nl |
| Van Der Werf | Adrie | Wageningen University & Research | adrie.vanderwerf@wur.nl |
| Van Hal | Jaap | ECN part of TNO | jaap.vanhal@tno.nl |
| Van Leeuwen | John | Seaweed Harvest | john@seaweedharvestholland.nl |
| Van Swam | Koen | North Sea Farm | koen@noordzeeboerderij.nl |
| Wald | Julia | Seaweed Harvest Holland | julia@seaweedharvestholland.nl |
| Wouters | Justus | The Seaweed Company | joost.wouters@theseaweedcompany.com |

## New Zealand

| | | | |
|---|---|---|---|
| Desmond | Matthew | University of Otago | matthew.j.desmond@gmail.com |
| Flack | Brendan | Te Rūnanga o Ngāi Tahu | paradisesouth@xtra.co.nz |
| Hepburn | Christopher | University of Otago | chris.hepburn@otago.ac.nz |
| Lawton | Rebecca | University of Waikato | rebecca.lawton@waikato.ac.nz |
| Magnusson | Marie | University of Waikato | marie.magnusson@waikato.ac.nz |
| Nguyen | Hang | Otago University | nguha960@student.otago.ac.nz |
| Pritchard | Daniel | Te Rūnanga o Ngāi Tahu | daniel.pritchard@ngaitahu.iwi.nz |
| Sanchez-Medina | Rigoberto | University of Auckland | rigobertosam@gmail.com |
| Scott | Nigel | Te Rūnanga o Ngāi Tahu | nigel.scott@ngaitahu.iwi.nz |
| Twigg | Isla | University of Otago | twiis993@student.otago.ac.nz |
| Tyrrell | John | University of Waikato | john.tyrrell@waikato.ac.nz |
| Zuccarello | Giuseppe | Victoria University of Wellington | joe.zuccarello@vuw.ac.nz |

## Norway

| | | | |
|---|---|---|---|
| Forbord | Silje | NTNU/Sintef | silje.forbord@sintef.no |
| Handå | Aleksander | SINTEF OCEAN | aleksander.handa@sintef.no |
| Hovland | Frode | Sogn og Fjordane county counsil | frode.hovland@sfj.no |
| Lavik | Andreas | Seaweed Energy Solutions | lavik@seaweedenergysolutions.com |
| Rebours | Celine | Møreforsking AS | celine.rebours@moreforsk.no |
| Saifullah | Saifullah | Norwegian University of Science and Technology | mr.saifullah@ntnu.no |
| Skjermo | Jorunn | SINTEF Ocean | jorunn.skjermo@sintef.no |
| Stévant | Pierrick | Møreforsking | pierrick.stevant@moreforsk.no |

## Peru

| | | | |
|---|---|---|---|
| Bustamante | Danilo E. | Universidad Nacional Toribio Rodriguez de Mendoza | ddanilobm@gmail.com |
| Dupuy | Juan | PSW SA | juan.dupuy@pswsa.com |
| Marsano | Carlos | PSW SA | jddupuy@gmail.com |
| Pérez Calvo | Juan Diego | Algaex | jdcalvoperez@algaex.pe |
| Talledo | Jose Antonio | Algaex | jatalledo@algaex.pe |

## Portugal

| | | | |
|---|---|---|---|
| Abreu | Helena | ALGAplus Lda | helena.abreu@algaplus.pt |
| Bakken | Paal | SeaForester | bakken@oceancasulo.com |
| Engelen | Aschwin | CCMAR | aengelen@ualg.pt |
| Martins | Neusa | University of Algarve | nemartins@ualg.pt |
| Mata | Leonardo | CCMAR | lmata@ualg.pt |
| Nunes | Nuno | University of Madeira | nunonunes96@gmail.com |
| Parente | Manuela | CIBIO/InBio | nelaparente@hotmail.com |
| Patarra | Rita F. | cE3c/GBA - Centre for Ecology, Evolution and Environmental Changes/Azorean Biodiversity Group | patarrarf@gmail.com |

## Republic of Korea

| | | | |
|---|---|---|---|
| Ahn | Chi-Yong | Korea Research Institute of Bioscience and Biotechnology | cyahn@kribb.re.kr |
| Ahn | Ginnae | Chonnam National University | gnahn@jnu.ac.kr |
| Ahn | Jung Kwan | National Park Research Institute | jungkwanahn@gmail.com |
| An | Jae Woo | Pukyong National University | anjewoo@pukyong.ac.kr |
| Bai | Jongil | Chonnam National University, Yeosu | vici96@naver.com |
| Boo | Gahun | Chungnam National University | gahunboo@gmail.com |
| Boo | Sung Min | Chungnam National University | smboo@cnu.ac.kr |
| Byeon | Seo Yeon | Sangji University | sybyeon94@gmail.com |
| Byun | Kyunghee | Gachon University | khbyun1@gachon.ac.kr |
| Chae | Hyunsik | Korea Polar Research Institute | chaehs85@kopri.re.kr |
| Cheon | Seongmin | Chonnam National University | s.cheon1995@gmail.com |
| Cho | Chung Hyun | Sungkyunkwan University | cndgus56@gmail.com |
| Cho | Ga Youn | National Institute of Biological Resources | gycho@korea.kr |
| Cho | Tae Oh | Chosun University | tocho@chosun.ac.kr |
| Cho | Yu Jung | Incheon National University | jyj3705@gmail.com |
| Choi | Chang Geun | Pukyong National University | cgchoi@pknu.ac.kr |
| Choi | Han Gil | Wonkwang University | hgchoi@wku.ac.kr |
| Choi | Han-Gu | Korea Polar Research Institute | hchoi82@kopri.re.kr |
| Choi | Ji Won | Sungkyunkwan University | cjw9588@gmail.com |
| Choi | Jimin | POSTECH | jmjm334@postech.ac.kr |
| Choi | Jong-Il | Chonnam National University | choiji01@jnu.ac.kr |
| Choi | Seok-Wan | Sungkyunkwan University | swchoi3791@gmail.com |
| Choi | Soyeon | Incheon National University | chlthdus0501@hanmail.net |

