22nd International Seaweed Symposium 2016

Academia meets Industry

June 19 - 24, 2016
Copenhagen
Denmark

The Council of the International Seaweed Association wishes to thank all the sponsors supporting the organization

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22nd International Seaweed Symposium

Academia meets Industry

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Professional Conference Organizer for the 22nd International Seaweed Symposium:
BDP, Denmark

Table of Contents

WELCOME

Dear 22nd ISS delegates,

I'm delighted to show and present to you the wonderful Copenhagen, the venue Scandic Copenhagen Hotel in the very city center right next to the beautiful lakes, and not least the excellent scientific program of the 22nd ISS. I would like to thank so many of you for sending your abstract and thereby contribute to an excellent symposium. The program includes all aspects of modern and traditional seaweed research and applications which create the scientific platform for sustainable and innovative industries for the future society. The scientific committee that has read all the abstracts, and hopefully also you delegates, will struggle to split into all four parallel sessions, due to such an interesting program.

I sincerely hope that this ISS will give you a chance to meet and greet with "old" acquaintances and give you new contacts and international colleagues to support your future research and work. Traditionally the ISS embraces industry. At this 22nd ISS we have made an extra effort to foster meetings between academia and industry by introducing a new event, namely the Seaweed Matchmaking with industrial pitches and speed dating on Tuesday.

The National Organizing Committee also introduces poster pitches this year to make posters more visible and "louder" among the almost 400 abstracts submitted. More than 400 delegates from almost 50 nationalities have registered for this great event that we have all been waiting for during the last three years; promoted/facilitated and "lent" by the International Seaweed Association Council (ISAC).

We kick off the 22nd ISS by a historical session and end with a session on Friday embracing/looking into the future. Hopefully all sessions in between will also open your eyes to new ideas and to historical seaweed art at the City Hall on Tuesday. Your other senses will also be touched by having great Danish cuisine (incl. seaweed also on the night of the symposium banquet overlooking the Little Mermaid), and by smelling the fresh air and feeling the summer at the Mid Symposium tours. Furthermore, you will hear about the fifth flavor (Umami) by one of the most significant chefs in the world and the ambassador of the 22nd ISS, René Redzepi from the world famous restaurant NOMA.

I'm sure you will enjoy the long bright Danish summer nights with international colleagues combined with a palette of presentations of research and company contacts, and I wish you a fruitful 22nd ISS in Copenhagen 2016.

On behalf of the National Organizing Committee and the host institute, The National Food Institute, Technical University of Denmark,
Susan Løvstad Holdt, Chair of ISS 2016

AWARDS

The University of British Columbia Award for the best student paper
Three awards will be given to the three best graduate student papers presented at the 22nd International Seaweed Symposium (ISS) from a fund established at the University of British Columbia, Canada, in 1989 (13th ISS). These awards are now administered by the International Seaweed Association (ISA).
Springer, the publishing company of Journal of Applied Phycology, supplements this award with an additional gift certificate for each of the three winners.
The awards are for graduate students only. The oral presentations will be evaluated by a committee appointed by the National Organizing Committee of the 22nd ISS.

Poster Pitch Award
The National Organizing Committee of the 22nd ISS will give awards to the three best pitches ('elevator speeches') of posters at the Symposium.

Awards will be announced at the closing ceremony.

GENERAL SYMPOSIUM INFORMATION

Symposium venue
The 22nd ISS will take place from June 19-24 2016 at the Scandic Copenhagen Hotel

Registration and information desk

The registration and information desk will be open:

Sunday, 19 June	17:00 - 20:00
Monday, 20 June	08:00 - 14:00
Tuesday, 21 June	08:30 - 13:00
Wednesday, 22 June	Closed
Thursday, 23 June	08:15 - 13:00
Friday, 24 June	08:30 - 13:00

Oral presentations
Participants with oral presentations must submit their presentation(s) either on USB or CD at the 'Speakers Preparation Room' at least one day before their presentations.
Participants with presentation for Monday have to hand in their presentation on Sunday at registration (17:00-20:00). Presentations must be in Power Point Windows format.
For the sake of the symposium and the other participants it is very important that times in the program are respected, and that the speakers stay within the scheduled time.
The presenter will see a special computer screen that clearly displays the remaining time for the presentation.

Posters: Two sets of posters and two poster sessions
Posters will be presented in the break area. There will be two sets of posters: one set displayed Monday and Tuesday, after which they will be taken down. After the excursions on Wednesday the second set of posters will be displayed Thursday and Friday.
There will be two poster sessions: one Tuesday afternoon and another Thursday afternoon. The speakers or presenters of the posters must be present at the sessions.

Poster Pitches
During each poster session, the presenters of posters are given the opportunity to give a very brief oral presentation ('elevator speech' or pitch) of her/his poster on stage in one of the session rooms.
Poster-presenters that want to take this opportunity must submit an electronic copy of the poster (maximum 2 slides, PowerPoint) at the 'Speakers Preparation Room' at least one day before their presentation. The copy must be in the Power Point Windows format.
Awards will be given to the best poster-pitches.

Meals
Lunches will be provided at the Venue during the ISS except for the mid symposium excursion, where you will receive a lunch box. On Friday you will also have a lunch box which you may choose to eat at the Venue or bring with you as you leave.
Dinners during Sunday to Wednesday are not included in your registration fee. The Symposium Dinner Thursday evening is included for all participants registered as 'Regular' as well as for students and accompanying persons if they have bought an optional ticket during registration. Tickets are also for sale at the registration and information desk.
Snacks will be served at the welcome reception at Scandic Copenhagen on Sunday 19 June and the reception at the City Hall on Tuesday 21 June.

Coffee, tea and cold sparkling water
Coffee, tea and cold sparkling water is available free of charge in the break area during the entire ISS.

At the venue you have free access to WiFi
- Connect to the wireless network called Scandic_easy
- Open your Internet browser and choose the button labeled CLICK TO CONNECT
- Enter your name and phone number and you are online immediately.

Once you have successfully been connected to Scandic_easy the system will recognize you when you return and you should only press the button labeled CONTINUE to be online.

The premises at the venue – Scandic Copenhagen

On the last page of this book you will find a bigger version of the floorplan of the venue.

Plenaries and sessions
During the Symposium plenaries and some sessions will take place in the *Grand Ball*-room. Other sessions will take place in the rooms *Christiansborg, Fredensborg* and *Kronborg.*
The names of the rooms refer to famous Danish castles: Christiansborg (where the parliament is), Fredensborg (where the Danish Queen lives in spring and autumn) and Kronborg (home for Shakespeare's Hamlet).

MatchMaking event
On Tuesday the special MatchMaking event for companies will take place in the Børsen-room. The name refers to the building for the Old Danish Stock Exchange.

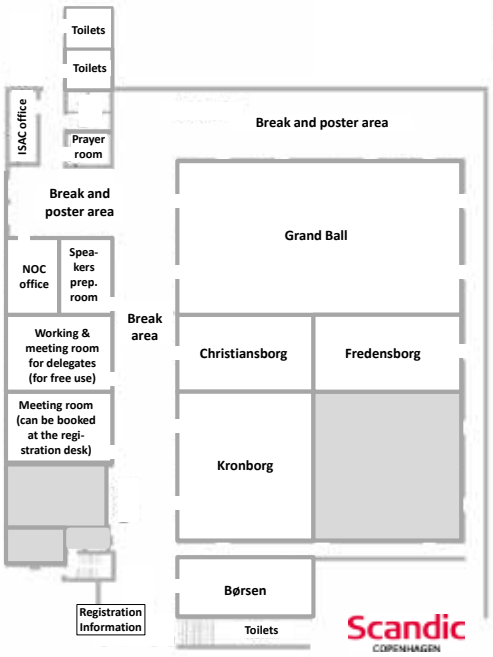
Break area
In the break area you will find coffee/tea-machines. The posters are also at show in the break area.

Free working and meeting room for delegates
Delegates who want a place where they can work on their computer or have a small meeting may freely use a special room opposite the session rooms for this purpose (see the floorplan). The name of the room is *Frederik* (name of the Danish Crown Prince).

A special meeting room can be booked
A room is available for groups wishing to arrange a meeting. Booking of this room must be made at the registration and information desk. The price is 400 DKK (= 60 USD or 55 Euro) per hour. If the room is not booked for a private meeting, it can be used free of charge by delegates who want a place where they can work on their computer. The name of the room is *Christian* (a name frequently used by Danish kings).

Prayer room
A special room is reserved for prayers for delegates who so wish. The room can be found on the floorplan, otherwise you can ask at the registration- and information desk.

Smoking
Smoking is not allowed in the conference area. Smokers are kindly asked to use a special outdoor area on the right when you exit the hotel main entrance.



Icebreaker reception

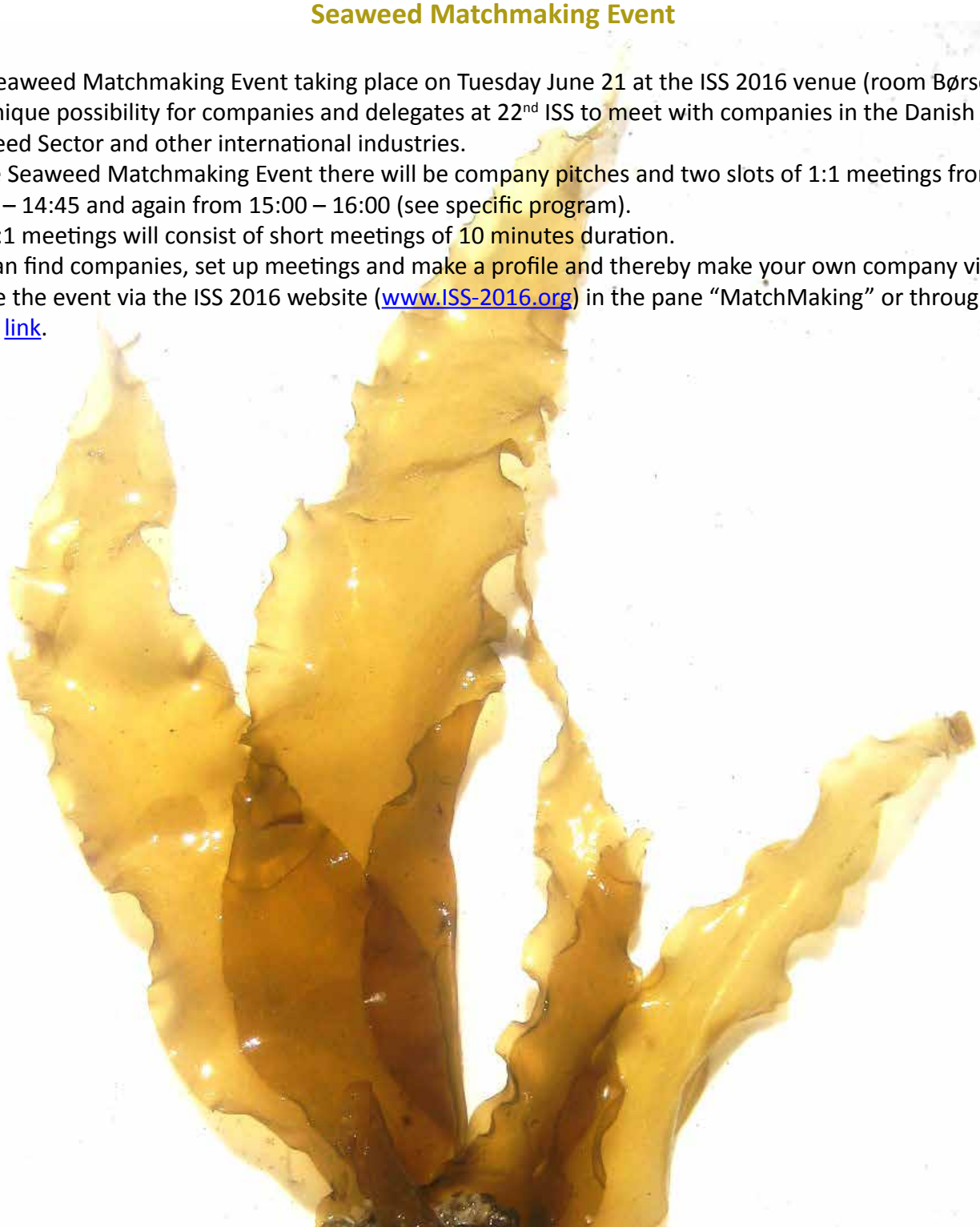
Sunday 18:30 – 20:00

We are pleased to welcome you at the Icebreaker reception on Sunday June 19, at 18:30-20:00. The reception will take place at the venue, Scandic Copenhagen Hotel, Vester Søgade 6, Copenhagen.

Meet and greet "old" international colleagues and collaborators, and get acquainted with new seaweed friends.
After the welcome from the chairman of the ISS 2016 you will be served snacks (not a full meal) and drinks and you will be able to enjoy the atmosphere with creative minds around seaweed. This includes seaweed jewellery from Iceland, a designed chair made of seaweed, fabric with seaweed print, Danish seaweed etc.

Seaweed Matchmaking Event

The Seaweed Matchmaking Event taking place on Tuesday June 21 at the ISS 2016 venue (room Børsen) is a unique possibility for companies and delegates at 22nd ISS to meet with companies in the Danish Seaweed Sector and other international industries.
At the Seaweed Matchmaking Event there will be company pitches and two slots of 1:1 meetings from 14:00 – 14:45 and again from 15:00 – 16:00 (see specific program).
The 1:1 meetings will consist of short meetings of 10 minutes duration.
You can find companies, set up meetings and make a profile and thereby make your own company visible before the event via the ISS 2016 website (www.ISS-2016.org) in the pane "MatchMaking" or through this direct link.



Seaweed MatchMaking Event

Place: Scandic Copenhagen Hotel (Room: Børsen)
Time: 9:30 am - 4.00 pm, June 21 2016

Program

9:30 Welcome to Seaweed MatchMaking Event at ISS-2016, Susan L. Holdt (Ass. Prof)

9:45 Company pitches

Startups, SME's and large industries from the Seaweed sector pitch their companies and products

10:45 Plenary at ISS 2016: The Seaweed Hydrocolloids Industry: 2015 Updates, Needs & Outlook, by **Hans Porse, Hydrocolloids and Brian Rudolph, CP Kelco, Denmark**

11.30 Plenary at ISS 2016: Research and Applications of Bioactive Seaweed Substances- A Brightmoon Perspective, by **Yimin Qin** director at State Key Laboratory of Bioactive Seaweed Substances **Qingdao Brightmoon Seaweed Group, China**

12:00 Networking Lunch (with ISS 2016 Symposium)

13:00 Company pitches

Startups, SME's and large industries from the seaweed sector pitch their companies and products

14:00 Speed dating

Short 1:1 meetings in parallel

14:45 Coffee (ISS Poster session)

15:00 Speed dating (continued)

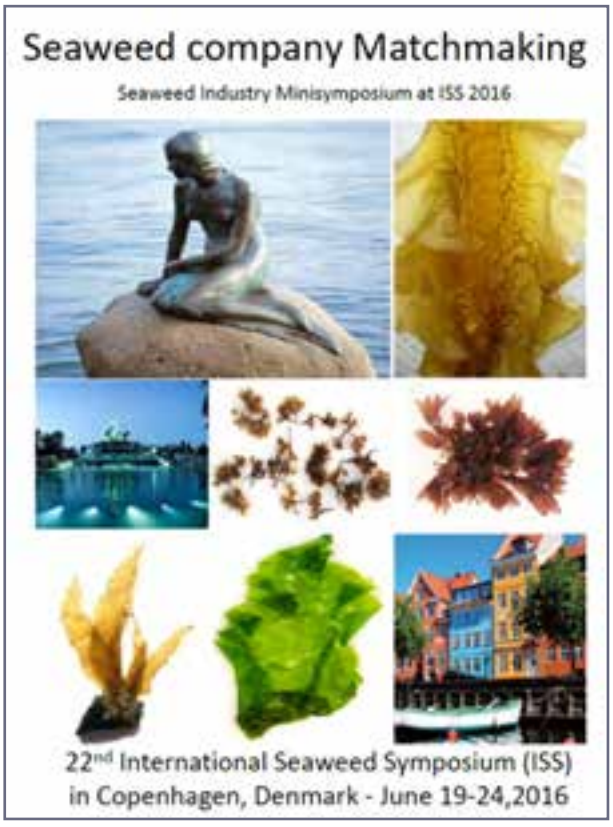
Short 1:1 meetings in parallel

16:00 Wrap up and end of Matchmaking Event

Networking

18.30-20.00 Join the reception at City Hall Copenhagen incl. pancakes and historical seaweed art

The Seaweed Matchmaking is sponsored by: Karl Pedersen and Wife's Industrial Foundation



Reception at the Copenhagen City Hall
Tuesday 18:30-20:00

Enjoy the nice stroll (<900 m) from Scandic Copenhagen to the City Hall at the City Square.
We will meet outside the lobby of Scandic Copenhagen hotel around 17.50-18.10 and walk in several groups to the City Hall.

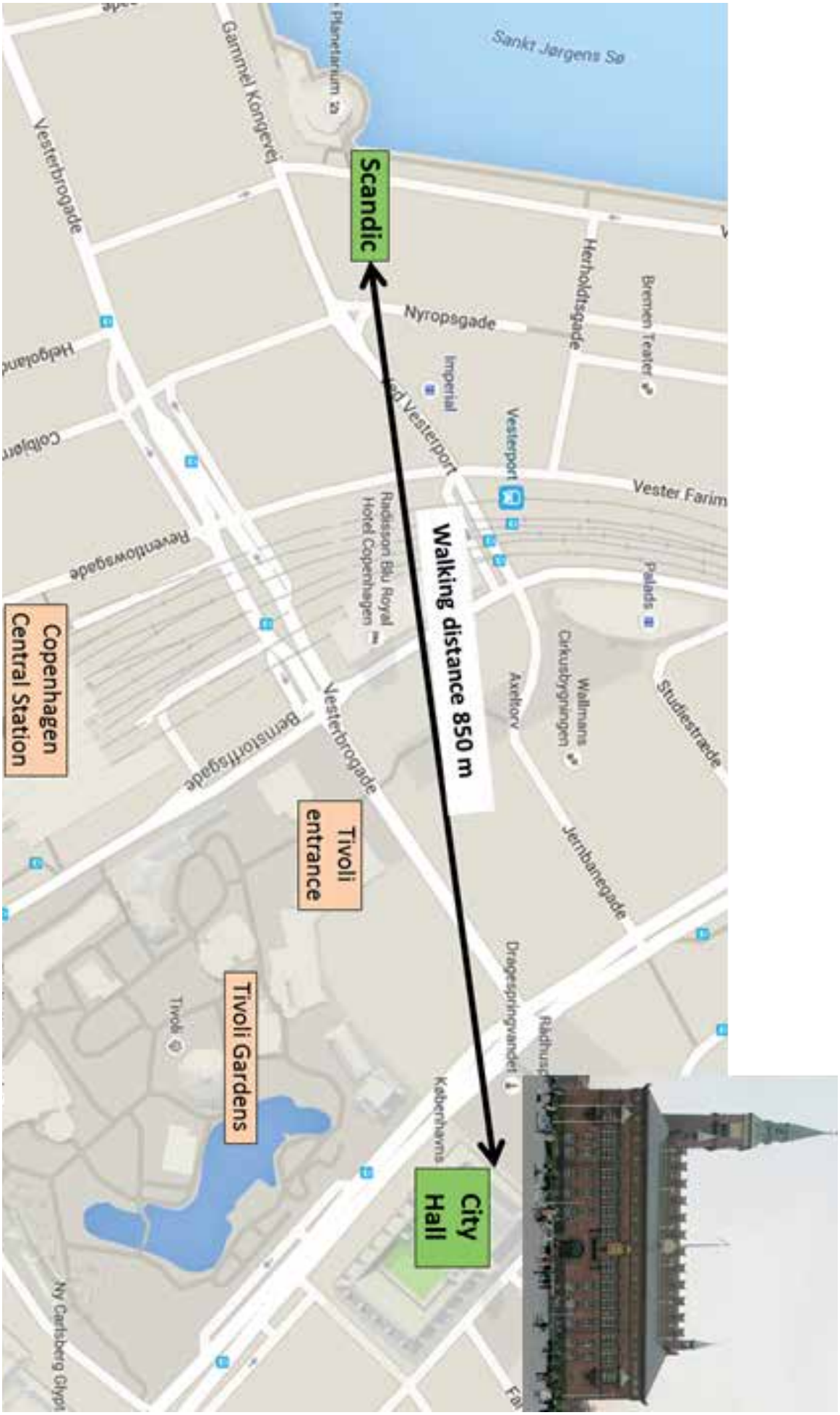
The designer of the City Hall was inspired by the City Hall of Sienna, Italy, with the high clock tower and the impressive building. From the square you can also see the amusement park Tivoli and a statue of the famous writer and storyteller H.C. Andersen.

You will get to see the beautiful architecture of the City Hall from the inside and be welcomed in the Main Hall be welcomed by a representative of the city council of wonderful Copenhagen.
Hereafter the renowned City Hall sweet pancakes will be served (this is not a full meal).
You will get a special and exclusive chance to see the unique seaweed wall paintings from back in 1902 by Jens Møller Jensen and wife decorating the office halls.

After the reception, Tivoli would be a nice choice of visit and in here you will be able to enjoy the beautiful garden and lakes, find a restaurant, and even try a carrousel and roller coaster.







Scandic
Walking distance 850 m
Copenhagen Central Station
Tivoli entrance
Tivoli Gardens
City Hall
Sankt Jørgens Sø
Gammel Kongevej
Vesterbrogade
Nyropsgade
Herholdtsgade
Bremen Teater
Imperial
Vesterport
Vester Farim
Radisson Blu Royal Hotel Copenhagen
Palads
Axeltorv
Wallmans Cirkusbygningen
Studiestræde
Jernbanegade
Bernstorffsgade
Tivoli
Ny Carlsberg

SYMPOSIUM DINNER

Thursday 18:30 –

The symposium dinner event will take place at restaurant Langelinie Pavillonen. It is an iconical and listed building designed by the same architects that designed the buildings for the Technical University of Denmark.
The new owners of the restaurant work seriously with their culinary artistry and have been awarded several times.

The busses will leave from Scandic towards the restaurant at 18:30. After the arriving at Langelinie Pavillonen (app. 19:00) welcome drinks are served at the restaurant terrace overlooking Copenhagen Harbour and with a view to the Little Mermaid sitting nearby on her stone.

For the ISS 2016 Symposium Dinner the chefs have created a special three-course menu consisting of Danish seasonal raw materials - and of course with seaweed in all three dishes.

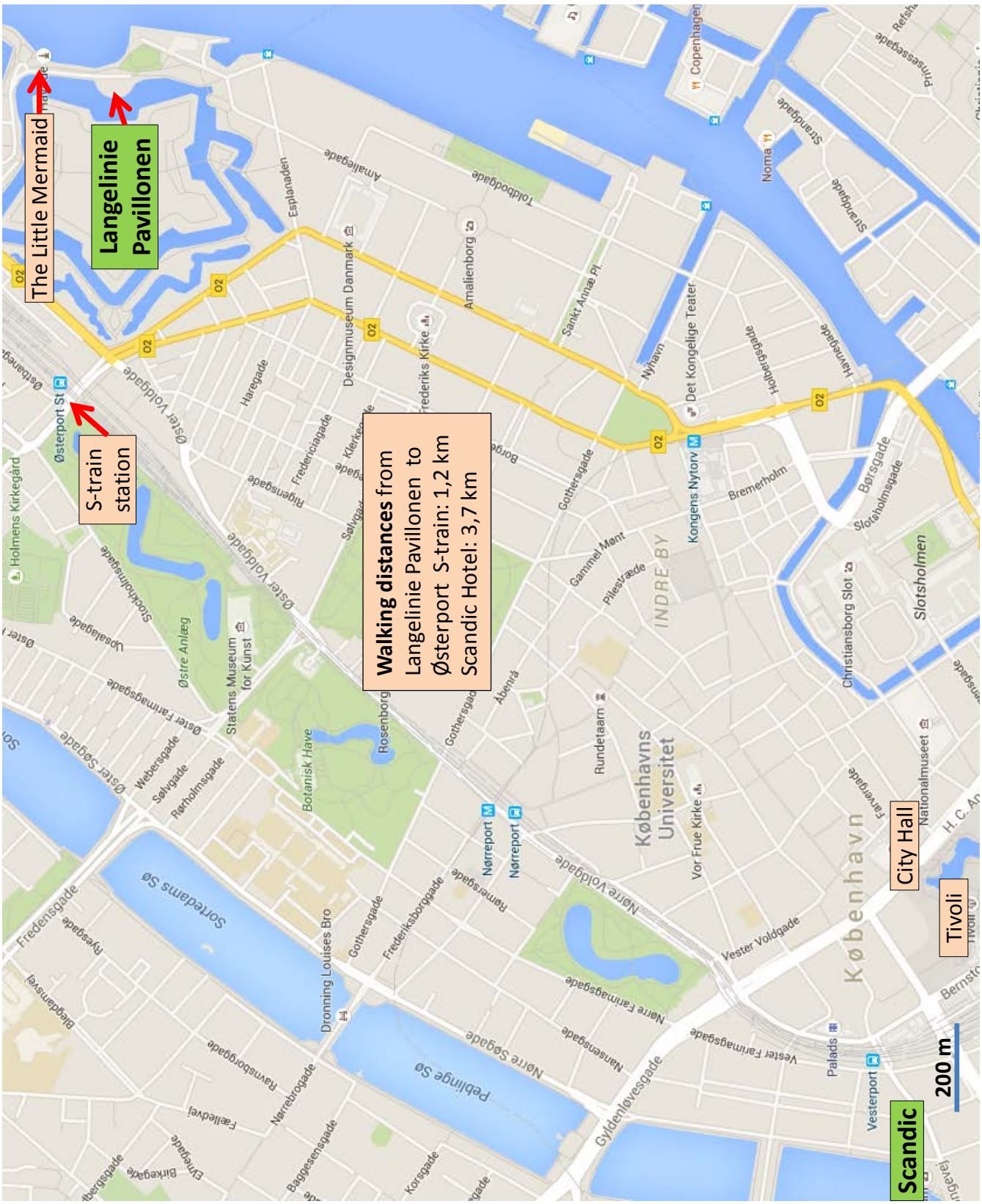
There will be a few speeches during the dinner. The main speech will be made by prof. Ole G. Mouritsen who will address “Those tasty weeds”.