| | | | |
|---|---|---|---|
| Choi | Sun Kyeong | Jeju National University | lovesk86@naver.com |
| Choi | Young-Eun | Incheon National University | youngchoi95@naver.com |
| Choi | Yung Hyun | Dongeui University College of Korean Medicine | choiyh@deu.ac.kr |
| Chun | Seong-Jun | Korea Research Institute of Bioscience and Biotechnology | sjchun@kribb.re.kr |
| Chun | Sook Jin | Korea Nationl Park Service | bluefish@knps.or.kr |
| Chung | Dong-Min | Shinwoocorp | jdm@shinwoocorp.com |
| Chung | Ik Kyo | Pusan National University | ikchung@pusan.ac.kr |
| Dai | Yulin | Jeju National University | hond0502@hanmail.net |
| Ettahi | Khaoula | Sungkyunkwan University | ettahi.khaoula@gmail.com |
| Fernando | K.H.N. | Jeju National University | hiruninfdo@gmail.com |
| Graf | Louis | Sungkyunkwan University | louis.graf@gmail.com |
| Ha | Yuna | Incheon National University | dbsk335@hanmail.net |
| Han | Eui Jeong | Chonnam National University | iosu5772@naver.com |
| Han | Jin-Woo | National Marine Biodiversity Institute of Korea | hiclow@mabik.re.kr |
| Han | Jong Won | National Marine biodiversity institute of Korea | jwhan@mabik.re.kr |
| Han | Kyoo Sam | 21C Ocean Development Co. | costata@hanmail.net |
| Han | Pyoil | Gangneung-Wonju National University | hanpoyil200@naver.com |
| Han | Se Jong | KOPRI | hansj@kopri.re.kr |
| Han | Sol | Incheon National University | tldk669@naver.com |
| Han | Young-Seok | NeoEnBiz Co. | han-kong@daum.net |
| Heo | Jin Suk | National Institute of Fisheries Science | hjs6383@korea.kr |
| Heo | Soo-Jin | Korea Institute of Ocean Science & Technology | sjheo@kiost.ac.kr |
| Hong | Chan Young | Kongju National University | nicegandy@naver.com |
| Hong | Hyun Dae | National Marine Biodiversity institute of Korea | zjzzj@nate.com |
| Hong | Hyun-Hee | Chonnam National University | hongh10@naver.com |
| Hong | Ji Won | Marine Biodiversity Institute of Korea | jwhong@mabik.re.kr |
| Hwang | Eun Kyoung | National Institute of Fisheries Science | ekhwang@hotmail.com |
| Hwang | Hyun-Ju | National Marine Biodiversity Institute of Korea | hjhwang@mabik.re.kr |
| Hwang | Jin | Jeju National University | ghkdwls9280@naver.com |
| Hwang | Mi-Sook | NIFS | 75mermaid@naver.com |
| Jang | Hyeong Seok | Marine Biodiversity Institute of Korea | horneri@mabik.re.kr |
| Jang | Jitae | Aqua Green Technology Co., Ltd. | whiteyasi@gmail.com |
| Jang | Junyeong | Oceanographic | wnemd1111@gmail.com |
| Jang | Sojin | Incheon National University | thwls5098@naver.com |
| Jang | Sol | NeoEnBiz Co. | clarasol417@gmail.com |
| Jang | Soonok | Aqua Green Technology Co., Ltd. | sojang@aquagt.co.kr |
| Jayawardena | Thilina U. | Jeju National University | tuduwaka@gmail.com |
| Je | Jun Geon | Jeju National University | wpwnsrjs@naver.com |
| Jeon | Hancheol | National Marine Biodiversity Institute of Korea | hjeon@mabik.re.kr |
| Jeon | Je Jin | Kongju National University | dmdld26@naver.com |
| Jeon | You-Jin | Jeju National University | youjin2014@gmail.com |
| Jeong | Jaewoo | Incheon National University | wjdowdn4@naver.com |
| Jeong | So Young | Chosun University | delesseriaceae@gmail.com |
| Jiang | Yunfei | Jeju National University | jiangyunfei0310@gmail.com |
| Jin | Eonseon | Hanyang University | esjin@hanyang.ac.kr |
| Jin | Soyeong | Chonnam National University | thdud9112@gmail.com |
| Jo | Jihoon | Chonnam National University | jojihoon98@gmail.com |
| Jung | Sangmok | Soonchunhyang University | thinkdi@gmail.com |
| Jung | Seung Wook | Pukyong National University | apple1936@naver.com |
| Kambey | Cicilia Selviane | Pusan National University | cicilia_kambey@yahoo.com |
| Kang | Do-Hyung | Korea Institute of Ocean Science & Technology | dohkang@kiost.ac.kr |
| Kang | Jeong Chan | Manta's Marine Lab. | mantachan@hanmail.net |

| | | | |
|---|---|---|---|
| Kang | Mangu | Mie University | algae815@gmail.com |
| Kang | Nalae | Korea Institute of Ocean Science & Technology | nalae1207@kiost.ac.kr |
| Kang | Pil Joon | Pukyong National University | redkpj486@pukyong.ac.kr |
| Kang | Su-Min | Jeju National University | rosenmoon@jejunu.ac.kr |
| Kim | Dongseok | Sungkyunkwan University | dongseokkim6662@gmail.com |
| Kim | Eun Jae | KOPRI | haninom@kopri.re.kr |
| Kim | Eun Jeong | Chung-Ang University | sassyej@gmail.com |
| Kim | Eun-A | Korea Institute of Ocean Science & Technology | euna0718@kiost.ac.kr |
| Kim | Geonhee | Incheon National University | jkh-011@hanmail.net |
| Kim | Gunhee | Duksung Women's University | ghkim@duksung.ac.kr |
| Kim | Gwang Hoon | Kongju National University | ghkim@kongju.ac.kr |
| Kim | Hawon | Kunsan National University | hawon9712@gmail.com |
| Kim | Hyemi | Chonnam National University | shms01@naver.com |
| Kim | Hye-Min | Naturetech | kimhm@naturetech.co.kr |
| Kim | Hye-Min | NeoEnBiz Co. | astrongirl.hm@gmail.com |
| Kim | Hyoung Hae | 21C Ocean Development Co. | h2kpf@naver.com |
| Kim | Hyung Geun | Gangneung-Wonju National University | kimhg@gwnu.ac.kr |
| Kim | Hyunsoo | Jeju National University | gustn783@naver.com |
| Kim | Jang.K | Incheon National University | jang.kim@inu.ac.kr |
| Kim | Jee-Hwan | Nakdonggang National Institute of Biological Resources | jhkim@nnibr.re.kr |
| Kim | Jeong Bae | National Institute of Fisheries Science | jbkim347@korea.kr |
| Kim | Jeong Ha | Sungkyunkwan University | jhkbio@skku.edu |
| Kim | Ji Hwan | Jeollanam-do Institute of Oceans & Fisheries Technology | kjh8810@korea.kr |
| Kim | Jonghee | Incheon National University | ckck106@nate.com |
| Kim | Joon | Gangneung-Wonju National University | joonsha@daum.net |
| Kim | Ju-Hyoung | Kunsan National University | juhyoung@kunsan.ac.kr |
| Kim | Junseong | Korea Institute of Ocean Science & Technology | junseong@kiost.ac.kr |
| Kim | Kyeong Mi | National Marine Biodiversity Institute of Korea | kmkim@mabik.re.kr |
| Kim | Mi-Kyung | Ecophycotech Co., Ltd. | mkkim@yu.ac.kr |
| Kim | Miok | Pohang University of Science and Technology | yellow77@postech.ac.kr |
| Kim | Moonjung | Sungkyunkwan University | mary960323@naver.com |
| Kim | Myung Sook | Jeju National University | myungskim@jejunu.ac.kr |
| Kim | Nahyeon | Kunsan National University | alvhdb2@gmail.com |
| Kim | Nam-Gil | Gyeongsang National University | ngkim@gnu.ac.kr |
| Kim | Sang-Cheol | Nakdonggang National Institute of Biological Resources | discoverkim505@nnibr.re.kr |
| Kim | Sangil | National Institute of Fisheries Science | kelpkim@gmail.com |
| Kim | Seo-Young | Jeju National University | shhssy1127@naver.com |
| Kim | Seungoh | National Institute of Fisheries Science | niceguya@korea.kr |
| Kim | Sinyang | POSTECH | sinyangk@postech.ac.kr |
| Kim | Sukjin | Duksung Women's University | kimsukjin333@naver.com |
| Kim | Taehee | Naturetech | taeheek@naturetech.co.kr |
| Kim | Taeho | KIOST | kt1024@kiost.ac.kr |
| Kim | Yong Yi | Kunsan National University | freekein@naver.com |
| Kim | Young Jin | Incheon National University | dudwls7794@naver.com |
| Kim | Young Sik | Kunsan National University | kimys@kunsan.ac.kr |
| Kim | Youngwoo | Incheon National University | 0woo@inu.ac.kr |
| Kim | Youn-Jung | Incheon National University | duckyj@inu.ac.kr |
| Ko | Jeoung Sook | 21C Marine Development Company | kjsook1104@hanmail.net |
| Ko | Shin Ja | Jeju National University | shinjasky@naver.com |
| Koh | Young Ho | Jeju National University | grandcross1999@nate.com |
| Kwak | Kwanhyuk | Kunsan National University | roboske@naver.com |