After the dinner, coffee and tea will be served and the band will play music for dancing.

There will be free drinks during dinner, and a bar will open after the coffee and tea, where you must pay for the additional drinks.

The event ends after midnight – around 00:30 – and then you can choose to walk in the bright Danish summer night to your hotel or another place, or you can take the S-train from the nearby station, or you can choose to take a taxi. The walking distances to the train station is 1.2 km and to Scandic Copenhagen 3.7 km. (see the map).

Note: Participation in this event is included for delegates registered as regular participants at the ISS and for those students and accompanying persons that have bought a special ticket for the event. Tickets are also for sale at the registration and information desk.


The Little Mermaid
Langelinie Pavillonen
S-train station
Walking distances from Langelinie Pavillonen to Østerport S-train: 1,2 km Scandic Hotel: 3,7 km
City Hall
Tivoli
Scandic
200 m

Sunday					
17:00 - 20:00	Registration at the venue - Scandic Copenhagen				
18:30 - 20:00	'Ice breaker' - opening reception in break area at the venue - Scandic Copenhagen				
Monday	**Grand Ball**	**Kronborg**	**Christiansborg**	**Fredensborg**	
08:00 - 09:00	Registration + coffee / tea				
09:00 - 09:45	Opening ceremony				
09:45 - 10:30	Plenary Lecture (1)				
10:30 - 11:00	Coffee / tea				
11:00 - 13:00	Cultivation (1) - Landbased systems	Processing (1) - Alginate	Biofuel	History	
13:00 - 14:00	Lunch				
14:00 - 15:30	Cultivation (2) - Breeding + genetics	Processing (2) - Carrageenan	Ecology (1)	Seaweed valorization	
15:30 - 16:00	Coffee / tea				
16:00 - 17:30	Cultivation (3) - Design + surfaces	Bioactives (1) - Fucoidan	Ecology (2)	Risks assessment	
Tuesday	**Grand Ball**	**Kronborg**	**Christiansborg**	**Fredensborg**	
09:00 - 10:15	Ecology (3)	Bioactives (2)	IMTA and biomitigation (1)	Seaweed farming - The next agriculture	
10:15 - 10:45	Coffee / tea				
10:45 - 11:30	Plenary Lecture (2)				
11:30 - 12:00	Plenary Lecture (3)				
12:00 - 13:00	Lunch				
13:00 - 14:40	Ecology (4)	Bioactives (3) - Antioxidants	IMTA and biomitigation (2)	Seaweed farming - The next agriculture	
14:40 - 16:00	Poster-session (1)				
16:00 - 17:45	Ecology (5)	Bioactives and non food	Seaweed cell wall + associated microbes	Challenges and novel enzymes	
18:30 - 20:00	Social event: Reception at Copenhagen City Hall				
Thursday	**Grand Ball**	**Kronborg**	**Christiansborg**	**Fredensborg**	
08:40 - 10:40	Molecular (1) - Taxonomy	Seaweed for feed	Socio economics	Cultiv. - Optimising temperate seaweed	
10:40 - 11:15	Coffee / tea				
11:15 - 12:00	Plenary Lecture (4)				
12:00 - 13:00	Lunch				
13:00 - 14:15	Molecular (2)	Seaweed for food and feed	Management and harvest	Processing and biorefinery	
14:15 - 14:45	Plenary Lecture (5)				
14:45 - 16:15	Poster-session (2)				
16:15 - 17:30	Molecular (3)	Seaweed for food	Ecosystem service	Biorefinery, processing+novel enzymes	
18:30 -	Departure for Symposium Dinner				
Friday	**Grand Ball**	**Kronborg**	**Christiansborg**	**Fredensborg**	
09:00 - 10:40	Climate and Ecology	Molecular (4) - Stress and defense	Cultiv.(5) - Stimu-lation of growth	Future	
10:40 - 11:15	Coffee / tea				
11:15 - 12:00	Plenary Lecture (6)				
12:00 - 12:30	Closing ceremony				
12:30 -	Lunch at the venue or to go				

MONDAY

OPENING CEREMONY

Monday, 20 June 09:00 – 09:45 Room: Grand Ball

PLENARY LECTURE (1)

Monday, 20 June 09:45 – 10:30 Room: Grand Ball
Chair: Thierry Chopin

09:45-10:30 Key-01 - **The integrated culture of seaweeds in waste waters – environmental drivers and product options** - Rocky de Nys

10:30-11:00 **Break - Coffee / Tea**

CULTIVATION (1)
LANDBASED SYSTEMS

Monday, 20 June 11:00 – 13:00 Room: Grand Ball
Chairs: Jose Zertuche-Gonzales, Iain Neish

11:00-11:20 OR-01-01 - **Growth and antioxidant content of *Rhodymenia pseudopalmata* improved by light and salinity** - Hugo Pliego, Yolanda Freile-Pelegrín, Daniel Robledo

11:20-11:40 OR-01-02 - **Systems for achieving high productivity during cultivation of *Kappaphycus* and *Eucheuma*** - Shrikumar Suryanarayan, Iain C Neish*, Nelson Vadassery

11:40-12:00 OR-01-03 - **Correlation between yield qualities and environments of *Gracilaria* fisheri cultivation in Thailand** - Rapeeporn Ruangchuay*

12:00-12:20 OR-01-04 - **Pond cultivation of *Ulva spp* in Baja California, Mexico.** - Jose A Zertuche*, Alberto I Galvez-Palacios, Jose M Guzmán-Calderón, Estefania Cervantes-Rios, Laura B. Chanes-Miranda

12:20-12:40 OR-01-05 - **Land-based culture of *Halymenia durvillei* under varying light conditions** - Najeen Arabelle M Rula*

12:20-13:00 OR-01-06 - **Algae Technology Educational Consortium** - Ira A Levine*

PROCESSING (1)
ALGINATE

Monday, 20 June 11:00 – 13:00 Room: Kronborg
Chair: Duncan Macquarrie, Anne-Belinda Bjerre

11:00-11:20 OR-02-01 - **Industrial process effects on extraction of commercial colloids and fucoidans from Chilean seaweeds.** - Franck Hennequart*, Antoine Riviere

11:20-11:40 OR-02-02 - **Bimonthly variation in the chemical composition and biological activity of *Eisenia arborea*** - Cristina Landa Cansigno, Gustavo Hernández Carmona*, Dora L Arvizu Higuera, Mauricio Muñoz Ochoa, Claudia J Hernández Guerrero

11:40-12:00 OR-02-03 - **From seaweeds to smart biomaterials** - André Schulz*, Johanne Dobringer, Luca Gentile, Heiko Zimmermann, Julio A Vásquez

12:00-12:20 OR-02-04 - **Bioactive surfaces for the cultivation of human stem cells on seaweed-derived alginates** - Michael M Gepp*, André Schulz, Johanne Dobringer, Julio A Vasquez, Luca Gentile, Julia C Neubauer, Heiko Zimmermann

12:20-12:40 OR-02-05 - **Towards a Seaweed Biorefinery - Microwave assisted deconstruction of *Ascophyllum Nodosum*.** - Duncan J Macquarrie*

12:40-13:00 OR-02-06 - **Characterization of alginate gels with chitooligosaccharides of varying composition as crosslinkers** - Yiming Feng*, Georg Kopplin, Kjell Varum

BIOFUEL

Monday, 20 June 11:00 – 13:00 Room: Christiansborg
Chairs: Rocky De Nys, Jessica Adams

11:00-11:20 OR-03-01 - **MacroFuels – a H2020 project for development the next generation transportation biofuels.** - Jaap W. van Hal, Anne-Belinda Bjerre*

11:20-11:40 OR-03-02 - **Enzymatic hydrolysis for algae-derived biofuels** - Francesco Ometto*, Hana Kuci, Annika Björn, Jörgen Ejlertsson

11:40-12:00 OR-03-03 - **SeaGas: farmed *Saccharina latissima* as fresh and ensiled feedstock for anaerobic digestion** - Michelle I Morrison*

12:00-12:20 OR-03-04 - **Production of bio-coal, methane and fertilizer from seaweed using hydrothermal carbonisation** - Aidan M Smith*

12:20-12:40 OR-03-05 - **North Ronaldsay algae eating sheep harbours isolates with Ulvan lyases and cellulase activity** - Lucy A Onime-Akinmosin*, Sharon A Huws, Jessica Adams, David Bryant

12:20-13:00 OR-03-06 - **Carbohydrate analysis of seaweed in the biorefinery to chemicals and fuel context** - Jaap W. van Hal*, Wouter Huijgen, Anne-Belinda Bjerre, Ana M. López Contreras, Michele Stanley, Gudmundur O. Hreggvidsson

HISTORY

Monday, 20 June 11:00 – 13:00 Room: Fredensborg
Chair: Ruth Nielsen

11:00-11:40 OR-04-01 - **Moments of phycological history in the algal herbarium, Copenhagen** - Ruth Nielsen, Aase Kristiansen

11:40-12:00 OR-04-03 - **The 1st ISS at Edinburgh 1952: Applied seaweed science coming of age.** - Mentz Indergaard

12:00-12:20 OR-04-04 - **The history, present and future of Bangiales farming in China** - Wen J Wang*, Fu L Liu, Fei J Wang, Xiu T Sun, Zhou R Liang

12:20-12:40 OR-04-05 - **The uses of seaweed in Iceland; past and present** - Karl Gunnarsson

12:20-13:00 OR-04-06 - **Ethno-ecological approach of the seaweed in channels and fjords Sub-Antarctic of southern Chile.** - Jaime Ojeda, Andrés Mansilla, Tamara Contador, Rosenfeld Sebastián, Ricardo Rozzi

13:00-14:00 **Lunch**

CULTIVATION (2)
BREEDING AND GENETICS

Monday, 20 June 14:00 – 15:30 Room: Grand Ball
Chairs: Agnes M. Mortensen, Job Schipper

14:00-14:15 OR-05-01 - **Commercial hatchery of two kelps *Saccharina* and *Undaria* in China** - Shaojun Pang*

14:15-14:30 OR-05-02 - **Establishment of seaweed microcultures for the evaluation of plant growth regulators** - Nayem A. Chequer, José Q. García, Daniel Robledo

14:30-14:45 OR-05-03 - **Crust Growth of *Gloiopeltis furcata* (Rhodophyta) in Laboratory Culture** - Joon Kim*, Hyuen Joo Kim, Hyung Geun Kim

14:45-15:00 OR-05-04 - **Research on the potential of a *Pyropia yezoensis* green mutant as a new cultivar** - Zhang Tao, Zhu Jianyi

15:00-15:15 OR-05-05 - **Experimental growth of filaments into plantlets of *Grateloupia asiatica* (Rhodophyta)** - Hyung Geun Kim*, Ratih I Adharini

15:15-15:30 OR-05-06 - **Shortening the generation time to improve selective breeding in *Saccharina latissima*.** - Wouter Visch*

PROCESSING (2)
CARRAGEENAN

Monday, 20 June 14:00 – 15:30 Room: Kronborg
Chairs: Harris Bixler, Brian Rudolph

14:00-14:30 OR-06-01 - **The Carrageenan Controversy** - Harris Bixler

14:30-14:45 OR-06-03 - **Red seaweed bioactive compounds extraction by innovative technology combination** - Romain Boulho*, Céline Le Quemener, Grégoire Audo, Jean-Philippe Kucma, Yolanda Freile- Pelegrin, Daniel Robledo, Nathalie Bourgougnon, Gilles Bedoux

14:45-15:00 OR-06-04 - **Enzyme technology for handling red seaweeds for carrageenan and more** - Shilpa Ramani*

15:00-15:15 OR-06-05 - **Beyond carrageenan: development of technologies for full utilization of *Kappaphycus* biomass** - Iain C Neish*, Shrikumar Suryanarayan, Sawan Kumar, Sailaja Nori

15:15-15:30 OR-06-06 - **Bioactive compounds in industrial red seaweed used in carrageenan production** - Alireza Naseri*, Susan L Holdt, Charlotte Jacobsen

ECOLOGY (1)

Monday, 20 June 14:00 – 15:30 Room: Christiansborg
Chairs: Susse Wegeberg, Raul Ugarte

14:00-14:15 OR-07-01 - **Are proliferative seaweeds an exploitable and sustainable resource?** - Anne-Sophie Burlot, Declan Bennett, Gilles Bedoux, Nathalie Bourgougnon, Isuru Wijesekara Liyanage*

14:15-14:30 OR-07-02 - **Structure of epibionts associated with *Sargassum* and *Acanthophora* in La Paz, México** - Neysi Gálvez-Zeferino, Rafael Riosmena-Rodríguez, Gustavo Hernández-Carmona*, Jaime Gómez-Gutierrez

14:30-14:45 OR-07-03 - **Seasonal phenology and metabolomic of *Gracilaria vermiculophylla* (Bay of Brest, France)** - Gwladys Surget*, Klervi Le Lann, Gaspard Delebecq, Nelly Kervarec, Anne Donval, Nathalie Poupart, Valérie Stiger-Pouvreau

14:45-15:00 OR-07-04 - **Assessment of seedling ability of the introduced brown alga, *Sargassum horneri*, in northeast Taiwan** - Roger Huang*, Showe-Mei Lin, Li-Chia Liu, Yushan Qiu, Yi-Chi Wang

15:00-15:15 OR-07-05 - **The chemical ecology of seaweed invasions** - Henrik Pavia*

15:15-15:30 OR-07-06 - **Morphological plasticity and productivity in Giant kelp *Macrocystis pyrifera*.** - Alejandro H. Buschmann*, Sandra V. Pereda, Felix López-Figueroa, José L. Kappes, Robinson Altamirano, Karina Villegas, Bárbara Labbe, et al.

SEAWEED VALORIZATION

Monday, 20 June 14:00 – 15:30 Room: Fredensborg
Chairs: Jaap van Haal, Dagmar Stengel

14:00-14:15 OR-08-01 - **Pro-SeaVeg – Profiling and enhancing bioactive yields in Irish red sea vegetables** - Dagmar B Stengel*, Anna Gietl, Elena Varela Alvarez, Paul Tobin, Juliane Stack, Richard FitzGerald

14:15-14:30 OR-08-02 - **Seasonal variation in nitrogenous components and bioactivity of *Porphyra dioica* protein hydrolysates** - Julianne Stack*, Paul Tobin, Anna Gietl, Dagmar Stengel, Padraigin Harnedy, Richard FitzGerald,

14:30-14:45 OR-08-03 - **Expansion and potential of valorization of *Grateloupia turuturu* along the French Western coast** - Valérie Stiger-Pouvreau, Erwan Plouguerné, Audrey Claude, Klervi Le Lann, Solène Connan*, Marie-Aude Poullaouec, Eric Deslandes

14:45-15:00 OR-08-04 - **Lipid composition of *Ulva armoricana, Solieria chordalis* and *Sargassum muticum* from Brittany** - Nolwenn Terme*, Melha Kendel, Gaëtane Wielgosz-Collin, Samuel Bertrand, Christos Roussakis, Nathalie Bourgougnon, Gilles Bedoux

15:00-15:15 OR-08-05 - **Macroalgae Biomass Supply Chain: Seasonal variation in the preservation parameters of *Ulva lactuca*** - Hilary Redden*, H. C. Greenwell

15:15-15:30 OR-08-06 - **The impact of sample preparation parameters on bioethanol and methane yields from *Laminaria digitata*** - Jessica Adams*

15:30-16:00 **Break - Coffee / Tea**

CULTIVATION (3)
DESIGN AND SURFACES

Monday, 20 June 16:00 – 17:15 Room: Grand Ball
Chair: Philip Kerrison, Jorunn Skjermo

16:00-16:15 OR-09-01 **– High yield seaweed cultivation using advanced textiles** - Bert Groenendaal*

16:15-16:30 OR-09-02 - **A novel cultivation method of filamentous *Ulva sapora* by seeding free-floating surfaces** - Tine Carl*, Rebecca J Lawton, Marie Magnusson, Nicholas A Paul, Rocky de Nys

16:30-16:45 OR-09-03 - **Cultivation of *Palmaria palmata* screening for viable substrates and improving spore growth** - Mette M Nielsen*, Paula Canal-Vergés

16:45-17:00 OR-09-04 - **The optimal substrate preference of *Saccharina latissima* for large-scale cultivation on textiles** - Philip D Kerrison, Michele S Stanley, Maeve Kelly, Kenny D Black, Adam D Hughes

17:00-17:15 OR-09-05 - **Effect of different planting distances on the growth of tissue-cultured *Kappaphycus alvarezii*** - La Ode M. Aslan*, Ruslaini R. Ongko, Walba Sahrir, Armin Sainuddin, Rahmad Sofyan Patadjai

BIOACTIVES (1)
FUCOIDAN

Monday, 20 June 16:00 – 17:30 Room: Kronborg
Chairs: Franck Hennequart, Charlotte Jacobsen

16:00-16:15 OR-10-01 - **Sustainable bioprocesses for the extraction of antiherpetic polysaccharides from *Solieria chordalis*** - Nathalie Bourgougnon*, Anne-Sophie Burlot, Romain Boulho, Yolanda Freile-Pelegrín, Christel Marty, Daniel Robledo, Gilles Bedoux

16:15-16:30 OR-10-02 - **Fucoidan: Connecting analysis and bioactivity** - Damien N Stringer*, Helen Fitton, Samuel S Karpiniec

16:30-16:45 OR-10-03 - **Crude fucoidan in Danish brown algae - seasonal variations and environmental impact** - Annette Bruhn*, Tina Janicek, Dirk Manns, Mette M Nielsen, Lasse H Nielsen, Anne S Meyer, Michael Bo Rasmussen, et al.

16:45-17:00 OR-10-04 - **The seasonal variation of fucoidan from 3 species of brown macroalgae** - Harriet Fletcher*, Andrew Ross, Patrick Biller

17:00-17:15 OR-10-05 - **Fucoidan and cancer: research and clinical interaction studies** - Helen Fitton, Damien N Stringer*, Nuri Guven, Judith A Smith

17:15-17:30 OR-10-06 - **Seasonal variance in polyphenol and polysaccharide content in brown seaweed.** - Rósa Jónsdótttir, Ásta H Pétursdóttir, Björn V Aðalbjörnsson, Hilma E Bakken, Jóna Freysdóttir, Karl Gunnarsson

ECOLOGY (2)

Monday, 20 June 16:00 – 17:30 Room: Christiansborg
Chairs: Helena Abreu, Henrik Pavia

16:00-16:15 OR-11-01 - ***Macrocystis pyrifera*** **prioritizes tissue maintenance in response to nitrogen fertilization** - Tiffany Stephens*, Chris Hepburn

16:15-16:30 OR-11-02 - **Phenology of *Chondracanthus tenellus* (Rhodophyta) in central Pacific coast of Honshu, Japan** - Yuhi Hayakawa, Kenta Kawata, Kazuma Machida, Shunro Yamano, Shingo Akita, Daisuke Fujita

16:30-16:45 OR-11-03 - **Genetic and environmental variation of *Undaria pinnatifida* originating from five sites in Japan** - Yoichi Sato*, Tomonari Hirano, Hiroyuki Ichida, Yutaka Ito, Miho Mogamiya, Motoko Murakami, Nobuhisa Fukunishi, Tomoko Abe, Shigeyuki Kawano

16:45-17:00 OR-11-04 - **Uptake kinetics and storage capacity of dissolved inorganic phosphorus in *Ulva lactuca*** - Alexander Lubsch*

17:00-17:15 OR-11-05 - **Species-specific patterns of induced defenses in Korean macroalgae and herbivores** - Jeong Ha Kim, Kwon Mo Yang*, Byung Hee Jeon

17:15-17:30 OR-11-06 - **Seawater pH, and not inorganic nitrogen source, affects pH at the blade surface of the giant kelp** - Pamela A Fernández, Michael Y Roleda, Pablo P Leal, Catriona L Hurd*

RISKS ASSESSMENT

Monday, 20 June 16:00 – 17:15 Room: Fredensborg
Chairs: Jens J. Sloth, Dagmar Stengel

16:00-16:30 OR-12-01 - **Toxic trace elements in seaweed – occurrence, analysis and food safety assessment** - Jens J Sloth*

16:30-16:45 OR-12-03 - **Biological monitoring of *Kappaphycus alvarezii* pilot farming in Ecuador** - Milton G Montúfar Romero*, Teodoro A Cruz Jaime, Raúl E Rincones León

16:45-17:00 OR-12-04 - **Iodine content in seaweeds: variability, and implications for dietary nutrition and health risks** - Michael Y Roleda*, Udo Nitschke, Céline Rebours, Jorunn Skjermo, Hélène Marfaing, Ronan Pierre, Rósa Jónsdóttir, Annelise Chapman, Dagmar Stengel

17:00-17:15 OR-12-05 - **In situ assessment of *Ulva sp*. as a biomonitoring tool of metal polluted estuaries** - Daniela R Farias*, Catriona Hurd, Ruth Eriksen, Carmen Simioni, Eder Schmidt, Zenilda Bouzon, Catriona Macleod

TUESDAY

ECOLOGY (3)

Tuesday, 21 June 09:00 – 10:15 Room: Grand Ball
Chairs: Michael Roleda, Kjersti Sjøtun

09:00-09:15 OR-13-01 - **Kelp forest communities at Cape Farewell, Greenland; a quantitative approach and associated food web** - Susse Wegeberg*, Frank Rigét, Jozef Wiktor, Jr., Jens T Christensen, Jens Deding, Michael B Rasmussen, Mikael K Sejr

09:15-09:30 OR-13-02 - **Contrasting timing of life stages across latitudes – a case of a marine forests forming species** - Tânia R Pereira*

09:30-09:45 OR-13-03 - **The recruitment of *Ascophyllum nodosum* in Eastern Canada: Is it really a stochastic event?** - Raul Ugarte

09:45-10:00 OR-13-04 - **Two Southern African commercial kelps: latitudinal changes in dominance and the environment** - Mark D Rothman*, John J Bolton, Chris J.T. Boothroyd, Derek A Kemp, Robert J Anderson

10:00-10:15 OR-13-05 - **Salinity effects on different life history stages of *Sargassum hemiphyllum* from Hong Kong** - Karen Y. Kam*

BIOACTIVES (2)

Tuesday, 21 June 09:00 – 10:15 Room: Kronborg
Chairs: Franck Hennequart, Gilles Bedoux

09:00-09:15 OR-14-01 – **An innovative approach to develop sustainable marine active ingredients from macroalgae** - Erwan Le Gélébart*

09:15-09:30 OR-14-02 - **Prebiotic potential of brown seaweed by in vitro human gut bacteria fermentation** - Suvimol Charoensiddhi*, Michael Conlon, Michelle Vuaran, Christopher Franco, Wei Zhang

09:30-09:45 OR-14-03 - **Seaweed as a tool against obesity** - Eva Kuttner*, Margrét E Asgeirsdottir, Hordur G Kristinsson

09:45-10:00 OR-14-04 - **Revealing the functional potential of seaweed and mesoherbivore-associated microbiomes** - Aschwin H Engelen*, Tania Aires, Gerard Muyzer, Ester A Serrão

10:00-10:15 OR-14-05 - **Brown seaweed and cancer: melanoma** - Jane Teas*

IMTA AND BIOMITIGATION (1)
Minisymposium

Tuesday, 21 June 09:00 – 10:15 Room: Christiansborg
Chair: Thierry Chopin, Alejandro Buschmann