| | | | |
|---|---|---|---|
| Kwak | Minseok | Marine Biodiversity institute of Korea | kwakms00@kongju.ac.kr |
| Kwon | Byeori | Algaeprona Inc. | love712601@naver.com |
| Kwon | Eunmi | NeoEnBiz Co. | kwonem0312@gmail.com |
| Lee | Bora | Chonnam National University | bora629@gmail.com |
| Lee | Chang Soo | Nakdonggang National Institute of Biological Resources | cslee@nnibr.re.kr |
| Lee | Chung Hyeon | Chonnam National University | chlee9201@gmail.com |
| Lee | Dajeong | Kongju National University | mume0812@smail.kongju.ac.kr |
| Lee | Dong Seok | Sungkyunkwan University | hubilla@naver.com |
| Lee | Heesuk | K-water | heesuklee@gmail.com |
| Lee | Hojun | Incheon National University | leehj9311@hanmail.net |
| Lee | Hyo Geun | Jeju National University | hyogeunlee92@gmail.com |
| Lee | Hyuk Je | Sangji University | lhjk622@gmail.com |
| Lee | Hyung Woo | Jeju National University | hyungwoo.lee26@gmail.com |
| Lee | Hyun-Gwan | Chonnam National University | hglee602@gmail.com |
| Lee | Jee Eun | National Institute of Fisheries Science | lje045849@korea.kr |
| Lee | Jeongjun | Naturetech | jjlee@naturetech.co.kr |
| Lee | Ji Hyo | Kunsan National University | dididias@naver.com |
| Lee | Ji Woong | Kongju National University | ljw86@kongju.ac.kr |
| Lee | Jin Ae | Inje University | envjal@inje.ac.kr |
| Lee | Joon-Baek | Jeju National University | jblee@jejunu.ac.kr |
| Lee | Juil | Chungnam National University | dlwndlf01@hanmail.net |
| Lee | Kitack | POHANG UNIVERSITY OF SCIENCE AND TECHNOLOGY | ktl@postech.ac.kr |
| Lee | Sang Deuk | NNIBR | diatom83@nnibr.re.kr |
| Lee | Songhyun | Wonkwang University | thdgus1119@gmail.com |
| Lee | Soon Jeong | National Institute of Fisheries Science | leesj73@korea.kr |
| Lee | Sukyeon | Kunsan National University | sukyeona@gmail.com |
| Lee | Sung-Gwon | Chonnam National University | sunggwonl22@gmail.com |
| Lee | Won-Hwi | Incheon National University | dnjsgnl_@naver.com |
| Lee | Won-Kyu | Korea Institute of Ocean Science & Technology | wonkyulee@kiost.ac.kr |
| Lee | Wonwoo | Nakdonggang National Institute of Biological Resources | 21cow@nnibr.re.kr |
| Lee | Youn-Ji | Kunsan National University | lyj@kunsan.ac.kr |
| Lhee | Duckhyun | Sungkyunkwan University | duckhyunlhee@gmail.com |
| Li | Xining | Jeju National University | chanchanaichigua537@gmail.com |
| Lim | Myeong Hwan | Chonnam National University | audghks267@gmail.com |
| Liu | Jay | Pukyong National University | jayliu@pknu.ac.kr |
| Lu | Yu An | Jeju National University | annie.lu1213@gmail.com |
| Min | Juhee | Chonnam National University | 1012juhee@naver.com |
| Monmai | Chaiwat | Gangneung-Wonju National University | bbuayy@gmail.com |
| Moon | Hanbi | Kunsan National University | hanbi5812@gmail.com |
| Moon | Kyeonglim | Jeju National University | klmoon@jejunu.ac.kr |
| Moon | Kyounghyoun | NAKHWASENG-GIM | pyropia@pyropia.com |
| Nam | Juhyun | Gangneung-Wonju National University | skawngussla@naver.com |
| Nam | Ki Wan | Pukyong National University | kwnam@pknu.ac.kr |
| Nam | Onyou | Hanyang University | namonew@naver.com |
| Nam | Seung Won | Nakdonggang National Institute of Biological Resources | seungwon10@nnibr.re.kr |
| Nam | Yoon Ra | Gangneung-Wonju National University | wis04136@hanmail.net |
| Oh | Hee-Mock | Korea Research Institute of Bioscience and Biotechnology | heemock@kribb.re.kr |
| Oh | Jae-Young | Jeju National University | ojy0724@naver.com |
| Oh | Jooseong | Chonnam National University | ojooseong@gmail.com |
| Oteng'O | Antony | Chosun University | aotinga@gmail.com |
| Park | Ahhyun | Incheon National University | dkgus3021@naver.com |

| | | | |
|---|---|---|---|
| Park | Ha Jun | Handong Global University | godprepare11@naver.com |
| Park | Jeong Kwang | National Marine Biodiversity Institute of Korea | pjk1717@mabik.re.kr |
| Park | Jihae | GHENT UNIVERSITY KOREA | jihae.park@ghent.ac.kr |
| Park | Mira | Incheon National University | mira0295@inu.ac.kr |
| Park | Mirye | Nakdonggang National Institute of Biological Resources | mirye@nnibr.re.kr |
| Park | Sang Rul | Jeju National University | srpark@jejunu.ac.kr |
| Park | Sejong | CJ Jeiljedang | parksejong006@gmail.com |
| Park | Seo Kyoung | Wonkwang University | p2hqueen@hanmail.net |
| Park | Seojeong | Chonnam National University | yap267@naver.com |
| Park | Seung In | Sungkyunkwan University | marine376@naver.com |
| Park | Woojung | Gangneung-Wonju National University | pwj0505@gmail.com |
| Park | Yeon-Jeong | K-water Research Institute | yjpark@kwater.or.kr |
| Peltroche Avila | Jose | Chosun University | jose_avila22@hotmail.com |
| Samanta | Palas | Incheon National University | samanta.palas2010@gmail.com |
| Sanjeewa | K. K. Asanka | Jeju National University | asanka.sanjeewa001@gmail.com |
| Seo | Doyeon | Incheon National University | doyeon0822@naver.com |
| Seo | Mark (Jongseok) | Marine Stewardship Council | mark.seo@msc.org |
| Seo | Min-Jeong | Nakdonggang National Institute of Biological Resources | mjseo0405@nnibr.re.kr |
| Seo | Seong-Hyun | Korea Research Institute of Bioscience and Biotechnology | tjtjdgus@kribb.re.kr |
| Shim | Eun Young | Kongju National University | tlasud@kongju.ac.kr |
| Shim | Jeonghee | East Sea Fisheries Research Institute | jshim@korea.kr |
| Shin | Gun Su | Chonnam National University | tlsrjstn123@gmail.com |
| Shin | Jiha | Wonkwang University | shin11714@naver.com |
| Shin | Jong-Ahm | Underwater Ecology Institute | yeosushin@naver.com |
| Shin | Sookkyung | Incheon National University | shin_78@naver.com |
| Song | Byeung Su | Jeju national university | blanaen@jejunu.ac.kr |
| Song | Hyein | Incheon National University | thdgpdls13@naver.com |
| Sun | Sangmi | Chonnam National University | smsun@chonnam.ac.kr |
| Wang | Lei | Jeju National University | comeonleiwang@163.com |
| Won | Gayeong | Duksung Women's University | gywon04@naver.com |
| Yamaoka | Yasuyo | POSTECH | yamaoka1982@postech.ac.kr |
| Yang | Eun Chan | Korea Institute of Ocean Science & Technology | ecyang@kiost.ac.kr |
| Yang | Hye-Won | Jeju National University | koty221@naver.com |
| Yang | Kwonmo | Sungkyunkwan University | noitcurtsed1@gmail.com |
| Yang | Mi Yeon | Jeju National University | agape0307@naver.com |
| Yih | Wonho | Kunsan National University | ywonho@kunsan.ac.kr |
| Yoo | Jong Su | National Marine Biodiversity Institute of Korea | jsyoo@mabik.re.kr |
| Yoon | Hwan Su | Sungkyunkwan University | hwansu@gmail.com |
| Yoon | Seonhye | Naturetech | yoon3406@naturetech.co.kr |
| Youngmin | Kim | Aqua Green Technology Co., Ltd. | ymkim1211@aquagt.co.kr |
| Yun | Suk Min | Nakdonggang National institute of Biological Resources | horriwar@nnibr.re.kr |

## South Africa

| | | | |
|---|---|---|---|
| Bolton | John | University of Cape Town | john.bolton@uct.ac.za |
| Du Plessis | Jamie | Stellenbosch University | 18265332@sun.ac.za |
| Goosen | Neill | Stellenbosch University | njgoosen@sun.ac.za |
| Le Masson | Virginie | ODI | v.lemasson@odi.org.uk |
| Maneveldt | Gavin | University of the Western Cape | gmaneveldt@uwc.ac.za |

## Spain

| | | | |
|---|---|---|---|
| Díaz-Tapia | Pilar | Universidade da Coruña | pdiaz@udc.es |
| Fernandez | Javier | Hispanagar S.A. | javierfdez@hispanagar.es |
| Gonzalez | German | HISPANAGAR S.A. | germang@hispanagar.es |

## SriLanka

| | | | |
|---|---|---|---|
| Kulendran | Sivaram | Aquagri Lanka (Pvt) Ltd | sksivaram@me.com |

## Sweden

| | | | |
|---|---|---|---|
| Albers | Eva | Chalmers University of Technology | albers@chalmers.se |
| Gröndahl | Fredrik | KTH, Royale Institute of Technology | fgro@kth.se |
| Halling | Christina | Stockholm University | christina.halling@su.se |
| Olsson | Joakim | Chalmers University of Technology | joakim.olsson@chalmers.se |