09:00-09:30 OR-15-01 - **The Canadian IMTA Network (2010-16): what have we learned regarding the inorganic component?** - Thierry Chopin*

09:30-09:45 OR-15-03 - **An economic analysis of Integrated Multi-Trophic Aquaculture (IMTA) – A Norwegian case study** - Nicolai A. Sandberg, Eirik S. Amundsen, Céline M.O. Rebours

09:45-10:00 OR-15-04 - **Macroalgal component of a novel recirculating land-based integrated multi-trophic aquaculture system** - Dennis Hanisak*, Paul Wills

10:00-10:15 Discussion

SEAWEED FARMNING: THE NEXT AGRICULTURE (1)
Minisymposium

Tuesday, 21 June 09:00 – 10:15 Room: Fredensborg
Chairs: Ricardo Radulovich, Holly Cronan

09:00-09:30 OR-16-01 - **Seaweed aquaculture as a match for agriculture** - Amir Neori*, Niva Tadmor Shalev, Moshe Agami

09:30-09:45 OR-16-03 - **Farming of agarophytes in India.** - Ganesan Meenakshisundaram*, Eswaran Karuppannan, Reddy C. Radhakrishna

09:45-10:00 OR-16-04 - **Institutional innovation and the emergence of sustainable seaweed aquaculture industries** - Holly Cronin*

10:00-10:15 OR-16-05 - **European production of kelps - an overview** - Annette Bruhn*, Benoit Queguineur, Maeve Edwards, Anna Soler-Vila

10:15-10:45 **Break - Coffee / Tea**

PLENARY LECTURES (2)+(3)

Tuesday, 21 June 10:45 – 12:00 Room: Grand Ball
Chair: Eric Ask

10:45-11:30 Key-02 - **The Seaweed Hydrocolloids Industry: 2016 Updates, Needs & Outlook** - Hans Porse, Brian Rudolph

11:30-12:00 Key-03 - **Research and applications of bioactive seaweed substances -A Brightmoon perspective** - Yimin Qin

13:00-14:00 **Lunch**

ECOLOGY (4)

Tuesday, 21 June 13:00 – 14:40 Room: Grand Ball
Chairs: Aleksander Handå, Catriona Hurd

13:00-13:20 OR-17-01 - **Evolution of size in large seaweeds: an empirical test of "universal" biomass scaling relationships** - Samuel Starko*, Patrick T Martone

13:20-13:40 OR-17-02 - **The importance of chimeric holdfasts as genetic reservoirs for kelp resilience and management.** - Alejandra Gonzalez*, Jessica Beltran, Veronica Flores, Bernabe Santelices

13:40-14:00 OR-17-03 - **Phylogeographical study revealed instability of annual *kelp Ecklonia radicosa* population** - Shingo Akita*, Keiichiro Koiwai, Keigo Kobayashi, Hidehiro Kondo, Ikuo Hirono, Daisuke Fujita

14:00-14:20 OR-17-04 - **Germplasm banking of the giant kelp: our biological insurance in a changing environment** - Sara I Barrento*, Carolina Camus, Isabel Sousa-Pinto, Alejandro Buschmann

14:20-14:40 OR-17-05 - **Characterization of newly developed EST-derived SSR markers specific to kelp *Saccharina latissima*** - Jaromir Guzinski*, Stéphane Mauger, J. Mark Cock, Myriam Valero

BIOACTIVES (3)
ANTIOXIDANTS

Tuesday, 21 June 13:00 – 14:40 Room: Kronborg
Chairs: Gilles Bedoux, Franck Hennequart

13:00-13:20 OR-18-01 - **Bioactive Compounds from Seaweeds: Cosmetic Applications and Perspectives** - Gilles Bedoux*, Romain Boulho, Anne Sophie Burlot, Maya Puspita, Isuru Wijesekara, Christel Marty, Nolwenn Terme, Nathalie Bourgougnon

13:20-13:40 OR-18-02 - **The natural variation of phlorotannin profiles in Irish commercially valuable brown seaweeds** - Dara A Kirke*, Dilip K Rai, Thomas J Smyth, Dagmar B Stengel

13:40-14:00 OR-18-03 - **Polyphenolic compounds from *Fucus vesiculosus* and their antioxidant activity** - Ditte B. Hermund*

14:00-14:20 OR-18-04 - **Seasonal variations of antioxidants in the brown seaweed *Saccharina latissima*** - Ann-Dorit M Sørensen, Hamed Safafar, Anja H Pedersen, Gonçalo S Marinho, Susan Løvstad Holdt*

14:20-14:40 OR-18-05 - **Total phenolic content and biological activity of *Sargassum muticum* enzymatic hydrolysates** - Maya Puspita*, Ita Widowati, Ocky K Radjasa, Philippe Douzenel, Christel Marty, Laurent Vandanjon, Gilles Bedoux, Nathalie Bourgougnon

IMTA AND BIOMITIGATION (2)
Minisymposium (continued)

Tuesday, 21 June 13:00 – 14:40 Room: Christiansborg
Chairs: Alejandro Buschmann, Thierry Chopin

13:00-13:20 OR-19-01 - **Optimizing high-value compounds in a land-based IMTA system: protein and natural dyes from seaweed** - Helena Abreu*, Andreia Rego, Rui Pereira, Juan-Luis G Pinchetti, Tamara Rodriguez

13:20-13:40 OR-19-02 - **Nutrient compensation as management tool – Sugar kelp production in sustainable aquaculture** - Peter Schmedes*, Teis Boderskov, Gonçalo Marinho, Susan Holdt

13:40-14:00 OR-19-03 - **The ecological processes and bioremendiation effects of *Gracilaria lemaneiformis* cultivation** - Yu Feng Yang

14:00-14:20 OR-19-04 - **Nutrient bioextraction and bioenergy recovery from ocean outfalls of treatment works** - Shane Rogers*

14:20-14:40 Discussion

SEAWEED FARMNING: THE NEXT AGRICULTURE (2)
Minisymposium (continued)

Tuesday, 21 June 13:00 – 14:40 Room: Fredensborg
Chairs: Ricardo Radulovich, Holly Cronan

13:00-13:40 OR-20-01 - **Effects of floating macroalga masses and farms on climate change and related issues** - Ricardo Radulovich

13:40-14:00 OR-20-03 - **Pilot scale cultivation of *Sarcothalia crispata* in southern Chile** - Jaime Zamorano*

14:00-14:20 OR-20-04 - **Drones for monitoring of seaweed farms** - Michael J.D. Linden-Vørnle

14:20-14:40 Discussion

POSTER SESSION 1

Tuesday, 21 June 14:40 – 16:00 Room: Break area

After this overview of the sessions and oral presentations follows an overview that shows topics and titles for the exhibited posters. Please note that these posters are exhibited only on Monday and Tuesday, as there are others on Thursday and Friday.

14:40-16:00 Poster session

ECOLOGY (5)

Tuesday, 21 June 16:00 – 17:45 Room: Grand Ball

Chairs: Kjersti Sjøtun, Catriona Hurd

16:00-16:15 OR-21-01 - **Subtidal benthic macroalgae from Easter Island obtained by germling emergence** - Liliana A Munoz*, Frithjof C. Kuepper, Maria E Ramirez, Pedro Murua, Akira F Peters

16:15-16:30 OR-21-02 - **Spatial and Temporal Patterns of Seaweeds in Macao SAR, PRC** - Karen A Tagulao*, Karen Kam Yi Lam

16:30-16:45 OR-21-03 - **Population fitness at the southern edge of species distribution** - Rita Araújo*

16:45-17:00 OR-21-04 - **The variable routes of rafting: dynamics of floating bull-kelp *Durvillaea antarctica*** - Martin Thiel*

17:00-17:15 OR-21-05 - **Coralline diversity along a kelp forest density gradient: how barren are urchin barrens?** - Patrick T Martone*, Katharine Hind

17:15-17:30 OR-21-06 - **Distribution, phenology and dominant carrageenan type of *Chondrus elatus* endemic to Japan** - Daisuke Fujita*, Heikichi Hosoya, Reina Hosoya, Yuhi Hayakawa, Rando Tuvikene

17:30-17:45 OR-21-07 - **Phylogenetic systematics and diversity of Seaweeds from Indian Coast** - Felix Bast*

BIOACTIVES (4) AND NON FOOD

Tuesday, 21 June 16:00 – 17:45 Room: Kronborg

Chairs: Ingrid Undeland, Jeff Hafting

16:00-16:15 OR-22-01 - **Seaweeds and the human brain** - Lynn Cornish

16:15-16:30 OR-22-02 - **Nutrient composition, antioxidant and antiobesity properties of Sabah red and brown seaweeds** - Patricia Matanjun*

16:30-16:45 OR-22-03 - **Biobased plastics from seaweed – Seabioplas EU project** - Yannick Lerat, Julie Maguire*, Marc Shorten, Helena Abreu, Rui Pereira, Ana Lopez-Contreras, Roel Helmes, et al.

16:45-17:00 OR-22-04 - **Alginate gels with new crosslinkers** - Kjell M Varum*, Georg Kopplin, Yiming Feng, Kimihiko Sato

17:00-17:15 OR-22-05 - **Seaweed compost for agricultural crop production** - Andrew J Cole

17:15-17:30 OR-22-06 - ***Ascophyllum nodosum* extracts mediated salinity tolerance in *Arabidopsis*** - Pushp S. Shukla*

17:30-17:45 OR-22-07 - **Effect of seaweeds on vegetables growth under glasshouse condition** - Ramal Yusuf*

SEAWEED CELL WALL AND ASSOCIATED MICROBES

Tuesday, 21 June 16:00 – 17:45 Room: Christiansborg
Chair: Balakrishnan Prithiviraj, Solene Connan

16:00-16:15 OR-23-01 - **A brown epi-endophyte, *Mikrosyphar zosterae*, produces galls on *Chondrus ocellatus* fronds** - Han Gil Choi*, Cyr Abel Ogandaga Maranguy, Young Sik Kim, Ki Wan Nam

16:15-16:30 OR-23-02 - **The response of *Chondrus ocellatus* to two endophytes, *Mikrosyphar zosterae* and *Ulvella ramosa*** - Cyr Abel Ogandaga Maranguy*, Han Gil Choi, Sang Rae Lee

16:30-16:45 OR-23-03 - **Convergence of mechanism(s) of action of bioactives of *Ascophyllum nodosum*** - Balakrishnan Prithiviraj*, Alan T Critchley

16:45-17:00 OR-23-04 - **Bacteria isolated from brown seaweed impart salinity tolerance in land plants** - Balakrishnan Prithiviraj, Saisrihari Prithiviraj*, Pramod Rathor

17:00-17:15 OR-23-05 - **Glycomics in brown algae: enzymatic profiling off cell-wall polysaccharides for population screening** - Kevin Hardouin*, Sophie Le Gall, Mirjam Czjzek, Gurvan Michel, Cécile Hervé

17:15-17:30 OR-23-06 - **Monoclonal antibodies generated against plant cell wall components bind to epitopes present in algae** - Zoe A Popper, Sandra C Raimundo

17:30-17:45 OR-23-07 - **Reversible cell wall swelling controls sieve tube transport in Laminariales** - Jan Knoblauch, Sarah Tepler Drobnitch, Winfried S Peters*, Michael Knoblauch

CHALLENGES AND NOVEL ENZYMES

Tuesday, 21 June 16:00 – 17:30 Room: Fredensborg
Chairs: Peter Stougaard, Xiaoru Hou

16:00-16:15 OR-24-01 - **Transcriptome analysis on the pathogen responsive genes in a red alga *Pyropia tenera*** - Gwang Hoon Kim*

16:15-16:30 OR-24-02 - ***Pythium porphyrae*, the agent of the red seaweed rot disease: a reformed plant pathogen?** - Claire MM Gachon, Jong Won Han, Antonios Zambounis, Tatyana Klochkova, Yacine Badis*, Lisa Breithut, Gwang Hoon Kim

16:30-16:45 OR-24-03 - **Back to basics: global shortage of bacteriological and technical agars** - Ricardo A Melo*, Rui O.P. Santos

16:45-17:00 OR-24-04 - **Extraction and characterization of alginate from Ghanaian brown seaweed** - Nanna Rhein-Knudsen, Marcel Tutor Ale, Gloria Naa Dzama Addico, Amoako Atta deGraft-Johnson, Anne S. Meyer

17:00-17:15 OR-24-05 - **Novel algae degrading enzymes for the production of bioactive oligosaccharides** - Mikkel Schultz-Johansen, Pernille K Bech, Mikkel A Glaring, Peter Stougaard

17:15-17:30 OR-24-06 - **Novel seaweed-degrading-microorganisms and enzymes technology for bioenergy production** - Marcel T Ale, Anders Thygesen*, Gloria N.D. Addico, Iddrissu A. Mumeen, Nanna R Knudsen, Moses Mensah, Anne S Meyer

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SOCIAL EVENT

18:30-20:00 RECEPTION AT COPENHAGEN CITY HALL
Find information about this event at the front of this book

WEDNESDAY

MID SYMPOSIUM EXCURSIONS

Special information thereon is sent to the registered participants of the different tours.
The information can also be picked up at the information desk.

THURSDAY

MOLECULAR (1)
TAXONOMY

Thursday, 23 June 08:40 – 10:40 Room: Grand Ball
Chairs: Ester Serrão, Michele Stanley

08:40-09:00 OR-25-01 - **Characterization of Genome Structure of *Pyropia haitanensis* Chang et Zheng (Bangiales, Rhodophyta)** - Yunxiang Mao*, Min Cao, Fanna Kong

09:00-09:20 OR-25-02 - **Towards the description of a new species of Phytomyxid parasite infecting *Durvillaea* (Phaeophyceae)** - Pedro Murúa*, Franz Goecke, Renato Westermeier, Pieter van West, Frithjof C. Küpper, Sigrid Neuhauser

09:20-09:40 OR-25-03 - **Taxonomy of *Amphiroa Lamouroux*, 1812 (Corallinales, Rhodophyta) from the Southern Mexican Pacific** - Edgar F. Rosas-Alquicira*, Susana Sánchez-Palestino*, Nancy Morales-Vásquez, José A. Montoya-Márquez

09:40-10:00 OR-25-04 - **Taxonomic Revision And Reproduction Of The green Algal Family Ulvaceae From Taiwan** - Showe-Mei Lin*, Teng-Yi Huang

10:00-10:20 OR-25-05 - **Diversity and molecular phylogeny of *Hydroclathrus* (Phaeophyceae) from the Western Pacific** - Wilfred John E Santiañez*, Kazuhiro Kogame

10:20-10:40 OR-25-06 - ***Sargassum* species from the Yucatan coast: morphological and chemical characterization** - Luis Alberto Rosado Espinosa, Emmanuel Hernández Nuñez, Yolanda Freile-Pelegrín, Daniel Robledo*

SEAWEED FOR FEED

Thursday, 23 June 08:40 – 10:40 Room: Kronborg
Chairs: Stefan Kraan, Rocky De Nys

08:40-09:00 OR-26-01 - **Effects of the humidity and glass transition on the shrinkage of sugar kelp during drying** - Balunkeswar Nayak*, Praveen Sappati, Peter vanWalsum, John Belding

09:00-09:20 OR-26-02 - **PROMAC - Energy-efficient processing of macroalgae in blue-green value chains** - Annelise S Chapman*

09:20-09:40 OR-26-03 - **Evaluation of minerals and vitamins in the Danish cultivated sugar kelp** - Gonçalo S Marinho*, Susan L. Holdt, Jens J Sloth, Jette Jacobsen, Irini Angelidaki

09:40-10:00 OR-26-04 - **Seaweed as Food and Feed - a future potential for Greenland** - Nuka Møller Lund*

10:00-10:20 OR-26-05 - **Seaweeds as a protein source for mono-gastric livestock** - Alex Angell*

10:20-10:40 OR-26-06 - **Cultivated *S. latissima* and *A. esculenta* as feed protein source** - Jorunn Skjermo*, Silje Forbord, Aleksander Handå, Kristine Steinhovden, Sophie Fische, Vera Kristinova, Rasa Slizyte, et al.

SOCIO ECONOMICS

Thursday, 23 June 08:40 – 10:40 Room: Christiansborg
Chairs: Marianne Thomsen, Celine Rebours

08:40-09:00 OR-27-01 - **The circular economy of seaweed as nutrient management instrument for biobased production** - Marianne Thomsen*, Michele Seghetta, Annette Bruun, Per Dolmer, Ditte Bruunshøj Tørring, Berit Hasler

09:00-09:20 OR-27-02 - ***Kappaphycus* farming a source of livelihood for the fishermen in Tamilnadu, Southeast coast of India** - Perumal Anantharaman*, C. Periyasamy, P. V. Subba Rao

09:20-09:40 OR-27-03 - **Preliminary assessment of *Kappaphycus alvarezii* cultivation in Ecuador** - Raúl E Rincones*, Teodoro A Cruz, Milton G Montúfar

09:40-10:00 OR-27-04 - **Socio-economic status of seaweed farming in the Philippines** - Frances Camille Rivera, Rex Samuel Jr Abao, Hilly Ann R Quiaoit

10:00-10:20 OR-27-05 - **Seaweed culture techniques and practices in Eastern Visayas and NorthWestern Mindanao** - Wilfredo H Uy*, Gergie Ambato

10:20-10:40 OR-27-06 - **Phycomorph, a European COST network on macroalgal growth and development** - Bénédicte Charrier*

CULTIVATION (4)
OPTIMISING TEMPERATE SEAWEEDS

Thursday, 23 June 08:40 – 10:40 Room: Fredensborg
Chair: Jose Zertuche-Gonzales, Job Schipper

08:40-09:00 OR-28-01 - **Semi-exposed large-scale seaweed cultivation pilot: results and lessons learnt** - Frank Neumann

09:00-09:20 OR-28-02 - **Yield optimization strategy of *Macrocystis pyrifera* aquafarming in Chile.** - Carolina Camus*, Javier Infante, Alejandro H. Buschmann

09:20-09:40 OR-28-03 - **Variation in growth and quality of *Saccharina latissima* cultivated in the Faroe Islands** - Agnes Mols-Mortensen*, Elma G Ortind, Susan L Holdt, Charlotte Jacobsen

09:40-10:00 OR-28-04 - **Regrowth and biofouling in two species of cultivated kelp** - Christine Rolin*, Rhiannon Rolin, Josh Laing, Lesley McEvoy

10:00-10:20 OR-28-05 - **Cultivation period elongation of *Saccharina japonica* for abalone feed industry in Korea** - Eun Kyoung Hwang*, Ho Chang Yoo, Dong Soo Ha, Chan Sun Park

10:20-10:40 OR-28-06 - **The inner Danish waters as suitable seaweed cultivation area-evaluation of abiotic factors** - Urd G Bak*, Susan L Holdt, Morten F Pedersen

10:40-11:15 **Break - Coffee / Tea**

PLENARY LECTURE (4)

Thursday, 23 June 11:15 – 12:00 Room: Grand Ball
Chair: Annette Bruhn

11:15-12:00 Key-04 - **Shifting genetic baselines in marine forests** - Ester A Serrao*

12:00-13:00 **Lunch**

MOLECULAR (2)

Thursday, 23 June 13:00 – 14:15 Room: Grand Ball
Chairs: Ester Serrão, Alejandra Gonzalez

13:00-13:15 OR-29-01 - **Evidence of a natural F1 *Macrocystis* x *Lessonia* (Phaeophyceae, Laminariales) hybrid from Chile** - Pedro Murúa, Renato Westermeier, Liliana A. Muñoz, Pieter van West, Frithjof C. Küpper, Akira F. Peters

13:15-13:30 OR-29-02 - **The genome sequence of the brown alga, *Cladosiphon okamuranus*: Novel evolutionary insights** - Koki Nishitsuji*, Asuka Arimoto, Manabu Fujie, Nana Arakaki, Chuya Shinzato, Eiichi Shoguchi, Nori Satoh

13:30-13:45 OR-29-03 - **Genome assembly and metagenomic analysis of the green alga, *Caulerpa lentillifera*** - Asuka Arimoto*, Koki Nishitsuji, Chuya Shinzato, Eiichi Shoguchi, Nori Satoh

13:45-14:00 OR-29-04 - **Distribution and morphology of *Gracilaria* spp. in selected coastal areas in the Philippines** - Ma. Salvacion R. Ferrer*

14:00-14:15 OR-29-05 - **Species diversity and phylogeny of crustose coralline algae from algal reefs in Northern Taiwan** - Li-Chia Liu*, Showe-Mei Lin

SEAWEED FOR FOOD AND FEED

Thursday, 23 June 13:00 – 14:15 Room: Kronborg
Chairs: Stefan Kraan, Annelise Chapman

13:00-13:15 OR-30-01 - **Development of an alternative food for juvenile culture of green abalone from brown algae** - Miguel Á. Villa-Arce, Gustavo Hernández-Carmona*, Yoloxóchitl E. Rodríguez-Montesinos, Mauricio Muñoz-Ochoa

13:15-13:30 OR-30-02 - **Synbiotic effects of Tasco, an *Ascophyllum nodosum* product used for animal feed applications.** - Franklin Evans*, Saveetha Kandasamy, Balakrishnan Prithiviraj, Alan Critchley

13:30-13:45 OR-30-03 - **Brown seaweeds dietary supplementation for white-leg shrimp** - Leila Hayashi*, Juliana R. Rosa, Delano D Schleder, Felipe N Vieira, Walter Q. Seiffert

13:45-14:00 OR-30-04 - **The use of stable isotopes to track the incorporation of *Ulva* from aquafeed into sea urchin gonads** - John Bolton*, Mark D. Cyrus, Brett M. Macey

14:00-14:15 OR-30-05 - **Macroalgae in the swine industry; do we have the answer to antibiotic replacement?** - Stefan Kraan*

MANAGEMENT AND HARVEST
Minisymposium

Thursday, 23 June 13:00 – 14:15 Room: Christiansborg
Chairs: Raul Ugarte, Nadege Rossi

13:00-13:15 OR-31-01 - **Utilization and exploitation of red seaweeds in Chile: Opportunities and challenges** - Marcela Avila*, Ricardo Riquelme, Gesica Aroca, Maria I Piel

13:15-13:30 OR-31-02 - **Development of a joint MSC-ASC standard for seaweed eco-labelling** - Shen Yan Liow, Sergio Cansado, Dan Hoggarth*, Iain Pollard*

13:30-13:45 OR-31-03 - **Tools for managing seaweed farming** - Nadege Rossi*, Pierre-Olivier Liabot, Thierry Perrot, Nur A.R. Setyawidati, Radiarta Nyoman

13:45-14:00 OR-31-04 - **Challenges of the ecosystem approach in the harvest of *Ascophyllum nodosum* in Eastern Canada** - Raul Ugarte*, Alan T Critchley

14:00-14:15 OR-31-05 - **Design and prototype of *Kappaphycus alvarezii* mechanical harvester** - Leila Hayashi*, André L.T. Novaes, Alex A. Santos

PROCESSING AND BIOREFINERY

Thursday, 23 June 13:00 – 14:15 Room: Fredensborg
Chairs: Anne-Belinda Bjerre, Charlotte Jacobsen

13:00-13:15 OR-32-01 - **Year-round storage of cultivated seaweed biomass through ensilage** - Philip D Kerrison*, Adam D Hughes, Maeve Kelly

13:15-13:30 OR-32-02 - **Processing of brown macroalgae to fish feed** - Svein Horn

13:30-13:45 OR-32-03 - **Fermentation studies for wise utilization of seaweeds** - Motoharu Uchida

13:45-14:00 OR-32-04 - **Sugar kelp as feedstock for fermentation-based succinic acid production in a biorefinery approach** - Gonçalo S Marinho*, Merlin Alvarado-Morales, Irini Angelidaki

14:00-14:15 OR-32-05 - **Seaweed salt from *Ulva*: developing the biorefinery concept** - Marie Magnusson*, Christina Carl, Leonardo Mata, Rocky de Nys, Nicholas A Paul

PLENARY LECTURE (5)

Thursday, 23 June 14:15 – 14:45 Room: Grand Ball
Chair: Ole G. Mouritsen

14:15-14:45 Key-05 - **The use of seaweed in higher gastronomy** - René Redzepi
The plenary lecture will be performed as an on-stage interview by professor Ole G. Mouritsen.

POSTER SESSION 2

Thursday, 23 June 14:45 – 16:15 Room: Break area
After this overview of the sessions and oral presentations follows an overview that shows topics and titles for the exhibited posters. Please note that posters for this session are exhibited only on Thursday and Friday.