## Taiwan

| | | | |
|---|---|---|---|
| Chen | Pin-Chen | Tunghai University | pinchen55@gmail.com |
| Chen | Yu-Chen | National Taiwan Ocean University | poppy0306@gmail.com |
| Chou | Hong-Nong | National Taiwan University | unijohn@ntu.edu.tw |
| Denis | Vianney | National Taiwan University | vianney.denis@gmail.com |
| Huang | Roger | Rising Sun Foundation | rogerxhuang@gmail.com |
| Lim | Wui Ting | National Taiwan Ocean University | limwuiting923@gmail.com |
| Lin | Hsiu-Mei | National Taiwan Ocean University | hmlin@mail.ntou.edu.tw |
| Perez | John | Tunghai University | jperez@thu.edu.tw |
| Shih | Chun Chi | Tunghai University | for.scc.lm@gmail.com |
| Sung | Chun-Ju | National Taiwan Ocean University | sung-66@hotmail.com |
| Tsou | Min-Hsuan | National Taiwan Ocean University | keanu27019885@gmail.com |
| Wu | Zhi Yuan | National Taiwan Ocean University | j12125202000@gmail.com |

## Thailand

| | | | |
|---|---|---|---|
| Boonprab | Kangsadan | Kasetsart University | bffisksb@yahoo.com |
| Chandaravithoon | Piamsook | Prince of Songkla University-Phuket | tigger_40@hotmail.com |
| Chirapart | Anong | Kasetsart University | ffisanc@ku.ac.th |
| Choosuwan | Pradtana | Kasetsart University | pradtana712538@gmail.com |
| Mayakun | Jaruwan | Prince of Songkla University | jaruwan.may@psu.ac.th |
| Muangmai | Narongrit | Faculty of Fisheries, Kasetsart University | ffisnrm@ku.ac.th |
| Pattarach | Kattika | Prince of Songkla University | k.pattarach@gmail.com |
| Phetcharat | Sinjai | Prince of Songkla University | sinn.gonly@hotmail.com |
| Praiboon | Jantana | Kasetsart University | ffisjtn@ku.ac.th |
| Prathep | Anchana | Prince of Songkla University, Thailand | a_prathep@hotmail.com |
| Ritchie | Raymond J. | Prince of Songkla University-Phuket | raymond.ritchie@uni.sydney.edu.au |
| Ruangchuay | Rapeeporn | Faculty of Science and Technology | rapeeporn.r@psu.ac.th |
| Titioatchasai | Jatdilok | Prince of Songkla University | jatdilok.titioatchasai@gmail.com |

## The Philippines

| | | | |
|---|---|---|---|
| Ahaja | Jan Raihan | Sitangkai Seaweeds Export Company | ahaja_jan@yahoo.com |
| Ahaja | Jolly | Sitangkai Seaweeds Export Company | yasmin.lee5984@gmail.com |
| Baricuatro | Farley | DuPont | farley.l.baricuatro@dupont.com |
| Blanco | Amado | Zoological Society of London | nickaohill@gmail.com |
| Borlongan | Iris Ann | Kagoshima University | irisborlongan@gmail.com |
| Faisan Jr. | Joseph P. | Southeast Asian Fisheries Development Center | jfaisan@seafdec.org.ph |
| Ferriols | Victor Marco Emmanuel | University of the Philippines Visayas | vnferriols@up.edu.ph |
| Gabutina | Maria Camille | Shemberg Marketing Corp. | camille.gabutina@shemberg.com.ph |
| Goodwin | Gray | Marine Algae | gray.goodwin@goodsource.biz |
| Hurtado | Anicia | University of The Philippines Visayas | anicia.hurtado@gmail.com |
| Luhan | Maria Rovilla J | Southeast Asian Fisheries Development Center (SEAFDEC) | mrjluhan@seafdec.org.ph |

| | | | |
|---|---|---|---|
| Mateo | Jonalyn P. | University of The Philippines Visayas | jpmateo@seafdec.org.ph |
| Relleta Ferrer | Ma. Salvacion | National Fisheries Research and Development Institute | sdp_coordinator@outlook.com |
| Saco | Jayvee | Batangas State University | jayvee.saco@gmail.com |
| Sibonga | Rema C. | Southeast Asian Fisheries Development Center | rcsibonga@seafdec.org.ph |
| Suyo | Jee Grace B. | University of The Philippines Visayas | jeegsuyo@gmail.com |
| Tan | Michael | Marcel Carrageenan | gay.rosales@marcelcarrageenan.com |
| Tan | Peter | TBK Manufacturing Corporation | sales@tbk.com.ph |
| Wee | John Stanislaus | W Hydrocolloids, Inc. | shiela.melgar@rico.com.ph |