14:45-16:15 Poster session

MOLECULAR (3)

Thursday, 23 June 16:15 – 17:30 Room: Grand Ball
Chairs: Michele Stanley, Mette Møller Nielsen

16:15-16:30 OR-33-01 - **Characterization of the GGPS responsible for carotenoid biosynthesis in Pyropia umbilicalis** - Lien Yang*

16:30-16:45 OR-33-02 - **Characterization and physical mapping of the rRNA genes and telomere sequence in *Saccharina japonica*** - Zhi-Gang Zhou*

16:45-17:00 OR-33-03 - **The evolution and maternal inheritance of chloroplast genome in *Saccharina japonica*** - Xiuliang Wang*

17:00-17:15 OR-33-04 - **Organellar genomes of *Ulva spp*. and phylogenomics of the "Core Chlorophyta"** - James T Melton, Juan M Lopez-Bautista

17:15-17:30 OR-33-05 - **Comparative genomics of chloroplasts and mitochondria in brown algae** - Feng Liu*

SEAWEED FOR FOOD

Thursday, 23 June 16:15 – 17:45 Room: Kronborg
Chairs: Ole G. Mouritsen, Annelise Chapman

16:15-16:30 OR-34-01 - **Analysis of nutritional quality of *Grateloupia sp*. from Indian coast** - Pooja Baweja*, Dinabandhu Sahoo

16:30-16:45 OR-34-02 - **Effects of washing treatments on the nutritional value of edible seaweeds** - Pierrick F. Stévant*, Hélène Marfaing, Annelise Chapman

16:45-17:00 OR-34-03 - **Cultivated seaweed for tasty and healthier "traditional" foods** - Helena Abreu*, Rui Pereira, Susana Cardoso, Carla Monteiro, Nuno Lobo, Pedro Bastos,

17:00-17:15 OR-34-04 - **Cultivated seaweed: An emerging seafood market in Quebec (Canada)** - Karine Berger

17:15-17:30 OR-34-05 - **Seaweed as a gourmet ingredient in gourmet products** - Kristian S Ottesen

17:30-17:45 OR-34-06 - **Deciphering the lipidome of the seaweed *Gracilaria sp*. from the IMTA system in the lagoon of Aveiro** - Elisabete V. da Costa*, Melo Tânia, Moreira S.P. Ana, Andreia Rego, Rui Pereira, Pedro Domingues, Maria Helena Abreu, Maria do Rosário Domingues

ECOSYSTEM SERVICE

Thursday, 23 June 16:15 – 17:45 Room: Christiansborg
Chairs: Ik Chyo Chung, Yufeng Yang

16:15-16:30 OR-35-01 - **The bad, the good and the not so ugly: disease and restoration in *Phyllospora comosa*.** - Peter Steinberg, Ezequiel Marzinelli, Alexandra Campbell, Adriana Verges, Mariana Mayer-Pinto, Brendan Kelaher, Melinda Coleman

16:30-16:45 OR-35-02 - **Tropical seaweed beds as habitats for juvenile fish** - Stina A Tano, Maria Eggertsen, Sofia A Wikström, Charlotte Berkström, Amelia Buriyo, Christina Halling,

16:45-17:00 OR-35-03 - **Inhibition of marine harmful algal bloom species by *Gracilaria lemaneiformis*** - Zhaoyang Chai*, Yingzhong Tang, Yufeng Yang

17:00-17:15 OR-35-04 - **Impacts of cultivation of seaweeds on plankton and benthos populations on open sea environment** - Rameshkumar Sethu*, Rajaram Rajendran

17:15-17:30 OR-35-05 - **Carbon dioxide mitigation potential of seaweed aquaculture beds (SABs)** - Ik Kyo Chung, Jin Ae Lee*, Network Members

17:30-17:45 OR-35-06 - **Effects of fish farm effluents on epiphytic algal communities in *Laminaria hyperborea* forests** - Barbro T Haugland*, Stein Fredriksen, Tina Kutti, Kjell Magnus Norderhaug, Camille White, Vivian Husa, Raymond Bannister

BIOREFINERY, PROCESSING AND NOVEL ENZYMES

Thursday, 23 June 16:15 – 17:30 Room: Fredensborg
Chairs: Jessica Adams, Alex Angel

16:15-16:30 OR-36-01 - **Seaweed biorefineries – Value chain analyses and cost assessments** - Inga Marie Aasen*, Olaf T Berglihn, Bernd Wittgens

16:30-16:45 OR-36-02 - **Brown seaweed as a bioresource for phloroglucinol based bio-polymers** - Marie Magnusson, Alexander K. L. Yuen, Rui Zhang, Nicholas A Paul, Jeffrey Wright, Richar Taylor, Thomas Maschmeyer, Rocky de Nys*

16:45-17:00 OR-36-03 - **Aqueous solutions of ionic liquids to extract phycobiliproteins from red seaweeds** - Sónia Ventura*, Margarida Martins, Flávia Vieira, Andreia Rego, Helena Abreu, João Coutinho

17:00-17:15 OR-36-04 - **Antiviral compounds isolation from red seaweeds by EAE using response surface methodology.** - Anne-Sophie Burlot, Gilles Bedoux, Nathalie Bourgougnon

17:15-17:30 OR-36-05 - **Application of surfactants on the extraction of added-value compounds from brown seaweeds** - Flavia A. Vieira*, Ricardo Guilherme, Andreia Rego, Helena Abreu, Marcelo Maraschin, João Coutinho, Sónia Ventura

SYMPOSIUM DINNER
Restaurant LANGELINIE PAVILLONEN
18:30 Busses leave from the venue, Scandic Copenhagen Hotel
Find information about this event at the front of this book

FRIDAY

CLIMATE AND ECOLOGY

Friday, 24 June 09:00 – 10:40 Room: Grand Ball
Chairs: Michael Roleda, Catriona Hurd

09:00-09:20 OR-37-01 - **Biomass and carbon content of calcareous green algae at the north coast of the Yucatan, Mexico** - Ileana Ortegon-Aznar*, Andrea Chuc-Contreras, Justin Campbell, Ligia Collado-Vides

09:20-09:40 OR-37-02 - **Can reduced ice scouring cause changes in the littoral zone in Spitsbergen, Svalbard?** - Stein Fredriksen*, Inka Bartsch, Siri Moy, Christian Wiencke

09:40-10:00 OR-37-03 - **Impact of ocean acidification on lipid composition in seaweeds and associated grazers** - Matthias J Schmid, Catriona L Hurd*

10:00-10:20 OR-37-04 - **Growth and competition in a warmer ocean: A field experiment with non-native and native seaweeds** - Caroline Armitage*, Kjersti Sjøtun, Vivian Husa

10:20-10:40 OR-37-05 - **Response of kelps from different latitudes to consecutive heat shock** - Tânia R Pereira*

MOLECULAR (4)
STRESS AND DEFENSE

Friday, 24 June 09:00 – 10:40 Room: Kronborg
Chairs: Susse Wegeberg, Peter Steinberg

09:00-09:20 OR-38-01 - **RNA-Seq revealed complex response to heat stress on transcriptomic level in *Saccharina japonica*** - Fuli Liu*

09:20-09:40 OR-38-02 - **Investigation on the higher tolerance in *Kappaphycus striatum* compared with *K. alvarezii*** - Tong Pang*, Litao Zhang, Jianguo Liu, Yi Yuan, Yongfu Li

09:40-10:00 OR-38-03 - **Dissecting the strategy of *Pyropia yezoensis* to survive in salty water through Na+/K+ homeostasis** - Eri R Adams*, Ryoung Shin

10:00-10:20 OR-38-04 - **Innate immunity and constitutional defense mechanism of *Pyropia tenera* against viral infection** - Soo Hyun Im*, Gwang Hoon Kim, Tatyana Klochkova

10:20-10:40 OR-38-05 - **Transcript analysis of hsp genes in different phase of *Gracilaria vermiculophylla*** - Di Xu

CULTIVATION (5)
STIMULATION OF GROWTH

Friday, 24 June 09:00 – 10:40 Room: Christiansborg
Chairs: Helena Abreu, Philip Kerrison

09:00-09:20 OR-39-01 - **Temperature induced changes in the biochemical composition of *Ulva lactuca* (Chlorophyta, Ulvales)** - Vasuki Subramanian*, Kokilam Ganapathy, Suja Mathan, Sajitha Nagamony, Babitha Dakshinamoorthy

09:20-09:40 OR-39-02 - **Use of AMPEP K+ and inhibitors in shoot formation of *Kappaphycus alvarezii* (Doty) Doty** - Anicia Q Hurtado*, Keneth R Tibubos, Alan T Critchley

09:40-10:00 OR-39-03 - **Use of fertilized molten slags for creating Sargassum forests in subtropical shallow waters** - Daisuke Fujita*, Rai Ma, Shingo Akita, Miki Kobayashi, Yuhi Hayakawa, Toshihiro Miyatani, Yuuji Seki, Yasuhiro Yamahira

10:00-10:20 OR-39-04 - **Utilization of ephiphytic bacteria on a red alga *Gracilariopsis chorda* for algal growth** - Hirotaka Kakita*, Hideki Obika

10:20-10:40 OR-39-05 - **The Use of *L. camara* extract to prevent Ice-ice disease & trigger growth rate of *K. alvarezii*** - Rahmad S. Patadjai*, Indriyani Nur*, La Ode M. Aslan*, Syamsul Kamri

FUTURE

Friday, 24 June 09:00 – 10:40 Room: Fredensborg
Chairs: Susan L. Holdt, Annette Bruhn

09:00-09:20 OR-40-01 - **Should South Australia increase its participation in the macroalgae value chain?** - Goran Roos

09:20-09:40 OR-40-02 - **Opportunities, challenges and outlook of seaweed cultivation in Europe: an industry vision** - Frank Neumann, Jon Funderud*

09:40-10:00 OR-40-03 - **Perceptions of kelp aquaculture and its social acceptability in Sweden** - Jean-Baptiste E. Thomas*, Jonas Nordström, Emma Risen, Maria E Malmström, Fredrik Gröndahl

10:00-10:20 OR-40-04 - **Cost of commercial-scale offshore cultivation in the Faroe Islands using multiple partial cutting** - Urd G. Bak*, Olavur Gregersen, Agnes Mols-Mortensen, Gilli Trond

10:20-10:40 OR-40-05 - **Introducing nephelometry for non-invasive biomass and growth monitoring macroalgae** - Claire MM Gachon*, Benoit Calmes, Martina Strittmatter, Bertrand Jacquemin, Céline Rousseau, Yacine Badis, Mark Cock, Christophe Destombe, Myriam Valero

10:40-11:15 **Break - Coffee / Tea**

PLENARY LECTURE (6)

Friday, 21 June 11:15 – 12:00 Room: Grand Ball
Chair: Stefan Kraan

11:15-12:00 Key-06 - **Shaken and stirred: water motion regulates seaweed resource acquisition and productivity** - Catriona L. Hurd*

CLOSING CEREMONY

Friday, 21 June 12:00 – 12:30 Room: Grand Ball

12:00-12:30 Closing Ceremony including the presentations of awards.

12:30- **Lunch** – to be eaten at the venue or to go

POSTERS EXHIBITED MONDAY AND TUESDAY

The special session for these posters is Tuesday at 14:40 – 16:00

BIOFUELS FROM SEAWEEDS

PO-01-01 - **Pretreatment, saccharification and fermentation of algae for the production of bioethanol** - Maria-Cristina Ravanal*, Ricardo Pezoa, Melanie Abrams, Päivi Mäki-Arvela, Jyri-Pekka Mikkola, Javier Gimpel, Oriana Salazar, Maria-Elena Lienqueo

NON-FOOD APPLICATIONS
AGRICULTURAL APPLICATIONS OF SEAWEED EXTRACTS

PO-01-03 - **Approach application of aldehyde bioflavor and gel for Kelp forest conservation** - Kangsadan Boonprab*, Norishige Yotsukura, Yoshinori Katsuyama, Takashi Maeda, Yusuke Takata, Tadahiko Kajiwara

PO-01-05 - **Sustainable fertilisers & biofuels from overabundant seaweeds for Pacific SIDS** - Antoine De Ramon N'Yeurt*, Catherine Soreh, Lodovika Tofinga, Viliamu lese

FUNCTIONAL SUBSTANCES FROM SEAWEEDS
APPLICATIONS IN FOOD, FEED AND PHARMA PRODUCTS

PO-01-06 - **Native agar quality of *Gracilaria parvispora* from coastal lagoons in the Southern Mexican Pacific** - María J. Trejo-Méndez*, Edgar F. Rosas-Alquicira*, Gustavo Hernández-Carmona, Dora L. Arvizu-Higuera

PO-01-07 - **A review : Therapeutic and medicinal utilities of marine macro algae** - Suparna Roy, Perumal Anantharaman*

PO-01-08 - **Increased value of seaweed processing** - Rósa Jónsdótttir, Birgir Ö Smárason, Bryndís Björnsdóttir, Eva Kuttner, Hordur G Kristinsson

PO-01-09 - **Extraction and quantification of phycobiliproteins from the red alga *Furcellaria lumbricalis*** - Rando Tuvikene*, Marju Robal

PO-01-10 - **Characterization of PMM genes and analysis of its transcriptions to *Saccharina japonica*** - Delin Duan*, Pengyan Zhang, Jianting Yao

PO-01-45 - **Phylogenetic identification and hydrocolloid characteristics of Ghanaian red seaweed** - Nanna Rhein-Knudsen, Marcel Tutor Ale, Kristian Barrett, Gloria Naa Dzama Addico, Amoako Atta deGraft-Johnson, Anne S. Meyer

FUNCTIONAL SUBSTANCES FROM SEAWEEDS
BIOACTIVE SEAWEED EXTRACTS

PO-01-12 - **Antioxidant and hepatoprotective effect of fucoidans from brown algae of Yucatan Peninsula** - Juan Chale-Dzul, Rosa Moo-Puc, Daniel Robledo, Yolanda Freile-Pelegrín*

PO-01-13 - **Extraction of polysaccharides from four Irish seaweeds** - Charlotte A O'Callaghan

PO-01-14 - **Seasonal variation in anti-proliferative activity of tropical brown alga against GLC4/Adr cell line** - Jantana Praiboon*

PO-01-15 - **Extracts from *Ulva lactuca* on seddling growth of *Vigna radiata* and toxicity in *Raphanus sativus*** - Laura G Castellanos-Barriga, Mauricio Muñoz-Ochoa, Rosalba M Hernández-Herrera*

PO-01-16 - **Activity of polysaccharide enriched extracts from seaweeds as growth promoters of plants** - Rosalba M Hernández-Herrera, Fernando Santacruz-Ruvalcaba, Julia Zañudo-Hernández, Gustavo Hernández-Carmona*

PO-01-17 - **Fusion of two process for obtain seaweeds extracts with stimulant effects in land crops** - Josué S. Martínez-Morales, Gustavo Hernández-Carmona*, Rosalba M. Hernández-Herrera, Yoloxóchitl E. Rodríguez-Montesinos, Mauricio Muñoz-Ochoa

PO-01-18 - **Bioactive compounds in the alien species *Undaria pinnatifida* (Laminariales, Phaeophyceae)** - Lucia Rizzo, Loredana Stabili, Rosa Anna Cavallo, Marcella Narracci, Antonella Petrocelli, Maria I Acquaviva, Ester Cecere*

PO-01-19 - **Effects of seaweed extracts on the growth of *Arabidopsis thaliana* under salinity stress** - Leila Hayashi*, Filipe A.S. Neves, Olivia G. Gemael, Ticiane Rover, Marcelo Maraschin, Balakrishnan Prithiviraj

PO-01-20 - **Purification and bioactivity of polysaccharide fractions from *Palmaria palmata*.** - Bjorn V. Adalbjornsson, Malfridur Bjarnadottir, Rosa Jonsdottir*

PO-01-21 - **Determination of SPF number of seaweeds from Drini Beach Gunung Kidul, Yogyakarta, Indonesia** - Windu Merdekawati*

PO-01-22 - ***Sargassum cymosum* and *Ascophyllum nodosum* extracts as biostimulants of red rice growth** - Leila Hayashi*, Eva R. Oliveira, Marília Shibata, Ester Wickert, Fernanda Ramlov, Katerine B. Basquet, Anabela Pizzatto, et al.

PO-01-24 - **Towards a novel ultra-high viscosity alginate scaffold for cardiac tissue engineering** - Benjamin Fischer*, Michael Gepp, André Schulz, Johanne Dobringer, Julio Vasquez, Luca Gentile, Heiko Zimmermann

PO-01-25 - **RIV-ALG, an applied project on the isolation of active ingredients for cosmetic applications** - Valérie Stiger-Pouvreau, Leslie Gager, Gwladys Surget, Klervi Le Lann, Fabienne Guerard, Nathalie Poupart, Maud Larnicol

PO-01-26 - **Potential habitat and bioactive compounds from brown algae in Lombok Island (Indonesia)** - Nur Azmi Ratna Setyawidati*, Klervi Le Lann, Ita Widowati, Pierre-Olivier Liabot, Valérie Stiger Pouvreau

PO-01-27 - **Antiviral and cytotoxic activities of four seaweeds from Yucatan Peninsula** - Edgar E Caamal-Fuentes, Christel Marty, Nathalie Bourgougnon, Guilles Bedoux, Yolanda Freile- Pelegrin, Daniel Robledo

PO-01-28 - ***Ulva rigida* from San Jorge Gulf, Argentina: Pharmacological aspects and traditional uses.** - Osvaldo León Córdoba*, Analía Uhrich, Susana Gorzalczany, Carlos Taira, Caroline Weinstein-Oppenheimer, Mauricio Reyna Jeldes, María Luján Flores

PO-01-29 - **Seasonal Variations in the Proximate Composition of the Southern Caspian Sea Macroalgae** - Neda Mehdipour

FUNCTIONAL SUBSTANCES FROM SEAWEEDS
BIOACTIVE SUBSTANCES FROM SEAWEEDS

PO-01-31 - **Antioxidant capacity and anti-UV compounds increase in *Rhodymenia pseudopalmata* under IMTA** - Hugo S Pliego*, Gilles Bedoux, Nathalie Bourgougnon, Yolanda Freile-Pelegrín, Daniel Robledo

PO-01-32 - **Different extraction procedures and analysis of protein from *Ulva sp*. in Brittany, France** - Isuru Wijesekara Wijesekara Liyanage*, Marie Lang, Marin-Pierre Gemin, Maya Puspita, Gilles Bedoux, Nathalie Bourgougnon

PO-01-33 - **Seasonal variation of nitrogenous components of red seaweeds, *Palmaria palmata* and *Chondrus crispus*** - Paul R Tobin*

PO-01-34 - **A red alga *Gracilariopsis chorda* is a source of a mitogenic hemagglutinin** - Hirotaka Kakita*, Hideki Obika

PO-01-35 - **Antioxidant activity and phytochemical of red algae from central basin of southern Thailand** - Wanninee Chankaew*, Chayakorn Pumas, Jantana Sangkaew, Wanlapa Luealae

PO-01-36 - **Indexing bioactivity of a commercial extract of *Ascophyllum nodosum* against freezing in BY-2 cells** - Mahbobeh Zamani Babgohari, Balakrishnan Prithiviraj, Alan Critchley, Jeff Norrie

PO-01-37 - **Mycosporine-like amino acids in benthic red seaweeds along Brazilian coast** - Bruno Briani, Marina N Sissini, Manuela B Batista, Leidson A Lucena, Iara O Costa, José C Nunes, Pablo Riul, et al.

PO-01-38 - **Bioactivity of fucoidan oligosaccharides from Icelandic seaweed** - Maria K Naumovskaya, Brynja Einarsdóttir, Bjorn V. Adalbjornsson*, Ólafur H Friðjónsson, Guðmundur Ó Hreggviðsson, Hördur G Kristinsson

PO-01-40 - **Antioxidant properties of degraded polysaccharides from the red alga *Chondrus elatus*** - Mihkel Saluri*, Daisuke Fujita, Rando Tuvikene

PO-01-41 - **Valorisation of *Sargassum muticum* in Normandy, France, a local answer to a global problem** - Jeremy Brebion*, Benoit Queguineur*, Marine Dehail, Clemence Michel, Sebastien Pien

PO-01-42 - **Effect of solvents and pretreatment method on fatty acids extracted from *Saccharina latissima*** - Ingrid Undeland*

PO-01-44 - **Structural characterization of fucoidan from the Norwegian brown seaweed *Laminaria hyperborea*** - Georg Kopplin*, Finn L. Aachmann, Gudmund Skjåk-Bræk, Hugo Mélida, Vincent Bulone, Kjell M. Vårum

FUNCTIONAL SUBSTANCES FROM SEAWEEDS
HEALTH EFFECTS

PO-01-43 - **Effect of degradation method on antioxidant activity of fuoidan** - Jong-il Choi*

RISK ASSESSMENT (QUALITY AND SAFETY)
ACCUMULATION AND MEASURING UNDESIRABLE COMPOUNDS

PO-01-46 - **Inorganic arsenic distribution in *Laminaria digitata* (Phaeophyceae)** - Jenny M Ronan, Linda O'Hea, Joerg Feldmann, Dagmar B Stengel*, Evin McGovern

PO-01-47 - **Metals content in macroalgas and concentrations of nutrients water coastal** - Leidy S. Ardila Poveda*, Maria M Casas Valdés, Lia C. Mendez Rodriguez

PO-01-48 - **Arsenic speciation on seaweeds in Korea by reversed phased column HPLC-ICP-MS** - Minchul Yoon*, Mi Ra Jo*, Kwang Tae Son, Ji Young Kwon, Woo Seok Choi, Ji Hoe Kim, Tae Seek Lee

CULTIVATION TECHNIQUES
CULTIVATION OF TEMPERATE SEAWEEDS

PO-01-49 - **Establishment of *Osmundea pinnatifida* mari-culture** - Cecilia Biancacci*

PO-01-50 - **Temperature and salinity tolerance in the different size groups of *Saccharina japonica* (Phaeophyta)** - Eun Kyoung Hwang, Ho Chang Yoo, Chan Sun Park*, Dong Soo Ha

PO-01-51 - **Effect of environmental factors on photosynthetic characteristics of *Pyropia yezoensis*** - Zhang Tao, Liu Qi, Lu Qinqin, Shen Zonggen, Zhu Jianyi

PO-01-52 - **Pilot cultivation of kelp species in Greenland** - Ole Geertz-Hansen, Susse Wegeberg, Agnes Mols-Mortensen

PO-01-53 - **Chemical composition from different genetic populations of the giant kelp *Macrocystis pyrifera*.** - Sara Barrento*, Carolina Camus, Alejandro H. Buschmann

PO-01-54 - **Macroalgal tank cultivation in Scotland: the s3eed project** - Philip D Kerrison*, Duncan R Smallman, Gail C Twigg, Rory MacPhee, Alistair Barge, Fiona A B Houston, Adam D Hughes

PO-01-55 - **The Development of New Sea Vegetable Aquaculture Crops in Maine, USA** - Sarah Redmond*, Susan Brawley, Charlotte Carrigan

PO-01-56 - **Optimization of the chemical composition of edible red seaweeds as a source of functional foods** - Elena Varela-Álvarez*, Dagmar B Stengel

PO-01-77 - **Spawning techniques for *Phyllospora comosa* integrated aquaculture in southern Australia** - Erin E Cumming

CULTIVATION TECHNIQUES
CULTIVATION OF TROPICAL SEAWEEDS

PO-01-57 - **Caulerpa farming in French Polynesia, a new source of income for local community.** - Mayalen Zubia*, Clara De Gaillande, Georges Remoissenet

PO-01-58 - **Seaweed culture techniques in the Philippines** - Warwin O Sabasaje, Jaylann Tuba, Patrice Bianca L Roa, Hilly Ann R Quiaoit

PO-01-59 - **Use of AMPEP K+ and PGRs in shoot induction of *Kappaphycus alvarezii* (Doty) Doty** - Anicia Q Hurtado*, Keneth R Tibubos, Alan T Critchley

PO-01-60 - **Cultivation of *Kappaphycus striatum* in the Huanghai sea of China** - Pang Tong*, Jianguo Liu, Yi Yuan, Yongfu Li

PO-01-63 – **Floating cage: New methods for culture and seaweeds management in Indonesia** - Ma'ruf Kasim*, Ahmad Mustafa, Muzuni Muzuni, Wardha Jalil

PO-01-64 - **Growth of New Strain *Eucheuma denticulatum* in Floating Cages in Indonesia** - Ma'ruf Kasim*, Ahmad Mustafa, Muzuni Muzuni, Wardha Jalil

CULTIVATION TECHNIQUES
IMPROVEMENT OF CULTIVATION METHODS

PO-01-65 - **Laying the foundation for an integrated industrial sector: Kelp cultivation in Quebec (Canada)** - Isabelle Gendron-Lemieux*, Éric Tamigneaux, Karine Berger, Henryette Michaud, Roxane Bernier, Juliette Garcia, Lisandre Solomon, Marie Lionard

PO-01-66 - **Examining the effect of seaweed associated bacteria on the growth of two seaweeds in culture.** - Friederike Eimer*

PO-01-67 - **Effects of plant growth regulators in the carrageenan-producing red algae *Sarcothalia crispata*** - Marcela Avila*, Constanza K De Zarate, Angelica C Alcapan, Maria I Piel, Nair S Yokoya

PO-01-68 - **New Applications: Cryopreservation of *Macrocystis pyrifera* (L.) C. Agardh (Phaeophyceae)** - Maria I Piel*, Gesica G Aroca, Marcela D Avila, Ricardo A Riquelme

PO-01-69 - **Calcium propionate treatment on oomycete diseases in *Pyropia* sea farms of Korea** - Ro won Kim*, Seong Jin Jung, Jong Seok Mun, Gwang Hoon Kim, Soo Hyun Im

PO-01-70 - **Production of *Kappaphycus alvarezii* (Doty) Doty clones by micropropagation** - Maria Rovilla J Luhan*

PO-01-71 - **Marine phycoculture in China** - Fuli Liu*, Feijiu Wang, Xiutao Sun, Wenjun Wang, Zhourui Liang

PO-01-76 - **Commercially important tropical and temperate red algae: Are they really different?** - Daniel Robledo, Yolanda Freile-Pelegrín, Sandra Pereda, Mariam C Hernández, Carolina Camus, Alejandro Buschmann,

CULTIVATION TECHNIQUES
REPRODUCTIVE BIOLOGY, BREEDING AND GENETICS

PO-01-72 - **Intra-organismal genetic heterogeneity in *Gracilaria chilensis* and its relation with cultivation** - Alejandra V Gonzalez*, Jessica Beltran, Veronica Flores, Renato Westermeier, Bernabe Santelices

PO-01-73 - **Isolation of an improved strain of *Pyropia chauhanii* with high-temperature resistance** - Xinghong Yan*, Shasha Chen, Hongchang Ding

PO-01-74 - ***Pyropia yezoensis* ST I: A new cultivar in China** - Wei Zhou, Qinqin Lu*

INTEGRATED MULTITROPHIC AQUACULTURE (IMTA)

PO-01-78 - **A comparison of the bioremediation potential of five seaweed species in a land-based culture system** - Yun Hee Kang, Sang Rul Park

PO-01-79 - **Algaplus: Production of Sustainable Seaweeds and seaweed based products** - Andreia M. Rego*, Helena Abreu, Rui Pereira, Ana Ribeiro, Pedro Sousa

POSTERS EXHIBITED THURSDAY AND FRIDAY

The special session for these posters is Thursday at 14:45 – 16:15

SEAWEED AS FOOD AND FEED
NUTRITION – TASTE – TEXTURE

PO-02-01 - **Chromatographic analysis for low molecular weight saccharides in edible seaweeds** - Hirotaka Kakita, Hideki Obika

PO-02-02 - **Amino acid content of green, brown and red seaweeds from the Magellan Strait, Southern Chile** - Mª. Soledad Astorga-España, B. Rodríguez-Galdón, E.M. Rodriguez-Rodriguez, C. Díaz-Romero

PO-02-03 - **Nutritional properties of the prepared dishes using sub-Antarctic macroalgae** - Maria Soldad Astorga*, Sebastian Rosenfeld, Johanna Marambio, Jaime Ojeda, Fabio Mendez, Juan Pablo Rodriguez, Paula Ocaranza, Andres Mansilla

PO-02-04 - **Fermented seaweed sauce prepared from nori *Pyropia yezoensis*** - Motoharu Uchida*, Hirotaka Kurushima

PO-02-05 - **Microwave assisted freeze drying of sugar kelp (*Saccharina latissima*) to improve product quality** - Balunkeswar Nayak*, Jacob Guralnick

PO-02-07 - **Utilization of brown seaweed for single-cell protein production** - Sandeep S Sharma, Svein J Horn

PO-02-08 - **Nutritional and antioxidant activity of 7 different seaweeds from Madeira Archipelago** - Nuno M V Nunes

CHALLENGES – DEVELOPMENTS WITHIN SEAWEED HARVESTING
HARVESTING MANAGEMENT

PO-02-10 - **Developing an integrated approach to seaweed resource assessment in Ireland** - Dagmar B Stengel*, Thomas Rossiter, Gema Casal, Tommy Furey

MOLECULAR BIOLOGY AND SYSTEMATICS
MOLECULAR TECHNIQUES

PO-02-11 - **Induction and isolation of *Porphyra lucasii* pigmentation mutants by gamma irradiation** - Jong-il Choi*, Hak-Jyung Lee, Gwang Hoon KIM

PO-02-13 - **DNA barcoding on brown algae from the intertidal zone of Shandong Peninsula, China** - Guoying Du*

PO-02-15 - **Evolutionary significance of the discovery of (1→3)(1→4)-β-D-glucan in brown algal cell-walls** - Armando A. Salmeán*, Delphine Duffieux, Jesper Harholt, Fen Qin, Gurvan Michel, William G.T. Willats, Cécile Hervé

PO-02-17 - **Establishment of a genetic transformation model for green seaweed *Ulva*** - Peng Jiang*

PO-02-18 - **Hybridization among *Ectocarpus siliculosus* and *E. crouaniorum*** - Alejandro E Montecinos

PO-02-19 - **Diversity and phylogeny of the agarophyte Gelidiellaceae, Rhodophyta based on multigene analyses** - Sung Min Boo*, Ga Hun Boo, Tu van Nguyen, Jung Youn Kim

MOLECULAR BIOLOGY AND SYSTEMATICS
PHYSIOLOGY AND SYSTEMATICS

PO-02-22 - **The reproductive pathways of floating *Ulva prolifera* and the response mechanisms to stress** - Guangce Wang*

PO-02-23 - **A new candidate species in epi/endophytic genus Ulvella (Ulvellaceae, Chlorophyta) from Korea** - Young Sik Kim*, Chansong Kim*, Han Gil Choi, Ki Wan Nam

PO-02-25 - **Sex specific importin alpha homology in male and female gametophyte of Bostrychia moritziana** - Eun Young Shim*, Junbo Shim, Giuseppe C. Zuccarello, Gwang Hoon Kim

PROCESSING AND BIOREFINERY
EXTRACTION TECHNOLOGIES

PO-02-26 - **NEPTUNA – applying novel extraction processes to algal source materials** - Dagmar B Stengel*, Freddy Guiheneuf, Bill J Baker, Alan Dobson

PO-02-27 - **Biorefining of macroalgae using hydrothermal processing: Analysis of product streams.** - Andrew Ross, Chris Rayner, Gillian Finnerty

PROCESSING AND BIOREFINERY
MULTIPLE PRODUCTS

PO-02-28 - **Fermentation of *Saccharina latissima* as a viable storage process?** - Hélène Marfaing*

PO-02-29 - **Biochemical composition of red, green and brown seaweeds common at the Swedish west coast** - Joakim Olsson, Gunilla Toth, Eva Albers

PO-02-30 - **What to do with all these seaweed's industrial waste?** - Savindra Kumar*, Dinabandhu Sahoo*

PO-02-31 - **Combined ethanol, butanol, and fish feed production from brown algae - a biorefinery concept** - Xiaoru Hou, Anne-Belinda Bjerre*, Nikolaj From, Lone Berg Frederiksen, Annette Bruhn, Irini Angelidaki

CULTIVATION TECHNIQUES
CULTIVATION OF TROPICAL SEAWEEDS

PO-02-32 - **Aquaculture, valorization and management for seaweed sustainability in Indonesia** - Nur Azmi Ratna Setyawidati*, Pierre-Olivier Liabot, Nicolas Longépé, Nadège Rossi, Valérie Stiger Pouvreau, Ita Widowati

OTHER

PO-02-34 - **Mechanisms and heritability of disease resistance in brown algae** - Martina Strittmatter*, Claire Gachon, Dieter Mueller, Amerssa Tsirigoti, Stephan Wawra, Max Beckmann, Christos Katsaros, Pieter van West, Frithjof Kuepper

PO-02-35 - **Seaweed industry in Indonesia : Challenges and Prospects** - Ateng Supriatna, Maman Hermawan, Catur Wicaksono

PO-02-36 - **Investigating potential effects of hypothetical large scale macroalgae farms** - Elisa Capuzzo*, John Aldridge, Rodney Forster, David Stephens, Johan van der Molen

PO-02-37 - **Mapping of kelp forest using integrated data from sonar and underwater video on GIS** - Ken-ichi Hayashizaki, Masahiro Hamana, Shuji Sasa, Teruhisa Komatsu

PO-02-38 - **Exploring and understanding the seaweed marketing system in Malaysia** - Adibi R Nor

PO-02-39 - **The introduction of Seaweed Cluster Project (SCP) to optimise seaweed production in Malaysia** - Adibi R Nor*

PO-02-40 - **Macroalgae exhibit non-invasive, reversible chimerisms** - Bernabe Santelices*, Alejandra V Gonzalez, Jessica Beltran, Veronica Flores

PO-02-41 - **Comparing bacterial-induced morphogenesis between Ulva species** - Fatemeh Ghaderiardakani*, Thomas Wichard, Juliet Coates

ECOLOGY (POPULATION & COMMUNITY)
ALIEN, INVASIVE AND BLOOM SPECIES

PO-02-42 - **An overview of introduced macroalgae in Norway** - Kjersti Sjøtun, Vivian Husa, Caroline S. Armitage

PO-02-43 - **Seasonal chemical ecology of introduced *Sargassum muticum* and *Codium fragile* in Brittany** - Gwladys Surget*, Klervi Le Lann, Gaspard Delebecq, Nelly Kervarec, Anne Donval, Nathalie Poupart, Valérie Stiger-Pouvreau

ECOLOGY (POPULATION & COMMUNITY)
ECOPHYSIOLOGY

PO-02-44 - **Copper impedes meiospore development of *Macrocystis pyrifera* and *Undaria pinnatifida*** - Pablo P Leal, Catriona L Hurd, Sylvia Sanders, Evelyn Armstrong, Michael Y Roleda*

PO-02-45 - **Study of microbial diversity in *Ulva lactuca* from North West coast of Gujarat, India** - Ghanshyam G. Patel*, Mukund C Thakur, Arif Khan

PO-02-46 - **Variability in populations of *Macrocystis pyrifera* in the Chilean sub-Antarctic region.** - Juan Pablo P Rodríguez, Andres O Mansilla*, Jaime A Ojeda, Sebastian A Rosenfeld, Johanna V Marambio, Fabio H Mendez, Paula U Ocaranza, et al.

PO-02-47 - **Seasonal photosynthetic performance of *Macrocystis pyrifera* in Puerto del Hambre, Subantarctic Chile** - Johanna V Marambio, Paula Ocaranza, Juan Pablo Rodriguez, Fabio Mendez, Sebastian Rosenfeld, Jaime Ojeda, Silvia Murcia, et al.

PO-02-48 - **Morphology-physiology of two morpho of the genus Durvillaea in the sub-Antarctic ecoregion of Chile** - Fabio Mendez, Andres A Mansilla*, Fadia F Tala, Silvia S Murcia, Jaime J Ojeda, Sebastian S Rosenfeld, Juan Pablo J Rodriguez, et al.

PO-02-49 - **Reproductive biology of *Durvillaea antarctica* (Chamisso) Hariot in southern Chile** - Andrés Mansilla*, Julian Cáceres, Marcela Ávila

PO-02-50 - **Recovery of seaweed beds under different sea urchin density regimes in the existing barren area** - Jeong Ha Kim, Byung Hee Jeon*, Kwon Mo Yang, Yong Soo Son

PO-02-51 - **The effects of eutrophication and acidification on the physiology of seaweeds** - Ik Kyo Chung*, Jin Woo Kang

PO-02-52 - **Restoration trials of an endangered brown alga, *Silvetia siliquosa*** - Sook-jin Chun*, Jong Kwan Choi, Han Gil Choi, Hyung-cheol Song, Dojin Song

ECOLOGY (POPULATION & COMMUNITY)
SEAWEED BIOGEOGRAPHY & PRODUCTIVITY

PO-02-53 - **Comparison of effects of the Great East Japan Earthquake on two kelp bed ecosystems** - Daisuke Muraoka*, Hitoshi Tamaki, Hideki Takami, Yutaka Kurita, Tomohiko Kawamura

PO-02-54 - **Population biology and long-term mariculture studies in the brown alga *Lessonia trabeculata*** - Renato Westermeier*, Pedro Murúa, David J. Patiño, Dieter G. Müller

PO-02-55 - **Morphology as a long-term monitoring tool for calculating individual biomass in *Ecklonia cava*** - Sangil Kim*, Sangil Kim, Sun Kyeong Choi, Min Ji Kim, Eun Ran Baek, Yun Hee Kang, Hyuk Je Lee, Sang Rul Park

PO-02-56 - **Meta-analysis of upwelling effects on marine producer-herbivore interactions** - Andrew J Sellers*

PO-02-66 - **Latitudinal variability of Chilean *Macrocystis* populations post 1997-1998 El Niño** - Alonso Vega, Bernardo R Broitman, Julio A Vásquez*

PO-02-67 - **Population dynamics of kelp *Macrocystis pyrifera* (ecomorph integrifolia) in northern Chile** - Alonso Vega, Julio A Vásquez*

ECOLOGY (POPULATION & COMMUNITY)
SEAWEED DIVERSITY AND BIOGEOGRAPHY

PO-02-57 - **Seaweed diversity in Teluk Awur Jepara, Indonesia** - SEAWEED UNDIP*

PO-02-58 - **Morphological plasticity of brown alga *Sargassum thunbergii* along the Korean coasts** - Sangil Kim*, Sang Rul Park

PO-02-59 - **Genome analysis of potential vegetation of a limpet dominant on urchin barren ground** - Daisuke Fujita*, Tomohiro Kosako, Yoshihito Takano, Satoshi Nagai

PO-02-60 - **Diversity of seaweed communities at Krakal Beach, Gunung Kidul, Yogyakarta** - Humairah A. Sabiladiyni*

PO-02-61 - **Intraspecific crosses in *Saccharina latissima* and opportunities for artificial selection** - Bertrand Jacquemin, Chloe Jollivet, Christophe Destombe, Myriam Valero

PO-02-62 - **Temporal variation in patterns of macroalgal assemblages in two localities in the Magellan Region** - Sebastián Rosenfeld, Johanna Marambio, Juan Pablo Rodriguez, Paula Ocaranza, Andrés Mansilla*

PO-02-64 - **Detection of brown algae *Sargassum* species in high turbid waters of Kuwait Bay** - Aws Y Alghunaim, Subrahmanyam M.N.V., Yousuf Alenezi, Hanan Aladeelah, Walid Al-Zakri, Turky Al-Said, Ali Al-Hashem

PO-02-65 - **Benthic marine macroalgae off the Northern coast of the Yucatan Peninsula, Mexico** - Ileana Ortegon-Aznar*, Andrea Chuc-Contreras, Andres A Morales-Guadarrama, Carlos Gonzalez-Salas, Alfonso Aguilar-Perera

SOCIO-ECONOMIC IMPACTS OF SEAWEED FARMING

PO-02-69 - **Development and transfer technology to repopulate red seaweeds in Chile** - Jacques Mazoyer, Julian Caceres*, Ricardo Ortaiza

PO-02-70 - **Impacts of *Eucheuma denticulatum* seaweed farming on seagrass meadows of Zanzibar, Tanzania** - Mirta Teichberg*, Agustín Moreira Saporiti, Dieuwke Hoeijmakers, Flower E Msuya

PO-02-71 - **Protype Design of the House of the Seaweed Farmers in Indonesia** - Akrim Djusdil

Key-01

The integrated culture of seaweeds in waste waters – environmental drivers and product options

Rocky de Nys*, *MACRO — the Centre for Macroalgal Resources and Biotechnology, James Cook University, Australia*

The integrated culture of seaweeds in waste waters from marine industries is a particularly attractive model for sustainability, reducing contaminant export while delivering biomass as a resource. However, the reality of delivering an integrated and sustainable solution can differ significantly from providing a conceptual model. The success of delivering the integrated culture of seaweeds in aquaculture waste waters is dependent on profitability, with key drivers being monetized environmental and product values. A case study is presented of the delivery of the integrated culture of seaweeds with intensive land-based aquaculture of shrimp, adjacent to the World Heritage Listed Great Barrier Reef Marine Park, with a focus on delivering environmental compliance and product options. The selection of species, optimization of productivity and assessment of biomass quality to deliver a target product have been key to its success. These are described in detail highlighting the bespoke nature of integrating the culture of seaweeds into aquaculture waste streams and the partnerships required to do so. The development and assessment of future product options, ranging from human foods to bioenergy, are also described in detail as they have been explored to maximize the value of a single biomass resource through the delivery of multiple products.

Key-02

The Seaweed Hydrocolloids Industry: 2015 Updates, Needs & Outlook

Hans Porse, *InterColloids, Denmark*
Brian Rudolph, *CP Kelco ApS, Denmark*

The seaweed hydrocolloids industry, comprising of agar, alginate and carrageenan extracts, continues to grow on the order of 2%-3% per year and with the Asia-Pacific region increasingly dominating the raw material and manufacturing aspects of the industry. Geographic overviews, also in a historic perspective, of seaweed raw material availability including prices and consumption, manufacturing capacities & utilizations and sales of extracts will be presented. Some current and future industry dynamics, requirements and changing structures for instance Indonesia's increasingly dominant role within farming of agar and carrageenan bearing seaweed species, randomly imposing of seaweed harvest restrictions or ban on exports, creation of a global certification standard for seaweed and supply-demand dynamics for seaweed versus future global population will be presented as well. The industry is increasingly being commoditized and China has become an important and in many cases dominant factor within all types of seaweed hydrocolloids being manufactured and some explanations to this and strategic response by the rest of the industry will also be touched upon.
Also presented are some areas where the seaweed industry could need help from the scientific community. The main challenge is the year-long general seaweed deterioration experienced in cultivated species – how are the strains improved and revitalized and can the cultivation techniques be improved further?. There is a general trend towards sustainability and although seaweeds are sustainable there is interest in development of greener processes. Background and suggestions will be discussed.

Key-03

Research and Applications of Bioactive Seaweed Substances -A Brightmoon Perspective

Yimin Qin*, *Laboratory, Qingdao Bright Moon Seaweed Group, People's Republic of China*

On 30th September 2015, the Chinese government approved the establishment of "State Key Laboratory of Bioactive Seaweed Substances" at Qingdao Brightmoon Seaweed Group, which is the largest manufacturer of seaweed based products in the world. This presentation offers a panoramic view of the various activities being carried out and planned for the future concerning the research, development and commercial applications of bioactive seaweed substances. After a brief analysis of the common scientific and technological problems in this industry, the presentation then introduces the three main areas of research work at the State Key Laboratory, i.e., extraction, functional modification and applications of bioactive seaweed substances in drugs, functional foods, nutraceuticals, biomedical materials, cosmetics and marine fertilizers, where the key properties and functional benefits are critically analyzed. The presentation ends with an overview of the comprehensive research and development platforms at Brightmoon Seaweed Group, with an invitation for scientists and engineers around the world to carry out joint research, development and commercial applications of bioactive seaweed substances.

Key-04
Shifting genetic baselines in marine forests
Ester A. Serrao*, *CCMAR, University of Algarve, Portugal*

Climate-driven range shifts shape the geographical distribution of genetic diversity of algal forests. By analysing genetic markers and developing species distribution models, we inferred the effects of range contractions and expansions on the spatial distribution of the gene pool of species. Our results show that range expansions create large areas of homogeneous gene pools. Range shifts provide also opportunities for introgressive recombination of genomes at contact zones. Pockets of unique genetic diversity are presently located in shrinking climatic refugia. The high genetic structure and differentiation of populations of marine algal forests from distinct regions provides powerful tools for the identification and tracking of specific strains for aquaculture purposes and to identify genetically appropriate source populations for restoration as well as the genetic source of new colonizations.

Key-05
The use of seaweed in higher gastronomy
René Redzepi, *Chef and Co-Founder, Restaurant Noma, Copenhagen, Denmark*

This special keynote presentation will be carried out as an interview by prof. Ole G. Mouritsen.

René Redzepi's interests in seaweed are both great and diverse. His interest is due to the diversity of seaweed, which is mind boggling, and the potential for gastronomical development (i.e. processing seaweeds into different forms of food, such as kombu into dashi). Another attractive property of seaweed is their potential to contribute with flavors, such as umami. It would probably take a whole generation of chefs to start exploring the potential, or the prospect of a research facility where chefs and scientists work together to explore these new possibilities.
Another seaweed related subject of interest is the fact that seaweed are highly nutritious and good for your health. Imagining a future where you eat a meal, even at the best restaurants, knowing that you are also taking care of yourself (health and nutrition wise). This future is believed to be created by accepting seaweed into the kitchen and as a part of your life.

Key-06
Shaken and stirred: water motion regulates seaweed resource acquisition and productivity
Catriona Hurd*, *IMAS, University of Tasmania, Australia*

Water motion physically controls nutrient acquisition, growth and productivity of seaweeds via its action in regulating the thickness of the diffusion boundary layer (DBL), and generating drag forces that can stimulate seaweed metabolic activity. This talk will consider how water motion controls the uptake of essential nutrients (nitrate, ammonium, dissolved inorganic carbon) and the removal of metabolic waste produces (e.g. O2). In slow flows typical of wave-sheltered bays or within dense seaweed beds, mixing is slow and nitrate supply from seawater may be limiting for seaweed growth, but other sources of nitrogen such as recycled ammonium and urea might offset the low nitrate supply. I will consider evidence for reduced productivity in slow flows and its causes such as photorespiration due to O2 accumulation with the DBL. Positive effects of thick DBLs include the retention of excreted nitrogen at the seaweed surface and the protection of calcifying seaweeds from ocean acidification. Findings will be discussed in relation to seaweed aquaculture.

OR-01-01

Growth and antioxidant content of Rhodymenia pseudopalmata improved by light and salinity

Hugo Pliego, Yolanda Freile-Pelegrín, Daniel Robledo
Marine Resources Department, Center of Advanced Studies and Research CINVESTAV-Mérida, Mexico

Light and salinity are two of the most important abiotic environmental factors that influence the growth, metabolism and distribution of seaweeds. R. pseudopalmata grows on the Mexican Caribbean Coast where the environment has a remarkably dynamic lighting regime. Studies on the responses of seaweeds to environmental variations are important to understand their physiological behavior in order to improve mariculture practice of new species. The aim of this study was to evaluate the influence of salinity and irradiance on the growth, morphology, biochemical and antioxidant content of R. pseudopalmata under controlled conditions. A factorial design with two treatments, salinity (20, 25, 30, 35, 40, 45 ups) and irradiance (~50, 100 and 200, µmol m-2s-1) was tested with five replicates. Fragments of 1 g FW L-1 were cultured in 500 mL transparent bioreactors with filtered and UV-sterilized seawater (25°C, 8.1 pH, 12 h light). Seawater was renewed every week and plants were reduced to the initial biomass, experiment was run during six weeks. SGR, morphometry of apical zone, C-N, pigments, TPC and DPPH were analyzed from the initial biomass and at the end of the experiment. Growth of R. pseudopalmata was significantly affected by the interactions between salinity and irradiance, an increase at 20 ups and high irradiance was noticed (1.79 ± 0.16 % d-1) while at 35 ups and low irradiance the lowest SGR was obtained (0.37 ± 0.25 % d-1). The higher C and N content were observed at low salinities. The interaction of 30 ups and low irradiation showed the lowest C:N ratio and highest protein content (11.87 ± 1.74 and 10.58 ± 1.43). A significant increase in Total Phenolic Content (43.21 ± 2.94 µg PGE mg-1) and DPPH antioxidant activity (24.7 ± 0.01%) was observed at 20 ups and medium irradiance.

OR-01-02

Systems for achieving high productivity during cultivation of Kappaphycus and Eucheuma

Shrikumar Suryanarayan, *Sea6 Energy Pte. Ltd., India*
Iain Neish*, *Sea6 Energy Pte. Ltd., Indonesia*
Nelson Vadassery, *Sea6 Energy Pte. Ltd., India*

As of 2015 most production of Kappaphycus spp. and Eucheuma spp. seaweeds farmed in tropical waters is utilized as raw material for the production of carrageenan with a minor portion of production being sold as sea vegetables.. Market prices clearly indicate that present farm systems are more than capable of supplying the needs of such markets when prices are attractive to farmers, however major developing markets that fully utilize seaweed biomass will require many-fold increases in production volumes that can be achieved without creating inflated unit costs. The vast majority of current farm systems are small-holder operations; many of which have low productivity and almost all of which involve a large drudge-labor content that comprises most of the seaweed production cost. An outstanding example of such drudge-labor is individual manual attachment of seaweed cuttings to ropes. Production of one ton of raw, dried seaweed can involve tens of thousands of such attachments and a high proportion of potential seaweed farmers decline to participate in the industry because they are averse to such drudgery. Methods of seaweed farming are therefore being developed that enable simple mechanization of tasks that involve drudge-labor and enable farmers to increase farm productivity per unit-of-effort several fold. The present paper presents an overview of such developments.