## United Kingdom

| | | | |
|---|---|---|---|
| Adams | Jessica | Aberystwyth University | jaa@aber.ac.uk |
| Badis | Yacine | Scottish Association for Marine Science | yacine.badis@sams.ac.uk |
| Biancacci | Cecilia | Scottish Association for Marine Science | cecilia.biancacci@sams.ac.uk |
| Brakel | Janina | Scottish Association for Marine Science | janina.brakel@sams.ac.uk |
| Brodie | Juliet | Natural History Museum | j.brodie@nhm.ac.uk |
| Brown | Aaron | University of Leeds | bs11aeb@leeds.ac.uk |
| Campbell | Iona | Scottish Association for Marine Science | iona.campbell@sams.ac.uk |
| Cottier-Cook | Elizabeth | Scottish Association for Marine Science | elizabeth.cottier-cook@sams.ac.uk |
| Gachon | Claire | Scottish Association for Marine Science | claire.gachon@sams.ac.uk |
| Ghaderiardakani | Fatemeh | University of Birmingham | fxg433@student.bham.ac.uk |
| Hutchison | Shona | DuPont | shona.hutchison@dupont.com |
| Kerrison | Phil | Scottish Association for Marine Science | philip.kerrison@sams.ac.uk |
| Macleod | Adrian | Scottish Association for Marine Science | adrian.macleod@sams.ac.uk |
| Mansur | Ahmad | The University of Plymouth | ahmad.mansur@plymouth.ac.uk |
| Mellor | Tom | Gel Systems Ltd | tmellor@gelsystems.co.uk |
| Michalek | Kati | Scottish Association for Marine Science | kati.michalek@sams.ac.uk |
| Montalescot | Valeria | Scottish Association for Marine Science | valeria.montalescot@sams.ac.uk |
| Murua | Pedro | The Scottish Asociation for Marine Science | pedro.muruaandrade@sams.ac.uk |
| O'Dell | Alasdair | Scottish Association for Marine Science | 17026166@uhi.ac.uk |
| Oliver | Catherine | Aberystwyth University | cao27@aber.ac.uk |
| Photiades | Angelos | Aberystwyth University | anp61@aber.ac.uk |
| Raynsford | Hayley | Gel Systems Ltd | hraynsford@gelsystems.co.uk |
| Razaq | Iram | University of Leeds | pm13ir@leeds.ac.uk |
| Ross | Andrew | University of Leeds | a.b.ross@leeds.ac.uk |
| Saha | Mahasweta | Plymouth Marine Laboratory | sahamahasweta@gmail.com |
| Sands | Jason | Ocean Harvest Technology | jason.sands@oceanharvest.ie |
| Shaxson | Louise | Overseas Development Institute | l.shaxson@odi.org.uk |
| Stanley | Michele | Scottish Association for Marine Science | michele.stanley@sams.ac.uk |
| Thomson | Alexander | Scottish Association for Marine Science | alexander.thomson@sams.ac.uk |
| Ward | Georgia | Natural History Museum | georgia.ward@nhm.ac.uk |
| Zhou | Lu | University of the Arts London | lookforward225@gmail.com |

## United Republic of Tanzania

| | | | |
|---|---|---|---|
| Al Rawayh | Hamil Said Soud | C Weed Corporation | accounts@cweed.com |
| Andrew | Msafiri | University of Dar Es Salaam | bornson1@yahoo.com |
| Buriyo | Amelia | University of Dar es Salaam | aburiyo@gmail.com |
| Fazal | Murtaza | C weed Corporation | morty@fazal.com |
| Gvasaliya | Georgy | Ariba Seaweed Limited | gvasalifornia@gmail.com |
| Matoju | Ivy | University of Dar Es Salaam | matojui@hotmail.com |
| Morre | Roger | C Weed Corporation | roger@cweed.com |

| | | | |
|---|---|---|---|
| Msuya | Flower | University of Dar es Salaam | fmsuya1@gmail.com |
| Rusekwa | Sadock | University of Dar es Salaam | rusekwas@gmail.com |
| Yona | Gloria Kavia | University of Dar es Salaam | glokavia@yahoo.com |