OR-01-03

Correlation between yield qualities and environments of Gracilaria fisheri cultivation in Thailand

Rapeeporn Ruangchuay*, *Faculty of Science and Technology, Prince of Songkla University, Thailand*

The earthen pond cultivation of Gracilaria fisheri, was mainly taken place in three provinces: Surat Thani, Songkhla and Pattani, in the south of Thailand. The relation between the yield quality and environment was investigated for efficient pond management. The samples including seaweed, water and sediment were collected at four ponds in each province for the analysis. The parameters of light intensity, salinity, pH, water depth and transparency were directly measured at the ponds. Agar yield and contaminants of the seaweed were measured. Pigment constituents and some elements in seaweed, in water and in sediment were determined. A highest yield of the seaweed was more than 58 ton ha-1 year-1 fw. The yield inversely related to salinity, nitrate-nitrogen ($r = -0.88$ and -0.80 respectively, $p < 0.05$) and epiphyte($r = -0.75$ $p < 0.05$). The pigments showed positive relation to the clay in water while the agar showed positive relation with Mn in water. For major elements, the concentration of K and Na in the seaweed related to nitrate-nitrogen and phosphate-phosphorous in water. The controlling of salinity and adding of fertilizer in water could improve biomass, agar and pigment of G. fisheri.

OR-01-04

Pond cultivation of Ulva spp in Baja California, Mexico.

JOSE ZERTUCHE*[1], Alberto Galvez-Palacios[1], Jose Guzmán-Calderón[1], Estefania Cervantes-Rios[1], Laura Chanes-Miranda[2]

[1] *Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California, Mexico.* [2] *Escuela de Gastronomía, Universidad Autónoma de Baja California, Mexico*

Ulva lactuca and Ulva fasciata are suitable species to be consider as food ingredients for human consumption. A disadvantage, however, is the fact that in the Pacific coast of Baja California the availibility of these species is seasonal. The purpose of this study is to test the feasibility to produce good quality Ulva throughout the year by pond cultivation. Preliminary experiments in 1 m3 tanks, indicated that both species can grow vigorously while keeping them in fertilized tumble cultures. In these study, tank culture conditions were tested using ponds of 40 and 100 m2 and a water column of 1m. Temperature ranged from 13 to 30 °C. This experiment coincided with the highest water temperatures recorded for the coastal area off the eastern Pacific in the last 100 yrs. Plants were mantained tumbling by providing air from the bottom. Water was replace twice a week. Previous to the water exchange, cultures were fertilized with NH4NO3 for 12 hrs. Cultures were initiated with 2-4 kg of plants per m2. Cultures were maintain for two weeks and harvested to its original density. The increase of biomass was used to estimate growth (%/d) and yield (g/m2/d). From July to December, U fasciata showed higher yields and better performance during high temperature conditions with an average yield of 277 g/m2/d (ww). The average yield for U lactuca was 174 g/m2/d. Cultures were free of epiphytes throughout the study. Minimum growth coincided with unusually high temperatures and partial reproduction of the plants. However, both species provided high yields sufficient to consider feasible to produce Ulva at a large scale by pond cultivation.

OR-01-05

Land-based culture of Halymenia durvillei under varying light conditions

Najeen Arabelle Rula*, *The Marine Science Institute, University of the Philippines-Diliman, Philippines*

Halymenia durvillei Bory de Saint-Vincent (Halymeniales, Rhodophyta) is typically harvested and consumed as food. More importantly, this red seaweed contains the high-value compounds r-phycoerythrin and lambda-like carrageenan. To utilize this valuable resource sustainably as raw material, cultivation methods have been recently developed, but improvement and optimization is needed to scale up research to commercial production. Among the factors that are known to affect growth and pigment production in seaweeds is light. Hence, this study investigated the influence of different light conditions on biomass, growth, phycoerythrin content and carrageenan yield and viscosity of tank-cultured H. durvillei. Cultivation was conducted in a land-based hatchery with continuous seawater flow and aeration in Bolinao, Pangasinan using cuttings from stocks collected from the wild. To manipulate the light intensity in the tanks, one, two, and three layers of net covers were installed. Tanks without net cover were also included as control. After seven weeks in culture, the fresh weight of H. durvillei in each tank was measured, from which growth rates were calculated. Crude r-phycoerythrin content and carrageenan yield of the harvested biomass were analyzed. Growth rates and biomass were highest in tanks without net cover and decreased with increasing number of net layers. Crude r-phycoerythrin was highest in tanks with two layers of net. Carrageenan yield did not vary significantly among treatments but was high for H. durvillei in tanks with single and triple layers of net. However, carrageenan viscosity of H. durvillei under these treatments were low. The results demonstrate the potential of using double net layers to decrease light intensity and obtain high r-phycoerythrin yield from the land-based culture of H. durvillei.

OR-01-06

Algae Technology Educational Consortium

Ira Levine*, *Algae Foundation, University of Southern Maine, United States*

The Algae Foundation is a non-profit, charitable educational 501(c) 3 organization that looks to promote the development of a vibrant industry based on algal biomass as a means to address many national and global issues including: algal-based bioproducts, energy security, mitigation of carbon emissions, sustainable resource utilization, and job creation. The mission of the Algae Foundation is to promote the power of algae to transform human society and the environment upon which it depends. This year, the organization launched its ATEC Initiative to develop an educational curriculum for a two year college degree in Algae Biology, Technology, and Cultivation. The United States Department of Energy's (DOE) Bioenergy Technologies Office BETO supports algal based education and job training programs to enhance its

program's objectives requiring a trained workforce to staff algal biotechnology and production/conversion facilities. The successful completion of this project will provide a training program to be reproduced at community colleges or vocational technology schools in addition to an aquaculture extension education program throughout the regions that become centers for algal biotechnology and production. Year One efforts include: establishing the primary and secondary collaborative partners; formalize relationships with community colleges and / or vocational technology schools in at least one school from each of the following States: California, Arizona, New Mexico, Texas, Hawaii, Maine, and Florida. The goal is to develop algal-based cultivation and biotechnology classes, a one year certificate and a two year curriculum for an associate degree as an Algae Technologist, including both scientific and engineering classroom training, and hands on wet lab courses with topics including basics of photosynthesis, algal cultivation, algae-based wastewater treatment methods, harvesting and processing methodologies.

OR-02-01

Industrial process effects on extraction of commercial colloids and fucoidans from Chilean seaweeds.

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Eviagenics, France

Eviagenics is a new company based in Paris developing natural extracts from different raw materials with a growing interest in seaweeds. Eviagenics has in particular secured an exclusivity agreement for the European and North America markets with Gelymar, one of the main manufacturers of colloids in Chile. In the frame of its development of new bioactive ingredients, the team in Eviagenics has worked intensively on several brown seaweed species and in particular Lessonia nigrescens. A great interest of the researchers was to investigate the potential for co-extracting commercial colloids such as alginate fractions with new bioactive ingredients such as fucoidans. If alginate industrial application are well developed nowadays, the commercial development of fucoidans remains limited. However, the commercial potential of active fucoidan fractions remains of great interest for sectors such as feed and food health but also pharmaceutical applications. The content of the work presented will therefore focus on the experimental approach developed by the team in order to extract and purify both alginates and fucoidans from Lessonia nigrescens. Two main industrial extraction processes have been studied in order to mainly assess the extractions yields, efficiency and effects on the composition and thus, commercial application of those polysaccharides. Extraction solvents, time and temperatures have been compared from classical industrial colloid extraction process to novel approaches. The main first outcomes have demonstrated interesting results, showing in particular the potential for parallel extraction protocols in order to optimize carbohydrate structural conformation for commercial development. These results will be presented and discussed before opening the discussion on further industrial follow up from it.

OR-02-02

Bimonthly variation in the chemical composition and biological activity of Eisenia arborea

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Because chemical composition of seaweed may vary seasonally, the objective of this study was to describe a bimonthly variation in the chemical composition and in the bioactivities and properties of the extracts obtained from blades and stipes of Eisenia arborea collected in Magdalena Bay, Mexico, over a period from September 2013 to July 2014. The proximate chemical analysis was carried out on dry milled algal samples and showed that the major constituents in both blades and stipes were carbohydrates (53.85 and 47.65 %, respectively) and ashes (28.44 and 33.90 %). The crude ethanolic extract (EtOH) yield was higher ($p<0.05$) in blades (3.25 %) than in stipes (1.3 %); this was also true for antioxidant activity (AAOX). September and November showed the highest EtOH yields (5.40 & 4 %) and AAOX (EC50= 82.7 & 55 µg mL-1) in blades, while in stipes May showed the highest EtOH yield (2.07 %) and AAOX (EC50=320.3 µg mL-1). The yield of crude fucoidan obtained from blades was higher (p0.05) within blades and stipes. Both blades and stipes showed the highest yield from November to March with a mean of 20.28 % and 22.52 for blades and stipes respectively. The highest viscosity and gel strength were determined in January in both blades (464 m Pa s y 3239 g cm-2) and stipes (1008 m Pa s y 3336 g cm-2). Our results suggest that the period from November to March is the best for collecting the algae due to highest yields and bioactivity and better properties of extracts. We suggest using only blades when a major yield of EtOH and fucoidan are needed. Moreover, if alginates are resource of interest, using both blades and stipes is recommended, because of the unique properties of each alginate.

OR-02-03

From seaweeds to smart biomaterials

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The success or failure of biomaterials used as implantable matrices in clinical trials is determined by the interaction of the biological systems with the introduced material. This is required to be both functional and biocompatible. Here, we present ultra-high viscosity (UHV) alginates obtained by a highly standardized and thoroughly monitored manufacturing process spanning from harvest to functionalization. UHV alginates are obtained from stipes of the brown algae Lessonia nigrescens and Lessonia trabeculata harvested directly from the sea. A defined procedure as well as an appropriate monitoring system of the algal material are described. The subsequent gentle extraction of UHV alginates out of the algae species ensure the conservation of alginates unique native characteristics which are comprehensively analyzed in terms of structural properties and biomedical factors such as sterility, endotoxin levels and protein content. To improve the functionality of the alginate hydrogel, versatile molecules are conjugated via carbodiimide or click chemistry strategies using streptavidin and biotin. Among others, stimulus-responsive modifications are of highly biomedical relevance and are presented here. Due to the combination of high biocompatibility and smart, stimulus-responsive functionalization that can be chosen ad-hoc, outstanding material properties are gained that fit to a broad range of applications in regenerative medicine.

OR-02-04

Bioactive surfaces for the cultivation of human stem cells on seaweed-derived alginates

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The interaction of human cells with biomaterials-based surfaces is a fundamental combination for novel innovative approaches in tissue engineering and regenerative medicine. In comparison to standard polystyrene-based cultivation surfaces, soft biomaterial-based surfaces mimic the natural cellular environment of living tissue more accurately. Hydrogels generated from ultra high viscosity (UHV) alginates from Chilean algae Lessonia trabeculata and Lessonia nigrescens are a promising biomaterial for this purpose. Due to their unique adjustable properties, like biocompatibility, porosity and mild gelation conditions, they are also well-suited for the encapsulation of sensitive cells. Upon engraftment, these cells are sheltered from the immune response, whereas the bidirectional mass transfer of nutrients, oxygen, metabolites and small active molecules like insulin is still possible. At the same time, alginate hydrogels are bioinert, leading to the dilemma that anchorage-dependent cells, such as human stem cells, cannot attach to the alginate surface in its native state what will lead, in worst cast, to cell death. Here we focus on the biofunctionalization of alginate hydrogel surfaces using bioactive proteins, as well as on approaches for the modification of the surface topography. Our preliminary studies suggest that UHV alginate hydrogel represents an excellent culture substrate for cells that are highly relevant foir medical applications, such as human mesenchymal stem cells, human induced pluripotent stem cells (hiPSC) and hiPSC-derived cardiomyocytes. Our work creates the basis for novel sophisticated in vitro cell-based assays for disease modelling, drug development as well as culture systems for the differentiation of patient-specific hiPSC-derivatives.

OR-02-05

Towards a Seaweed Biorefinery - Microwave assisted deconstruction of Ascophyllum Nodosum.

Duncan Macquarrie*, *Green Chemistry Centre of Excellence, University or York, United Kingdom*

Macroalgae remains an underutilised biomass resource. Nonetheless, they are rich sources of polysaccharides, in particular alginates, fucoidans and laminarins, which have many current and potential uses. This presentation covers the sequential isolation of alginates and fucoidans from a solid residue of the brown seaweed, Ascophyllum nodosum, generated by the extraction of a liquid fertiliser from the harvested seaweed. This process removes the monomeric sugars and much of the inorganic components, leaving behind the polysaccharides and other polymeric components as well as their counterions. The major polysaccharides in the seaweed used in this study are alginates and fucoidans Microwave enhanced hydrothermal extraction was used to extract alginates into water highly efficiently, leaving a solid residue which was then further treated, again under microwave conditions, to recover fucoidans from the fraction. Under optimal conditions, both polysaccharides could be isolated sequentially in yields of 14% (fucoidans) and 18% (alginates) representing ca 75% of the total carbohydrate content of the

seaweed. A further 10% of soluble sugars was found, which were fermentable without further treatment. The residual solid (biochar) was found to have a HHV of 21.23MJ/kg. the overall process was significantly more rapid than conventional extraction processes. References 1. Y Yuan D J Macquarrie, Microwave assisted step-by-step process for the production of fucoidan, alginate sodium, sugars and biochar from Ascophyllum nodosum through a biorefinery concept. Biores. Technol. (2015) 198 819-827 2. Y Yuan, D J Macquarrie, Microwave assisisted hydrolysis of brown seaweed Ascophyllum nodosum for bioethanol production and characterisation of algae residue. ACS Sust. Chem. Eng. 2015 3 1359-1365 3. Y Yuan, D J Macquarrie, Microwave assisted extraction of sulfated polysaccharides (fucoidan) from Ascophyllum Nodosum and its antioxidant ability. Carbohydr. Polym., 2015 129 101-107

OR-02-06

Characterization of alginate gels with chitooligosaccharides of varying composition as crosslinkers

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Alginates are a family of polysaccharides commercially isolated from brown seaweeds, e.g. Laminaria hyperborea in Norway. Recently a new gelling system of the polycation alginate only containing mannuronic acid (polyM) with chitooligosaccharides (CHOS) as crosslinker was introduced, which is biocompatible and has a variety of potential applications in, e.g., tissue engineering, cell immobilization and drug release (Biomacromolecules (2013) 14, 2765-2771). The two oppositely charged polyelectrolytes are mixed at a pH where the amino-groups of CHOS is uncharged, then decreasing the pH in a controlled way by adding D-Glucono δ-lactone (GDL) which protonates the amino-groups of CHOS to form an ionic gel. This procedure means that the CHOS crosslinkers must be soluble at neutral pH-values, which is a bottleneck for forming relatively strong alginate gels because the fully deacetylated CHOS are neutral-soluble only for the chain length (degree of polymerization, DP) up to 10, while the fully deacetylated CHOS with higher DP are insoluble at neutral pH. It is known that introducing acetylated units in the chitosan chain will improve the neutral-solubility of chitosan (Carbohydrate Polymers (1994) 25, 65-70). In order to increase the neutral solubility of CHOS with higher DP, we have introduced acetylated units in the CHOS in two different ways, the first at the reducing end units (and their nearest neighbor) and the second at random in the CHOS. The results of the neutral solubilities of individual CHOS with acetylation at the end units and in the chains have been compared to the neutral solubility of fully deacetylated CHOS. Furthermore, the mechanical strength of hydrogels between alginate (polyM) and individual CHOS of varying chemical composition will be reported.

OR-03-01

MacroFuels – a H2020 project for development the next generation transportation biofuels.

Jaap van Hal, *ECN, Netherlands*
Anne-Belinda Bjerre*, *DTI, Denmark*

Seaweeds or macroalgae are the fastest growing plants at the Northern EU latitude. To grow, seaweeds need only CO2, sunlight and the nutrients already present in the seas. By cultivating seaweeds in a rotating crop scheme, for the first time in Europe, MacroFuels, a newly started H2020 project, will expand biomass availability for the production of advanced biofuels in the EU. This rotating crop scheme, combined with the use of innovative textile growing substrates, will dramatically reduce the cost price and boost the availability of seaweed.

OR-03-02

Enzymatic hydrolysis for algae-derived biofuels

Francesco Ometto*, *Scandinavian Biogas Fuels AB, Linköping University, Sweden*
Hana Kuci, *Scandinavian Biogas Fuels AB, Linköping University, Sweden*
Annika Björn, *TEMA - Environmental changes, Linköping University, Sweden*
Jörgen Ejlertsson, *Scandinavian Biogas Fuels AB, Linköping University, Sweden*

To secure macroalgae as a future key role on the biofuels market, biomass energy conversion efficiency needs to be optimised. Looking into anaerobic digestion for vehicle fuels production, high methane yields and high biomass degradation rates are required to guarantee profitability. In this context, low energy pre-treatments represent a valuable solution. Applied to brown macroalgae, this work investigated the potential of the enzymatic hydrolysis to enhance methane production. Two nearshore algae, Ascophyllum nodosum and Fucus vesiculosus, and three offshore algae, Alaria esculenta, Laminaria digitata and

Saccharina latissima, were harvested from the Norwegian coastline. Enzymatic hydrolysis was performed at pH 5, 37°C and constant agitation (190rpm) for 24h using commercial cellulase, protease and pectinase solutions, added to blended and homogenised biomass (5% dry matter). Batch anaerobic digestion tests were performed in triplicates at 37°C for 60 days on treated and untreated biomass to evaluate the impact of the enzymatic pre-treatment on the methane yields. Optimal enzymatic dosage was observed to be equal to 100% (v/w) of the algae dry matter content. Protease allowed A. nodosum and F. vesiculosus to yield up to 230 ± 10 ml CH4/gVS showing 80% improvement compared to the untreated biomass value. Lower increments, between 12% and 48 %, were obtained treating offshore algae. Cellulase impacted the most S. latissima (370 ± 20 mlCH4/gVS) and L. digitata (460 ± 20 mlCH4/gVS), while protease was the most effective enzyme on A. esculenta (360 ± 20 mlCH4/gVS). Overall, this work proved the enzymatic hydrolysis as an effective low energy pre-treatment to enhance macroalgae biomethane production. In particular, the pre-treatment affected biomass bacterial resistant compounds such as polyphenols and sulphated polysaccharides, enabling high biodegradability with values between 80% and 90% depending on the algae species.

OR-03-03

SeaGas: farmed Saccharina latissima as fresh and ensiled feedstock for anaerobic digestion

Michelle Morrison*, *Centre for Process Innovation, The Wilton Centre, United Kingdom*

There have been many academic studies investigation various aspects of seaweed digestion through AD, as sole feed stock and co-digested with other feed materials. However, at the time of writing there do not appear to be any examples of pilot scale studies in the literature i.e. at greater than 50L. The Seagas project will address this and bring together key pieces of work which should lead to a more comprehensive understanding of what is required to achieve a successful, financially viable, AD operation using farmed seaweed in co-digestion with a small quantity of food waste. The project will test the AD element at three scales; small batch BMP-style experiments, 8 x 5L dynamic digestion experiments (operating as standard CSTRs) and finally at 800L pilot scale. Data from the small scale work will be used to establish the initial operating conditions at pilot scale, after which the steady state operation will be tweaked to optimize and, where possible, intensify the AD process. Finally, the 2 x 800L digesters will be left to run for a 6 month period, optimized and with no further changes, to allow us to collect a bank of stable data for that period. The work presented to this conference will focus on the results from the first AD work package; a series of experiments to determine key AD operational parameters and assess the temporal and nutritional variability of S.latissima across fresh and ensiled batches from the July 2015 harvest. By June 2016, there will be data on fresh-frozen seaweed from the August 2015 harvest, together with data from 3, 6 and 9 month ensiled seaweed (from that same harvest) and fresh-non-frozen seaweed collected and delivered with the 6 and 9 month ensiled batches of seaweed. We intend to make comparisons between all the possible seaweed + food waste combinations and so assess which seaweed types give the best biomethane yields. Seagas is a three year project, from July 2015 – July 2018, funded through InnovateUK and BBSRC.

OR-03-04

Production of bio-coal, methane and fertilizer from seaweed using hydrothermal carbonisation

Aidan Smith*, *Energy Research Institute, University of Leeds, United Kingdom*

Macroalgae has emerged as a potential future source of feedstock for the production of chemicals and biofuels. The main drawback of macroalgae in terms of a biofuel feedstock is its low heating value (HHV), high halogen content, high ash content and a high slagging and fouling propensity, which severely hinders its potential as a combustion fuel. In this investigation, three species of kelps; (i) Laminaria digitata (ii) Laminaria hyperborea and (iii) Alaria esculenta have been processed by hydrothermal carbonisation (HTC), a process which uses hot compressed water to simulate natural coal formation produce a coal like from biomass. HTC was carried out in a batch reactor at two temperatures (200 °C and 250 °C) and the yields and properties of the resulting hydrochars including their HHV, CHNS, mineral content and ash fusibility properties have been determined and compared to the starting material. Significant improvement in fuel quality is observed resulting in an increase in energy density from 10 MJ/kg to typically 25 MJ/kg, which is comparable to that of a low rank coal. The results indicate significant demineralisation of the fuel, in particular a significant removal of alkali salts and chlorine. This results in improved combustion properties due to reduction in slagging and fouling properties of the fuel. Analysis of the HTC water phase indicates the presence of considerable amounts of soluble organic carbon consisting of C6 sugars and organic acids. High concentrations of potassium, magnesium and phosphorous are also present in the water phase. This study also predicts the potential for nutrient recovery and biogas generation from the

water phase following hydrothermal carbonisation. Results show a large proportion of the total energy within the original biomass can be recovered, with results estimating fluctuations in yields throughout the seaweed growth season.

OR-03-05

North Ronaldsay algae eating sheep harbours isolates with Ulvan lyases and cellulase activity

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The marine seaweed Ulva belongs to the chlorophytes and it is made up of complex sulfated polysaccharides which require degradation prior to biomass utilisation and biofuel production. Enzymatic degradation of the sulfated polysaccharides can occur, but few are currently known. This study aims to discover novel enzymes for the degradation of sulfated polysaccharides from the North Ronaldsay sheep, an ancient breed which feed almost exclusively on macroalgae biomass including Ulva spp and consequently have a unique rumen microflora. In this study an effective medium for the isolation of previously unculturable bacteria was used for the culturing and isolation of the bacteria isolates from the faecal samples of the North Ronaldsay sheep. Bacterial isolates (250) from faecal samples were grown under anaerobic conditions in liquid and solid media in a Don Whitley workstation and using Hungate tubes. The isolates were then screened for exocellulase, β-glucosidase, carbohydrate sulfatases and Ulvan lyase, with many isolates showing one or more activities. Sequence analysis of the 16S rRNA gene revealed that 76 of them, belonging to 6 genera, were previously unculturable bacteria indicating that the media used in this study was able to improve the culturability of these bacteria. Selected isolates with multi-enzyme activity were then chosen for genome sequencing. Metagenomic libraries have also been constructed from the samples and the libraries are being screened for Ulvan lyase activity. These results highlight novel enzymes with potential relevance for the production of biofuels and thesl for enhancing conversion pathways from Ulva to biofuel.

OR-03-06

Carbohydrate analysis of seaweed in the biorefinery to chemicals and fuel context

Jaap van Hal*, *ECN, Netherlands*
Wouter Huijgen, *ECN, Netherlands*
Anne-Belinda Bjerre, *DTI, Denmark*
Ana López Contreras, *Wageningen UR Food & Biobased Research, Wageningen University, Netherlands*
Michele Stanley, *SAMS, United Kingdom*
Gudmundur Hreggvidsson, *Matis OHF, Iceland*

Seaweed biomass is a complementary carbon source for fuels and chemicals that could be produced using a biorefinery approach [1]. The analysis of seasonal variation and exact composition of the different seaweeds is critical to develop the appropriate technology. Even in recent literature carbohydrates are regularly misidentified or simply determined by total carbohydrate methods, which does not allow for an accurate mass balance. In this presentation, we will present a critical experimental evaluation of acid- and enzyme-based hydrolysis methods for the determination of the different types of carbohydrates found in species common to North Western Europe. The results will be placed in the context of adapting the biorefinery concept to the production of chemicals and fuels. As examples, the biorefinery of the green macroalgae Ulva will be presented to isolate specialty carbohydrates such as rhamnose as well as conversion of these carbohydrates into furans. Another example is the biorefining of Kelps such as Laminaria digitata and Saccharina latissima. From these Kelps, mannitol was successfully isolated and purified, in addition alginate and glucose. References: [1] Hal, J.W. van, Huijgen, W.J.J. & López-Contreras, A.M. (2014) Opportunities and challenges for seaweed in the biobased economy, Trends in Biotechnology 32(5), 231-233. Acknowledgements: This presentation is part of the MacroFuels project. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654010. The project has also received funding in a national seaweed project in 2015.

OR-04-01

Moments of phycological history in the algal herbarium, Copenhagen

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Bangia is well known as a filamentous red alga growing in the upper littoral. You may also know the bluegreen alga Lyngbya, with L. aestuarii common in saltmarshes. Both names memorize Danish phycologists, as do names like Boergesenia, Boergeseniella, Kolderupia, Liebmannia, Rosenvingea, Rosenvingiella, Ruthnielsenia and a number of species names. We intend to present the persons behind the names. Niels Hofman Bang (1776-1855) was the owner of the estate Hofmansgave in the island of Funen, a center for phycology in Scandinavia, with many lines radiating from it. Hans Christian Lyngbye (1782-1837) became a teacher at Hofmannsgave and by the influence of Hofman Bang became interested in algae. He is famous for Tentamen Hydrophytologiae Danicae published in 1819. Caroline Rosenberg (1810-1902) also came to Hofmansgave, she made numerous herbarium specimens all carefully prepared and labeled in her elegant handwriting. Her name is memorized in Navicula rosenbergii Østrup, 1910 'in recognition of her contributions of diatom collections'. She also contributed to Flora Danica where some plates are duplicates of her herbarium specimens. Flora Danica is a prestigeous botanical work intended to illustrate all Danish plants published in 51 (+3) parts in the years 1761–1883 with several editors, among them Liebmann. Included are algae of which Ulva intestinalis represents the lectotype. Boergesenia, Boergeseniella memorize Frederik F. Børgesen (1866-1956). He studied the Marine algae of the Faroe Islands; later warm-water algae and published about the Marine Algae of the Danish Westindies; the Canary Islands; the Persian Gulf, India and Mauritius. Kolderupia, Rosenvingea, Rosenvingiella, memorize L. Kolderup Rosenvinge (1858-1939), he studied marine algae of Greenland when young, but spent most of his life with marine algae of Denmark. He completed the studies of red algae and started with brown algae in collaboration with Søren Lund.

OR-04-03

The 1st ISS at Edinburgh 1952: Applied seaweed science coming of age

Mentz Indergaard*, *Dept. of Biotechnology, Norwegian University of Science and Technology, Norway*

Since the first use of large brown algae for potash in the 18th century, chemists have applied their know-how to benefit the industrial utilization of seaweeds. Towards the end of the 19th century the focus of seaweed chemistry shifted from the inorganic to the organic content. Trailing the chemists, seaweed botanists also became directly involved in the industrial efforts by surveying and assessing seaweed populations. One early example is the mapping of the seaweed beds off California just prior to WWI, as a possible new source of potassium salts. In the 1930's, a modern seaweed industry emerged, based on seaweed polysaccharides and seaweed meal. The influence of WWII on applied seaweed science was considerable. The immediate post-war period held a spirit of internationalism, and a hope for science as a contributing instrument for peace and progress. The 1st International Seaweed Symposium was held in Edinburgh 14–17 July 1952. The symposium was referred to as the follow-up of the limited "Conference on Utilization of Seaweeds" of September 1948 at Dalhousie University in Halifax, Nova Scotia, Canada. The Halifax conference in turn originated from the annual Canadian "Irish Moss meetings" in Ottawa 1944–1947, instigated by the Canadian war effort to extract substitute gelling materials from local seaweeds for use in the foodstuff industry. Prior to WWII seaweed botanists, chemists and industrialists had no regular common international arena. I will argue for the 1st ISS as a timely "coming of age" gathering for applied, multi-disciplinary seaweed science. The event was joined by some 160 scientists from more than 20 countries. The symposium was organized with the sessions "Phycology", "Algal Chemistry" , "Utilisation" , "Seaweed Harvesting Technology", and "World Seaweed Resources". This division and some of the papers will be discussed as an indication of central topics at the time.

OR-04-04

The history, present and future of Bangiales farming in China

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There are over 130 species in the order Bangiales. Several species has been used and farmed for economic purpose, such as the most famous nori. Bangia fuscopurpurea farming has only been reported in China. The Bangiales product is flavored by the high percent of free alanine, glutamic acid, aspartic acid and glycine and has long been a popular food for the locals in some coastal areas in China, Japan and Korea. The earliest record regarding nori cultivation in China can be traced back to 960-1279 AD. Traditional farming practice spread from late 16th and/or early 17th centuries in Japan, China and Korea. Revolutionary progress has been made in nori farming technique since 1949 when conchocelis has been demonstrated as another phase of Bangiales. Modern nori industry has been established and great development has been achieved in Japan, Korea and China since then. Nori industry has been the largest as the term of farming scale. P. yezoensis and a domestic species P. haitanensis has been predominantly farmed in China.

Based on genetic research and application of selective breeding, hybridization and mutation, 5 excellent strains have been issued by the National Certification Committee for Aquatic Varieties. Extensive effort has been made to elucidate the genetic foundation and regulation mechanism of quality traits at the genomic and transcriptomic level. Researchers are trying to draw a high density genetic linkage map and special metabolic pathways. There has been challenge in nori industry in China: limited farming scale, reduced genetic diversity of the farmed germplasm, global climate changes. We are studying new farming techniques to extend the farming area from near-shore shallow water to off-shore deep water, recruiting completely new germplasm to diversify the genetic background of the cultivars, and trying to increase the stress tolerance of the germplasm based on physiological and molecular mechanism of stress acclimation.

OR-04-05

The uses of seaweed in Iceland; past and present

karl Gunnarsson*, *Marine Research Institute, Iceland*

Iceland has a long and relatively well documented history of the uses seaweed. Seaweeds have probably been used as food in Iceland from its colonization in the end of the 9th century. The first written records of the uses of dulse, Palmaria palmata as food date from 12th and 13th century. They are found in books of law and regulations which are amongst the first documents written in Iceland. Through the ages dulse has been a valuable commercial commodity in Iceland sold as food from the littoral communities to inland farms. References to the use of other species as food start appearing in the 15th century. Other important traditional uses of seaweeds in Iceland include uses as fodder for farm animals, fertilizers and to some extend as fuel for cooking and heating up houses. Traditional uses of seaweeds in Iceland declined in the beginning of the 20th century except in few communities where dulse has continued to be collected for household uses. Industrial uses of seaweeds started in the later half of the 20th century with trials of harvesting and processing Ascophyllum nodosum at the south coast. In 1975 seaweed harvesting and processing started in Breiðifjördur Western Iceland harvesting A. nodosum and Laminaria digitata and using geothermal energy for drying the seaweed. Presently the annual harvesting amounts to about 18.000 tonnes of A. nodosum and 4.000 tonnes of L. digitata. Small amounts of L. hyperborean have also been harvested since 2010. A. nodosum is cut with mechanical harvesters and Laminaria spp by drag rakes. A number of small businesses have started in the last decade processing seaweed for food and cosmetics.

OR-04-06

Ethno-ecological approach of the seaweed in channels and fjords Sub-Antarctic of southern Chile

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One worldview more frequent in the valuation of biodiversity are ecosystem services, it is associated to an economic perspective. However, there are others worldviews that can be more explicit in the profundity of the human interactions with the coastal biodiversity, such as the environmental ethic and its distinction between instrumental and intrinsic value of biodiversity. Some sites, interesting for its high diversity of seaweed are channels and fjords of southern Chile. In this ecosystem, some previous research found that ethnic people used seaweed since 14.600 years before present, such as Macrocystis pyrifera and Durvillaea antarctica, they were used in food and medicine. In this context, our aim is to identify the different uses ethnicities such as yagan, kaweskar and artisanal fishermen gave to seaweed. To do this, we performed a review of the anthropological and archaeological literature associated to ethnic groups; also we performed semi-structured interviews to ethnic people and fishermen. We found multiple uses associated to instrumental and intrinsic value as: feeding, medicine, navigation, fishing instrument, geographical and ecological planning. Within of variety of interactions, we can mention at least three examples: i) Yagans used the stipe as fishing line and blades for healing wounds. ii) Kaweskar did a territorial division of the channels Sub-Antarctic, this is associated with the presence of D. antarctica. In kaweskar language, it is called “Málte” to places with D. antarctica; and “Jáutok” to sites without D. antarctica. iii) Artisanal fishermen told us about the ecological value of kelp forest as nursery. Currently, diverse values of the coastal human groups have been important in the implementation of management and conservation measures. Such is the case of Chile with the drafting the new law “Coastal Marine Areas to Native People” on which it is stated fundamentally the identification of the customary uses of people in the areas.

OR-05-01
Commercial hatchery of two kelps Saccharina and Undaria in China

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Roughly one million and 0.17 million tons of Saccharina japonica and Undaria pinnatifida are produced in China, all from cultivation in 5 provinces. To support such a huge production each year, about 3 hundred millions of seedlings of the former has to be produced in about 20 hatchery companies in the north and south. For Undaria pinnatifida, roughly 100,000 collectors are needed each year. Both kelps have large capacity of releasing spores when sorus are mature enough. The number of parental plants used determines the genetic structure of the resulted offspring, thus the agronomical features of the crops, thus the benefits eventually. In this talk, I will introduce different ways to produce seedings in different parts of China, analyze the problems in each and give some suggestions for the future.

OR-05-02
Establishment of seaweed microcultures for the evaluation of plant growth regulators

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Seaweed tissue cultures have been established before to study the effect of plant growth regulators (PGR) with contradictory results. Particularly the axenity of such cultures is questioned, and the relationship of epiphytic/endophytic bacteria with macroalgae may affect the interaction of PGR described before. In this study we aim to quantify the effect of plant growth regulators on the axenic apical segments of four species of macroalgae in microcultures. Ulva lactuca, Kappaphycus alvarezii, Eucheuma isiforme and Rhodymenia pseudopalmata were pretreated with osmotic shock, sonication and sterile seawater washes. Apical segments were cut and incubated for 48 h in enriched seawater (VSES) 1X with antibiotics. Thereafter segments were immersed in 0.25% NaClO and detergent, and washed with specific antibiotics. Apical segments of each species were placed in sterile microplate in VSES 1X with PGRs. Concentrations of 0.5, 5, 50 µM of 1-naphthaleneacetic acid (NAA), kinetin (Kin), gibberellic acid (GA), Spermine (Spm), combinations of NAA+K+GA, K+GA+Spm, NAA+K+Spm and Ascophyllum nodosum extract were used. To evaluate growth of seaweed cultures a new software was developed in LabView platform and AxioVision. The analysis included longitude, area, branching and callus formation. The culture tests indicate that there is a direct relationship between the growth of algal tissue and the concentration of PGRs. It should be noted that combinations of regulators showed higher growth when compared to those administered individually. A. nodosum extract showed the lowest growth of all treatments. In some cultures the presence of Gram-negative, rod-shaped bacteria, was noted 96 h after sowing, and its identification by sequencing the 16s rRNA will indicate if these microorganisms are endophytes of the algal tissue. The use of growth regulators can enhance the in vitro growth rates of all the species studied. We discuss on the applicability of this methods for germoplasm storage.

OR-05-03
Crust Growth of Gloiopeltis furcata (Rhodophyta) in Laboratory Culture

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Hyung Geun Kim, *Department of Marine Bioscience, Gangneung-Wonju National University, South Korea*

We studied the optimal growth condition of crusts from tetraspores of Gloiopeltis furcata for mass cultivation. G. furcata is used for making jelly(gasirimuk) in a county of Korea. Mass cultivation of this alga is required for a large scale production of this unusual jelly to attract more travelers to this county. Temperatures were varied by 10, 15, 20, 25, 30℃ and irradiances were varied by 20 and 54 µmole photon·m-2·s-1. After 30 days of cultivation, maximum diameter(483.03 ± 98.86 µm, specific growth rate(SGR) = 8.45) of crusts from tetraspores were shown at 20℃, 54 µmole photon·m-2·s-1. Second optimal condition was 25℃, 54 µmole photon·m-2·s-1, crusts grown up to 364.80 ± 99.34 µm and SGR was 7.51. During the experiment, crusts were developed upright direction also and formed dome shapes. 3D shape of a 10 day cultured crust was analysed by confocal microscopy. Cells made layers and became smaller in upper layers. Cells in the slant were shaped oblique and covered the crust. We cultured this alga for a year and a half up to about 1 cm in a 10L aquarium in lab and observed spermatia release. Electron microscopic image of them was taken which revieled two or three vesicles inside spermatia. We can develop a mass cultivation method in the future based on those results.

OR-05-04

Research on the potential of a Pyropia yezoensis green mutant as a new cultivar

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Through the measurement of photosynthetic parameters, soluble protein and free amino acids content, we analyzed the potential of a Pyropia yezoensis green mutant (GM) as a new cultivar. Results indicated that the GM had less phycoerythrin while more phycocyanin than the wild type (WT), which might be the reason for the green phenotype; there were little difference between the GM and the WT in photosynthetic oxygen evolution rate, the effective and the optimal quantum yield of PSII when cultured under low light conditions, while all those parameters were lower in GM when cultured under high light conditions; the GM tends to increase the content of soluble protein, free amino acids (especially essential amino acids and delicious amino acids) in compare with the WT when harvested in the same sea area. All results suggested that although the GM might have low photosynthetic activity under high light condition, it still had potential as a good breeding material for P. yezoensis breeding.

OR-05-05

Experimental growth of filaments into plantlets of Grateloupia asiatica (Rhodophyta)

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Grateloupia asiatica is an important economic source for food and carrageenan. We studied how filaments develop into plantlets and experimented to find the best conditions for the growth in laboratory culture. Morphological changes of spores into plantlets were observed under 20^{o}C, 30 µmol photons m-2s-1 and 12L:12D photoperiode. The specific growth rates of plantlets from differentiated filaments were observed in different temperatures (14, 17, 20, 23 and 26 ^{o}C) combined with different irradiance conditions (10, 40, 70 and 100 µmol photons m-2s-1). The best combination of temperature and irradiance then was used to find the best photoperiode condition. Data of specific growth rates were analyzed by two-way ANOVA with Sigma plot 11 program. Spores developed into filaments, crusts and single-celled spherical structures. Heavily pigmented cells were marked where uniseriate filaments differentiated into multidimensional cell groups. Subsequently, such cell groups developed to spherical structure then organized to form plantlets. A temperature of 23^{o}C combined with irradiances of 40 µmol photons m-2s-1 showed the optimum condition for the best specific growth rate. Photoperiode of 10L 14D; 12L 12D; 14L 10D and 16L 8D were conducted, but it does not give significance difference of plantlet growth. Plantlet could be used for alternative seedling in G. asiatica instead of upright thalli from crusts.

OR-05-06

Shortening the generation time to improve selective breeding in Saccharina latissima

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The worldwide interest in seaweed products has increased in recent decades, so that in addition to the harvesting of natural resources, the cultivation of seaweeds from aquaculture is gaining more and more importance. Cultivation in East Asia, which globally dominates the market, is traditionally approached by use of pedigree selection, mutation and hybridization in combination with self-crossing and selection. In order to make seaweed cultivation an important industry also in Europe, an increased focus on selective breeding is needed. The effectiveness of breeding is highly dependent on generation time. Here I will present results from an ongoing study with the aim to reduce the generation time of the Kelp Saccharina latissima by inducing the formation of sporangial tissue in young sporophytes. This will be done by adjusting the light period to a short day (8h light), meristem removal and addition of the plant growth regulator Abscisic Acid (ABA). Preliminary results suggest that using this method sorus formation can be induced in sporophyte of 3-4 months (110 days) old. Thus, there is a great potential to improve the efficiency of a selective breeding program by shorting the length of the natural reproductive cycle.

OR-06-01

The Carrageenan Controversy

Harris Bixler, *Marinalg International, MIT, United States*

The Carrageenan Controversy Except for Japanese nori, the production of seaweed hydrocolloids consumes the largest amount of macro algae annually, and carrageenan is the largest consumer of this group. However, carrageenan has run into rough water with food processors and consumers, especially

those who read ingredient labels. Carrageenan is being singled out on the Internet as being unsafe for human consumption; even though it is approved for food use by all major food regulatory agencies worldwide. Most recently it has been approved for use in liquid infant formula, a particularly sensitive application when it comes to food safety. How did this negative attitude toward carrageenan evolve? It can be traced to a research group at the University of Illinois who claim that carrageenan up regulates inflammatory genes of the intestinal epithelium. There is no evidence that this in vitro model applies in vivo and a growing body of research is showing it doesn't. Nevertheless, it was picked by various bloggers feeding on contradictory issues and quickly went viral. This short talk will present what is being done to calm down this controversy.

OR-06-03

Red seaweed bioactive compounds extraction by innovative technology combination

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Red macroalgae, Solieria chordalis (Solieriacea, Rhodophyceae) has attracted attention as a potential source for industrial and biotechnological feed-stock. Solieria sp. constitues an interesting source of compounds with many applications, including carrageenans, phycobiliproteins, proteins, sterols and mycosporine like amino acids. The complexity of seaweed composition and its cell structure requires the study of the extraction technologies. This study aims to compare different sustainable and green technologies and the development of multistep extraction processes. Different innovative methods such as enzymatic hydrolysis (EAE), supercritical carbon dioxide (scCO2) and microwave assisted extraction (MAE) were evaluated beside two traditional methods (aqueous and organic extraction). These technologies are somewhat specific with the nature of target compounds and lead to different efficiency. The organic maceration using ethyl acetate and methanol yielded 2% and 20%. Higher extraction yields were observed for EAE (42 – 61 %) under optimal conditions (enzymes, time/temperature) whereas ScCO2 shows an efficiency of 1 at 2 %. The MAE has increased the carrageenan's yield extraction (> 5%) and reduce the time treatment by five. The evaluation of the crudes extracts was performed by the measurement of antiviral and cosmetics bioactivities (Herpes simplex virus type-1, antioxidant, whitening and anti-aging). Centrifugal Partition Chromatography (CPC) was applied for fractionation. Analytical methods (HPLC, LC-MS, MNR) reveal different active compounds. The bioguided fractionation highlighted extracts with anti-aging (decrease 30% of elastase effect) and whitening (decrease 20% of tyrosinase effect) activities. We discuss on the different efficiency/specificity balance of the innovative technologies used. The optimization of processes and their combination could be used to isolate various bioactive compounds with interesting anti-aging and anti-whitening bioactivities.

OR-06-04

Enzyme technology for handling red seaweeds for carrageenan and more

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Switching to a newer production technology, in any given industry, mandates one, more, or all of the following viz., better process economy, better utilization of the raw material and existing facilities, lower water, chemical and energy consumption, better product and yield. Novozymes has developed an enzymatic technology for carrageenan extraction, which provides benefits in both the process and the product obtained. Carrageenan obtained using enzymes also aligns to the jecfa requirements. The enzyme technology developed also provides a starting point for product diversification for future applications using carrageenan.

OR-06-05

Beyond carrageenan: development of technologies for full utilization of Kappaphycus biomass

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Shrikumar Suryanarayan, *Sea6 Energy Pte. Ltd., India*
Sawan Kumar, *Sea6 Energy Pte. Ltd., India*
Sailaja Nori, *Sea6 Energy Pte. Ltd., India*

As of 2015 most production of Kappaphycus spp. farmed in tropical waters is utilized as raw material for the production of kappa carrageenan. Components of seaweed biomass other than carrageenan are

conventionally discarded during processing. Carrageenan markets have demonstrated sluggish growth and low levels of product innovation for about three decades so opportunities for many-fold increases in markets for Kappaphycus biomass are undeveloped. Indian government laboratories developed patented technology for separating Kappaphycus liquid and solid fractions almost two decades ago and that technology showed promise for full utilization of Kappaphycus biomass in agricultural nutrient applications; however the technology was still bound to carrageenan markets as it specified that the solid 'pulp' fraction be dried and utilized in carrageenan production. With the growth of innovation in biotechnology, notably at incubator facilities in the Bangalore region of India, there is now developing technology that is opening opportunities for development of a wide range of products from Kappaphycus biomass that extend well beyond dependence on carrageenan markets that approximate zero-sum games. Such products fully utilize one hundred percent of seaweed biomass. They include not only hydrocolloids, human food and animal feed items, agricultural nutrients and plant biostimulants but also petroleum replacement products such as biofuels and plastics. Such products are opening major new markets that can support many-fold production increases by seaweed producers. Furthermore, the fact that these new product value chains commence with live biomass from farms are driving a shift of value addition toward seaweed producing areas where multiplier effects can benefit farm communities.

OR-06-06

Bioactive compounds in industrial red seaweed used in carrageenan production

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The main seaweed species used in industrial scale for carrageenan production are Kappaphycus alvarezii, Eucheuma denticulatum, Chondrus crispus, Gigartina sp. and also Furcellaria lumbricalis as a source of furcellaran (Danish Agar) is also classified together with carrageenan. The chemical compositions of these five industrial red seaweeds were evaluated. Protein, lipid and total phenolic content, total amino acid and composition, fatty acid profile, tocopherol content and pigment composition were analyzed. The results demonstrate that there is potential possibility to develop a method to extracts most of the bioactive compounds, before the main process for carrageenan extraction, leading to a future multi-product extraction (biorefinery) approach, instead of the traditional single-extraction procedure.

OR-07-01

Are proliferative seaweeds an exploitable and sustainable resource?

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Seaweeds represent a unique marine environment. They are often attached forms on different substrates under and/or over water that undergo periodic diverse chronic stresses arising from variations in desiccation, radiation, salinity, tidal currents, temperature, nutrients and others from biotic and anthropogenic activities. These factors have an impact on the seaweed compounds variations. In this study, the proliferative red macroalga Solieria chordalis is investigated in terms of quantity and of quality since more than two years. Since October 2013 until today, S. chordalis is collected each month on the same beach in South of Brittany, in France. Biochemical compositions are analyzed by colorimetric methods, chromatography and by Fourier transform infrared spectroscopy. During two years, the dry matter rate changes a bit (13.6 ± 3.0 % of seaweed). Concerning neutral sugars, sulfate groups linked to polysaccharides and ash, their proportions vary from more than 5.5 % in a year. The profile of simple sugars showed differences in the composition as well as the type of carrageenan present in S. chordalis. More galactose was detected in spring compared to the samples collected in the rest of year. According to these results, some hypothesis can be made. The quantity of compounds constituting S. chordalis may be representative of the life cycle that is repeated every year. The quality of the dry matter varies with seasons and it is affected by environmental factors. Lastly, some steps in the life cycle seems to be regulated by the seasonality (temperature of water, photoperiod). Red macroalgae blooms representing an available marine resource and the biochemical composition of these seaweeds depend on environment. The variability in term of quantity and of quality of seaweeds must be studied prior to considering potential applications depending of natural population as well as for aquaculture.

OR-07-02

Structure of epibionts associated with Sargassum and Acanthophora in La Paz, México

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Sargassum horridum is an ecologically important habitat that provides shelter to various organisms in the Gulf of California (GC). Acanthophora spicifera is an invasive seaweed in the GC that is currently sharing habitat with S. horridum. In this study, a comparison of the seasonal variation in the structure of epibionts associated with S. horridum and A. spicifera was carried out April to July 2014 and February to March 2015 in Punta Roca Caimancito. In S. horridum we quantified in 713,396 epibionts in 1.53 m2 and identified 124 taxa representing 11 phyla, 15 classes, 33 orders, 43 families, 58 genera and 46 species. In A. spicifera, we quantified 432,840 epibionts in 1.53 m2 and 90 taxa from seven phyla, 15 classes, 26 orders, 39 families and 34 species were identified. S. horridum harbored 25 unique species and A. spicifera, seven. There were significant differences in richness and diversity between algae, months and seasons. While significant differences in abundance and equity were seen only for season. We found seasonal changes in Gastropod taxa, Protohyale yaqui, Leptochelia dubia, Ampithoe plumulosa and Podocerus fulanus, which are the most abundant in both algal communities. We conclude that both algae have a structure different community, this is due to having a different morphology that allows epibionts specificity to each. It does not represent changes in abundance during the months studied, because A. spicifera maintains its size and thus provide a more stable shelter to organisms.

OR-07-03

Seasonal phenology and metabolomic of Gracilaria vermiculophylla (Bay of Brest, France)

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Seaweeds represent one of the largest groups of marine aliens in Europe, and constitute between 20 and 29 % of all introduced marine species. Alien species have been shown to be particularly adaptive through phenotypic changes. Moreover, to colonize their novel environment, introduced species have to adapt their defense by e.g. production of chemical cues. In Brittany, the red macroalga Gracilaria vermiculophylla has invaded the bare areas of brackish waters in saltmarshes since 1996. In the Bay of Brest, the alga forms dense monospecific mats on mud surface and occupies a free ecological niche, in association with the invasive halophyte, Spartina alterniflora. The phenology of G. vermiculophylla was studied through a seasonal monitoring of biomass, density and size of fragments, complemented by a metabolomic monitoring using HRMAS 1H NMR chemical footprinting analyses. Moreover, pigments were quantified by HPLC and spectrophotometry. Both species were more abundant with a maximum of biomass in summertime. G. vermiculophylla is present all around the year, never fixed to any substrate on mud. Phenologic observations on algal populations demonstrated a high capacity of fragmentation with a dominance of fragments inferior to 3 cm. Metabolomic analysis highlighted a temporal variability of pigments between sites and seasons. These results put in relation with ecological data make it possible to better understand the acclimation of G. vermiculophylla, mainly present throughout the year at a vegetative state. Our study is an important contribution in order to understand the ecological strategies of this invasive seaweed, in association with Spartina alterniflora, to colonise and persist in the Bay of Brest. This work was financed with the support of the EU FP7 ERA-NET Program, Seas-Era INVASIVES project nr. ANR-12-SEAS-0002.