## United States of America

| | | | |
|---|---|---|---|
| Alberto | Filipe | UW-Milwaukee | albertof@uwm.edu |
| Andersen | Robert | University of Washington | raa48@uw.edu |
| Arkoosh | Mary | NOAA/ Northwest Fisheries Science Center | mary.arkoosh@noaa.gov |
| Ask | Erick | DuPont Corp. | erick.i.ask@dupont.com |
| Augyte | Simona | University of Connecticut | simona.augyte@uconn.edu |
| Bhattacharya | Debashish | Rutgers University | debash.bhattacharya@gmail.com |
| Booher | Leslie | Sunken Seaweed | leslie@sunkenseaweed.com |
| Brenna | James | University of Texas at Austin | tbrenna@utexas.edu |
| Dietrich | Joseph | NOAA Fisheries Service | joseph.dietrich@noaa.gov |
| Dobbins | Paul | World Wildlife Fund | paul.dobbins@wwfus.org |
| Espinal | Maria Mercedes | Florida International University | mariaespinal24@naver.com |
| Gabrielson | Paul | University of North Carolina, Chapel Hill | drseaweed@hotmail.com |
| Johndro | Kevin | Ingredients Solutions, Inc. | kevinj@isi.us.com |
| Kaye | Jon | Moore Foundation | jon.kaye@moore.org |
| Kothapalli | Sesha Durga Kumar | Dell Medical School at UT Austin | kkothapalli@utexas.edu |
| Kübler | Janet | California State University at Northridge | janet.kubler@csun.edu |
| Lee | Wenshan | Highline college | ilovinvest@aol.com |
| Lindell | Scott | Woods Hole Oceanographic Institute | slindell@whoi.edu |
| Marty-Rivera | Michael | University of Connecticut | madeline.hennessey@uconn.edu |
| Nayak | Balunkeswar | University of Maine | balunkeswar.nayak@maine.edu |
| Nuzhdin | Sergey | Univ. Southern California | snuzhdin@usc.edu |
| Polizzi | Torre | Sunken Seaweed | torre@sunkenseaweed.com |
| Raymond | Ann | University of Alaska Fairbanks | aethomson2@alaska.edu |
| Raymond | Wendel | University of Alaska Fairbanks | wraymond2@alaska.edu |
| Stekoll | Michael | University of Alaska SE | msstekoll@alaska.edu |
| Teas | Jane | University of South Carolina | teas@mailbox.sc.edu |
| Tuart | Ian | Marine Algae products | ian.tuart@marinealgaeproducts.com |
| Umanzor | Schery | University of Connecticut | schery.umanzor@uconn.edu |
| Von Herzen | Brian | Climate Foundation | brian@climatefoundation.org |
| Von Keitz | Marc | U.S Department of Energy | marc.vonkeitz@hq.doe.gov |
| Yarish | Charles | UConn | charles.yarish@uconn.edu |

## Vietnam

| | | | |
|---|---|---|---|
| Diem Hong | Dang | Institute of Biotechnology, Vietnam Academy of Science and Technology | ddhong60vn@yahoo.com |
| Thi Hoai Thu | Ngo | Institute of Biotechnology, Vietnam Academy of Science and Technology | nhthu@ibt.ac.vn |
| Tran | Thi Lan Anh | Gent university | anhttl@hus.edu.vn |

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  - 해조류, 어패류, 쌀, 벼잎, 옥수수, 대두, 모발, 선충, 동물조직 등.

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- 동결파쇄로 시료의 분해 및 변성 억제 -193℃ 액체질소 처리

  ※ 파쇄과정 중 열 발생이 억제되며, 파쇄 후 ' 성분분석, 단백질 · RNA/DNA 추출가능'
- 밀폐구조 생균 · 유해시료 · 유해수지 파쇄 가능
- 반영구적 반복 사용 - 파쇄기 세척, 살균 가능
- 간편한 세척
- 기존 bead를 이용한 파쇄도 가능

GENOMICBASE
(주)제노믹베이스

**제품 문의 및 판매처**

서울시 동대문구 장안1동 375-8 공감대빌딩 4층

Tel : 02.2215.4925 / FAX : 02.2215.4929

Mail : info@genomicbase.com

미래 100년 좋은 일자리와 먹거리 창출

# 완도 해양치유 산업

## 해양치유란?

**청정한 해양자원을 이용하여 몸과 마음을 치유하는 건강증진 활동**

전문의료인의 진단 및 처방으로 적합한 해양치유요법 시행

**해양치유산업**

해양치유를 기반으로 의료, 관광, 바이오 산업과 융합되어 고부가가치로 발전되는 미래 전략산업

## 어떤 사람들이 이용하는가?

일반 국민
(심혈관계 및 관절염)

운동선수 및 사회체육인
(경기력 향상 및 재활치료)

수술 후 회복기 환자

## 해양자원을 어떻게 치유에 활용하는가?

**해양기후요법**

노르딕워킹, 비치비스켓, 해변요가, 산책 등 | 호흡기 질환, 면역, 피부질환, 관절염 등

**해양생물요법**

섭취, 입욕, 도포, 팩, 바이오 소재 등 | 피부질환, 항염증, 비만개선 등

**해수요법**

해수흡입, 수중운동, 해수입욕 등 | 호흡기 질환, 관절염, 피부질환, 재활 등

**해양광물요법**

도포, 입욕 등 | 피부질환, 관절염, 재활 등

## 해양치유산업을 위한 완도의 환경은 어떠한가?

완도는 해양치유를 할 수 있는 모든 해양자원을 확보하고 청정성을 유지하고 있어 국내 최적지로 평가받고 있음

Vitality in fishing villages
Value in aquatic products
Cure to marine tourism
Safety and convenience to ports and fishing ports
Beauty to ocean environment
Historic nature to our Haenyeo culture

**We support sustainable development for Jeju Marine Fishery Industry**

Jeju Special Self-Governing Province

“
Seaweeds:
From Tradition to Innovation!
”

ISS 2019

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Unit 83687, Research Complex 2, SKKU, 2066 Seobu-Ro, Jangan-Gu, Suwon-Si, Gyeonggi-Do, Korea
**Tel.** +82-31-290-5922 **Fax.** +82-31-296-5922 **E-mail.** secretariat@iss2019.org