OR-07-04

Assessment of seedling ability of the introduced brown alga, sargassum horneri, in northeast taiwan

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Some species in the marine brown algal genus Sargassum possess the ability to detach and drift far away from its native home. Drifting Sargassum has been sparsely reported from Taiwan since the 1920s. In recent years, two drifting Sargassum species, S. horneri and S. fusiforme, have periodically invaded the northern coast of Taiwan. In particular, several thousand tons of drifting S. horneri washed ashore in 2012, requiring extensive cleanup and hindering navigation around fishery ports. In the past few years, both

drifting Sargassum species started to appear offshore around late February and lingered through late April or early May depending on sea surface temperature. In general, drifting S. horneri arrived earlier but died earlier as the seawater temperature rose higher than 20° C, whereas drifting S. fusiforme could tolerate higher seawater temperatures and even established some new persistent populations in northern Taiwan. Fertile receptacles and fertilized eggs were often found in the drifting plants of S. horneri, but surprisingly, new populations of S. horneri have not been found along the coast after May. In this study, we aimed to study whether or not the fertile receptacles of the drifting S. horneri can produce offspring in Taiwan. In late March of 2015, we collected drifting S. horneri masses comprised of branches bearing female or male receptacles from the eastern coast of Keelung City. We applied artificial fertilization and observed all development stages of pre- and post-fertilization. We found the fertilized eggs were able to undergo cell divisions and develop into embryos. Moreover, most embryos survived for at least 4 weeks under dim light (300-500 lux) and low temperature (15-18° C). Our preliminary results suggested that the drifting S. horneri may be able to establish young seedlings in the northern coast when the seawater is below 18° C, but the young plants may die out when the surrounding seawater temperature rises after early May.

OR-07-05

The chemical ecology of seaweed invasions

Henrik Pavia*, *Departmnet of Marine Sciences, University of Gothenburg, Sweden*

The filamentous red alga Bonnemaisonia hamifera, which has its origin in western Pacific Ocean waters, has invaded large parts of the Atlantic coasts of Europe and North America. It has rapidly become one of the most abundant subtidal macroalgae in Scandinavian coastal waters, outcompeting many native species. We show that B. hamifera contains a poly-halogentated 2-heptanone that is effective against multiple native enemies, including herbivores, microbes and competitors. The production of the defense chemical entails a cost for B. hamifera but this cost is outweighed by ecological benefits. The provision of shelter from fish predation to consumers of native algae gives B. hamifera an additional advantage over native competitors and facilitates its spread in the new area. In conclusion, the results suggest that the costly but highly effective chemical defense produced by B. hamifera, which is novel to native enemies, is important in explaining the remarkable invasion success of this red alga

OR-07-06

Morphological plasticity and productivity in Giant kelp Macrocystis pyrifera

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One prominent characteristic of Giant kelp is its highly plastic morphology, physiology and life history traits therefore it seems of great ecological relevance to explain the global success of this species, also because of its high productivity makes it commercially important. It has been recognized, that kelp responds to hydrodynamic regimes through modifying biochemical processes and morphology, influencing resource acquisition in variable flow regimes and biomechanics properties of the thalli. This study tests how morphological traits of Giant kelp allow maintaining their productivity in stressful environments (high summer surface temperature, i.e.thermocline). The morphology can vary between different latitudes and habitats (wave exposed or protected coastal habitats). We have determined that in average in some sites Giant kelp can allocate only 38% of its biomass to the canopy but in other sites can be above 50%. If we consider photosynthetic surface (blade numbers) the subcanopy can reach in some cases almost 80%. As in summer the canopy is under a higher light and temperature regimes than the subcanopy we tested how one Giant kelp individual can acclimate to these different environments by using PAM technology and experimental 400-L bioreactors with two different light gradients. The results found showed a significant decrease ($p < 0.05$) in the productivity with depth and light extinction, with values varying from 18.75 ± 5.75 µmol C m-2 s-1 in the canopy, down to 1.09 to 3.08 µmol C m-2 s-1 (94 % of productivity reduction). We discuss these results considering the morphological variability of the Giant kelp and conclude that kelp morphology can partially compensate photosynthetic losses due to kelp stress in the canopy. Financial support: Fondecyt 1150978

OR-08-01

Pro-SeaVeg – Profiling and enhancing bioactive yields in Irish red sea vegetables

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Following their inclusion in traditional western diets over centuries, a range of red macroalgae (including Chondrus crispus, Mastocarpus stellatus, Palmaria palmaria and some members of the Bangiales) are commonly consumed in Ireland today. In contrast to the recent focus on research into bioactivities in crude extracts as part of a number of research initiatives, there is an outstanding lack of detailed knowledge of population- and habitat-specific, and temporal variation of the specific biochemical profiles of these important food species; their capability to acclimate to ambient environments is well described but implications for food quality are usually not considered. In order to support their utilisation as sea vegetables, the Pro-SeaVeg project aims to 1) characterise seasonal and spatial variation in the biochemical profiles of harvested natural populations in Ireland and 2) explore mechanisms to optimise and enhance bioactive profiles by modifying culture conditions to produce high-value biomass in culture. Specifically, this project focusses on characterising the seasonal and spatial variation in pigments including phycobilin, fatty acids, and nitrogenous components in C. crispus, P. palmata, and Porphyra dioica from several locations around the Irish west coast. Furthermore, it investigates growth, biochemical and bioactive responses of algae to different culture regimes. The bioactivities being assessed include the anti-oxidant, DPP-IV inhibitory and ACE-inhibitory properties; in some instances, the variation in bioactivity levels may be related to changes in the biochemical profile. The results to date highlight the potential of selective sampling and optimised algal culture conditions to obtain high value (bioactive) biomass for food applications.

OR-08-02

Seasonal variation in nitrogenous components and bioactivity of Porphyra dioica protein hydrolysates

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The edible red seaweed, Porphyra dioica, has been harvested and consumed in Ireland for centuries. Based on its nutritional composition, availability and familiarity, a significant potential exists to develop this species as a high-value functional food ingredient. To identify optimal seasons for harvesting biomass with high bioactive peptide potential and therefore fully realise its potential in food applications, an assessment of the natural variation in P. dioica bioactives was required. This study characterised the seasonal variability in nitrogenous components and SDS-PAGE protein profiles of P. dioica. The effect of time of harvest on the in vitro antioxidant and angiotensin converting enzyme (ACE) inhibitory activities of P. dioica protein hydrolysates was also investigated. Kjeldahl analysis revealed P. dioica total nitrogen and protein nitrogen contents ranging from 24.8-49.4% (w/w) and 19-43 mg per gram dry matter. Significant differences in total and protein nitrogen contents ($P < 0.05$) were observed between samples harvested in summer months and those harvested in winter. Electrophoretic analysis showed substantial differences in the protein profiles of P. dioica harvested at different times of the year. P. dioica protein extracts were hydrolysed with food-grade proteolytic preparations, Alcalase 2.4 L and Flavourzyme 500 L. The Oxygen Radical Absorbance Capacity (ORAC) and Ferric Reducing Power (FRAP) values of the hydrolysates ranged from 229.5-1015.3 and 4.1-28.7 µmol Trolox Equivalent (TE) per gram of dry matter, respectively. The P. dioica hydrolysates also inhibited ACE activity (half maximal inhibitory concentration, IC50: 0.42–1.78 mg/mL). Significant seasonal differences were observed in all in vitro bioactivity assays. These data demonstrate that seasonal variation in P. dioica nitrogenous components affects the bioactivity of the protein hydrolysates. P. dioica hydrolysates have potential for development as health enhancing food ingredients.

OR-08-03

Expansion and potential of valorization of Grateloupia turuturu along the French Western coast

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Grateloupia turuturu is a red macroalga introduced in Brittany since 1970s. This alien species present a strong potential of proliferation through inherent characteristics, i.e. its tolerance to many environmental

parameters, a rapid growth, a strong polymorphism, marginal and remote dispersals, together with the production of secondary metabolites. During 40 years, G. turuturu populations expanded from Brittany to the North (Normandy) and to the South (Vendée) of France. An up-to-date distribution of this exotic species is presented along the Western coasts of France, together with a spatio-temporal monitoring of the species carried out monthly during 16 months and seasonally during 10 years. The high biomass of some populations of G. turuturu in Brittany, together with the production by this species of some bioactive metabolites, suggest its strong potential for an industrial valorization. This introduced species is for the moment hidden. Nevertheless it enlarges little by little its geographical range, vertically all along the intertidal zone, but also horizontally at the scale of the French coast. The expansion of G. turuturu, in a context of global change, together with its potential of valorization, are discussed.

OR-08-04

Lipid composition of Ulva armoricana, Solieria chordalis and Sargassum muticum from Brittany

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For the last fifty years, scientists have carried out a large amount of studies about marine natural products and especially about seaweeds which are known for their content in nutritional beneficial components and in bioactive compounds like proteins, carbohydrates, antioxidant, minerals, fibres, vitamins or lipids. In recent years, lipid composition of marine algae was investigated due to the content of polyunsaturated fatty acid which play an important role in the prevention of cardiovascular diseases, osteoarthritis, and diabetes and for having antimicrobial, antiviral, anti-inflammatory or anti-tumoral properties. Using coastal proliferative seaweed species could be of interests to find sources of marine lipids. Ulva armoricana (Chlorophyta), Solieria chordalis (Rhodophyta) and Sargassum muticum (Ochrophyta) are proliferative species present in Brittany (North West of France) and which cause environmental and public health problems that should be taken into consideration. The lipid composition of these three species, representatives of the three phyla of macroalgae, was investigated. The potential value of lipid composition (total lipids, glycolipids, phospholipids, sterols, fatty acids, unsaponifiable fraction) of these proliferative species was determined to find new applications. The macroalgae Ulva armoricana, Solieria chordalis and Sargassum muticum exhibit low total lipid contents, 2.6%, 3.0% and 3.2% dry weight respectively. However they reveal a diversity in lipid class distribution. The main fractions of S. chordalis are neutral lipids (37%) and glycolipids (38%), U. armoricana contains mostly neutral lipids (55%) whereas the main fraction of S. muticum is glycolipids (69%). U. armoricana and S. chordalis exhibit high amount of nutritionally essential n-6 and n-3 polyunsaturated fatty acids and two monounsaturated 2-hydroxy and 3-hydroxy fatty acids are identified here for the first time in seaweeds.

OR-08-05

Macroalgae Biomass Supply Chain: Seasonal variation in the preservation parameters of Ulva lactuca

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Macroalgae is an attractive biomass source for energy production (through digestion, fermentation, pyrolysis or gasification) as many species have rapid growth rates and aquaculture potential. To use this biomass, the EPSRC MacroBioCrude project aims to produce a transport biofuel using the pyrolysis products of ensiled marine macroalgae. However, once harvested, the wet biomass of macroalgae degrades rapidly. To prevent degradation, an efficient, scalable and economic preservation route for macroalgae is to adapt terrestrial agricultural ensilage methodologies. Ensilage involves treating the biomass with bacteria or chemicals to induce a drop of pH within the material to below 4.5. This environment slows down biological degradation, producing a stable biomass, with predictable properties, for further processing. The quality of ensiled biomass is dependent on the harvest and preservation time, owing to variability in the composition of both biomass and the biofilm on the biomass. Ideally, on ensiling, the pH will drop rapidly, with low levels of leachate (a liquid exudate with a high biological oxygen demand), which, if not controlled, can contaminate soil and freshwater. Presently under investigation is Ulva lactuca. This prolific, adventitious species can be cultivated but, in the wild it can produce periodic troublesome 'green tides'. The optimum harvest period for preserving Ulva lactuca as marine silage has been investigated. Biomass was collected throughout the summer growing season and either treated with the silage inoculant

Lactobacillus plantarum or left untreated before vacuum sealing and storage. Samples were tested for pH, leachate volume and dry mass per gram of wet material ensiled 0, 4, 8, 6, 32, and 90 days after ensiling. The findings show the months of late April, May, June and particularly July are recommended for harvesting and ensiling of Ulva lactuca. Keywords: Biomass; Macroalgae; Silage; Ulva lactuca, leachate, pH

OR-08-06

The impact of sample preparation parameters on bioethanol and methane yields from Laminaria digitata

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Macroalgae are capable of generating more organic carbon per hectare than terrestrial plants and have additional benefits including those of not requiring land, fertiliser or fresh water to grow, or being a major food in Europe. Despite this, macroalgae are not yet fully exploited as a biomass source for bioenergy or platform chemical production in Europe, with one issue being the high harvesting and processing costs. This paper addresses some of the processing stages involved and uses the production of bioethanol and methane to demonstrate the effect of altering these processes on biofuel outputs. It is important that biomass processing for lower value products needs to be as simple as possible, requiring minimum energy input to maximise the process viability. This paper will address 3 processes: 1) The process of washing macroalgae before use, common practice in academic studies but potentially problematic at scale. 2) To consider different drying methods to allow biomass storage. 3) Whether maceration, allowing the pumping of macroalgal particles, also improves sugar release and utilisation of the algae through increased surface area to volume ratios. Recent findings in process 3 will be reported at the conference; for processes 1 and 2, a study was conducted with the kelp Laminaria digitata following summer and winter harvests. For each harvest samples were either briefly washed with tap water or left unwashed, then subjected to different drying regimes. Material was used to produce bioethanol and methane and the yields correlated to the washing and drying methods. Results showed that the higher ethanol yields were seen from the unwashed kelp containing higher sugar concentrations; whereas for anaerobic digestion washed samples gave higher methane yields, possibly due to a lower salt-tolerance in the anaerobic microbial consortia.

OR-09-01

High yield seaweed cultivation using advanced textiles

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Macroalgae (seaweeds) are generally considered as a very important and valuable source of biomass for numerous applications such as food and feed (additives), biochemicals and biomaterials, pharmaceuticals and nutraceuticals, and biofuels/energy. The H2020 project MacroFuels - Developing the next generation macro-algae based biofuels for transportation via advanced bio-refinery processes - targets the development of technology for the production of fuels which are suitable as liquid fuels or precursor thereof for the heavy transport sector as well as potentially for the aviation sector. Targeted biofuels are ethanol, butanol, furanics and biogas. This paper describes the high yield cultivation of several seaweed species using 1D and 2D advanced textile cultivation substrates. Based on the developments of the FP7 project AT~SEA (Advanced textiles for open sea biomass cultivation) partners SIOEN, SAMS and AU target the advanced, large scale and year round cultivation of red, green and/or brown seaweeds as biomass for advanced onshore biorefinery processes towards the next generation of transportation biofuels. Topics that will be discussed are 1) large scale cultivation of red, green and/or brown seaweeds in Denmark and Scotland, 2) high yield rotating crops, 3) determination of the seasonal variation of sugars contents during the cultivation of selected species, 4) mechanical harvesting, 5) large scale seaweed storage and transportation at sea. The MacroFuels project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654010.

OR-09-02

A novel cultivation method of filamentous Ulva sapora by seeding free-floating surfaces

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The new filamentous species Ulva sapora has become a target for scalable on-land production of biomass for bioremediation and bioproducts in North Queensland, Australia. Filamentous species of Ulva are

commercially cultivated by seeding nets and transferring these to cultivation grounds in open water. In contrast to this traditional method, we have developed the free-floating cultivation of U. sapora to deliver high stocking densities and growth rates with consequently high productivities. We have for the first time developed a method for the controlled formation, release and settlement of zoids. This in turn enabled us to cultivate U. sapora over multiple successive generations using harvested biomass as the seed-stock for the subsequent generation, enabling the sustainable long-term cultivation. This fundamental baseline data has resulted in the cultivation of U. sapora on small floating surfaces to deliver sustainable, self-seeding and scalable cultivation systems, which provide environmental services while adding value by providing high-value food products. We have demonstrated the suitability of this innovative approach by remediating waste water from the intensive aquaculture of prawns (shrimp) and this method is transferrable to any marine waste water rich in nutrients.

OR-09-03

Cultivation of Palmaria palmata screening for viable substrates and improving spore growth

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Palmaria palmata (dulse) is one of the most requested seaweeds by the food industry in Denmark and the demand for a production is high. Most countries commercializing P. palmata harvest from wild populations and sell it directly or grow the wild harvest in nets or tanks for further increment until commercial size is reached. In order to implement a more sustainable production of the species, various efforts to cultivate it from spores has been tried; nevertheless, big scale sea cultivation has not successfully been implemented. Thus, further studies in the life cycle of P. palmata and its cultivation, upscaling and mechanization are needed to secure and develop a sustainable exploitation of this popular seaweed. The aim of the current project was: 1) to monitor spore release over time and subsequently follow the survival and development; 2) to test different materials as spore substrate (coconut net, cotton textile, spat collector bands, propylene (PP) rope, sinker PP rope and kuralon); and 3) to test different hatchery infrastructures to improve gametophyte/sporophyte growth performance prior to deployment at sea. Results showed that spore survival and general performance to a minor extent was linked to timing of their release. Further, the recruitment was highly dependent on the type of substrate. Natural textiles were not suitable, whereas the spat collector was the most efficient. However, the large surface area of this substrate increased the biofouling at sea to a degree that seedlings could not withstand. The remaining substrates performed equally well and healthy spore-lines were successfully produced. Implementing microalgae cultivation technology in the hatchery proved beneficial for growth and furthermore, it was easier in handling, cleaning and required less consumables. From the results so far obtained we conclude that the bottleneck now lies in the development at sea – particularly in eutrophic shallow waters with high risk of disruptive biofouling.

OR-09-04

The optimal substrate preference of saccharina latissima for large-scale cultivation on textiles

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Saccharina latissima is a phaeophyte macroalgae under investigation as a cultivation crop. In the fp7 project at~sea (advanced textiles for open sea biomass cultivation), the substrate preference of this species was determined to optimise its growth from settlement, early development through to adulthood. Laboratory and tank trials determined the optimal surface chemistry and roughness using: polymer blocks, pure chemical films, different twines and small sections of various textiles. Large scale field testing was also performed at three sites: in scotland, norway and ireland over three years. These trails increased from 1, to 4 to 20m2 as the selection was refined. Other field trials were conducted to determine optimal seeding method and growth density. Large differences were found in the suitability of polymers. Meiospore settlement varied substantially, generally highest on high contact angle surfaces. When 20-50 mm, sporophytes grew successfully only on substrates where they had a high attachment force. These were usually polymers which had low initial settlement. When textiles and twines were tested, the effect of surface chemistry was reduced but still present. However, a complex surface allowed the physical interlocking of the holdfast into the substrate, and so growth was possible, even with a poor surface chemistry. A new seeding method was developed, removing the need for a large dedicated hatchery space. An adhesive was used to apply juvenile sporophytes (<2mm) directly onto twines, ropes or textiles, while at the cultivation site. The sea trial results supported the laboratory and tank experiments. Certain textiles were excellent for cultivation, achieving up to 16 kg m-2 after four months of growth, Others were

not at all suitable, achieving 0<1 kg m-2. The final 2x10m sheets achieved 8-12 kg m-2 at the deployment sites in Norway or Ireland.

OR-09-05

Effect of Different Planting Distances on the Growth of Tissue-cultured Kappaphycus alvarezii

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K. alvarezii is the most economically important red seaweeds in the world trade market especially for phycocolloid production in Indonesia. In order to increase the productivity of the seaweed, micropropagation has been suggested as a best method to resolve the issue by producing seedlings with higher growth rate. However, seaweed tissue culture has still encountered several challenges including the lack of experiment protocols especially the effect of planting distance differences on growth and semi refined carrageenan (SRC) properties using tissue-culture produced seedlings. In addition, superior seedlings could also be obtained through a clone selection. Clone selection is a selection using repeteadly cultivated seedlings within 30d regularly for six consecutive times. Therefore, the present study was the first study done to investigate the effects of planting distance differences on growth and SRC properties of K. alvarezii tissue-cultured seedlings through a clone selection using long line method. This study was done for 6 (six) months from May to November 2015 in South Konawe, SE Sulawesi. Each plantation period was conducted for 30 days. Highest specific growth rate (SGR; >3.50 %/day) of seaweed clones in each period were planted for the next period until the sixth period continuously. The treatments were different wet weights (10, 15, 20 and 25 cm) using long line method. Variables measure were specific growth rates (SGRs) and carrageenan properties (carrageenan yield, gel strength, and viscosity). Results showed that the highest SGR was found in a planting distance of 10 cm that reached 5.67-7.54%/day. Furthermore, although 10 cm-planting distance were higher for the carrageenan analyses, no significant differences were found among the treatments. Carrageenan yield, gel strength, and viscosity of the treatment were 32.6 -38.3 %, 417.5-560.0 g.cm-2, and 27.5-77.5 cp, respectively.

OR-10-01

Sustainable bioprocesses for the extraction of antiherpetic polysaccharides from Solieria chordalis

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Carrageenan is a generic name for a family of natural, water-soluble, sulphated galactans that are isolated from Rhodophyta and exploited on commercial scale. These phycocolloids exhibit high viscosity, and stabilizing, emulsifying and unique gelling properties used in the pharmaceutical, chemical and food industries. They were also shown to be potent and selective inhibitors of several enveloped viruses replication in vitro. Their modes of action have been attributed to the blockage of some early stages of the virus replication cycle. The carrageenophyte Solieria chordalis (C. Agardh) J.Agardh (Gigartinales, Solieriaceae) has been observed in the Gulf of Morbihan (France) since 2005 and in the Sarzeau peninsula (Morbihan, France) where strandings have become more abundant between July and October. S. chordalis is a real economic and environmental burden due to its littoral anarchic proliferation. The processing of this raw material is little developed and provides little added value whereas it constitutes a biomass potentially rich in highly bioactive polysaccharides that could represent useful avenues for the development of new functional ingredients in pharmaceutical industries. The aim of this presentation is then to compare and discuss the use of sustainable bioprocesses for extracting and purifying antiviral polysaccharides from Solieria chordalis. To improve the extraction conditions of polysaccharides, we propose to use Microwave Assisted extraction (MAE) and Enzyme-Assisted Extraction (EAE) techniques in comparison with the conventional Hot Water Extraction (HWE). Comparison of yields and chemical composition analysis of extracts were performed for each processes. Antiviral activity from oligo- and polysaccharides was evaluated in mammalian cell lines infected by Herpes simplex virus type 1 (HSV-1; family Herpesviridae) in vitro. Financial support ECOS-Anuies project M14A03

OR-10-02
Fucoidan: Connecting analysis and bioactivity

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Fucoidans have an attractive array of bioactivities that offer great potential for human health applications, with benefits including immune modulation, anti-cancer, gut health, and pathogen inhibition. Research into fucoidan has continued to gain pace over the last few years and has demonstrated many opportunities in therapeutic and adjunct roles. Despite this increasing research focus, the relationship between the diverse chemistries of different fucoidans – extracted from differing species, and by differing processes – and their ensuing bioactivities, remains poorly understood. Here, these variations and their ramifications are discussed, along with the bioactivities of three well-defined commercial fucoidan extracts.

OR-10-03
Crude fucoidan in Danish brown algae - seasonal variations and environmental impact

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Fucoidans are a complex group of sulphated polysaccharides predominantly found in the cell walls of brown algae. The bioactive properties of fucoidans (including antivirus, antitumor, anticoagulant and anti-inflammatory effects) attract increasing interest from the medico-pharmaceutical industries and may drive an increase in demand of brown algae biomass. In nature, the biochemical composition of brown algae displays a seasonal fluctuation driven by environmental factors. However, the interactions between fucoidan content and environmental factors are only sparsely explained. In order to produce algae that are optimal for the extraction of fucoidan, we need more knowledge on seasonal variation and impact of environmental conditions on the fucoidan content of brown algae. In this study, the seasonal variation of fucoidan in three common species of brown algae, Saccharina latissima, Laminaria digitata and Fucus vesiculosus, was coupled to the seasonal fluctuations of key environmental factors: Availability of light and nutrients (nitrogen), salinity, temperature and exposure. Laboratory experiments isolating the effects of the single factors were carried out. The results demonstrated interspecific differences in the dry matter concentrations of crude fucoidan: F. vesiculosus (15%) > L. digitata (12%) > S. latissima (7%), with maximal concentrations in April, March and August, respectively. Salinity and light availability were positively correlated to the tissue content of fucoidan, whereas the availability of inorganic nitrogen decreased the content. Exposure had no significant impact. Experimental data supported the field observations. Intraspecific comparison of two populations of L. digitata showed contrasting seasonal patterns that to some degree could be explained through environmental factors, though potential genetic differences could also play a role. The implications for future cultivation of brown algae for fucoidan production are discussed.

OR-10-04
The seasonal variation of fucoidan from 3 species of brown macroalgae

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Fucoidan is currently being widely reported in the literature due to its biomedical properties, which range from anti-cancer to antithrombotic, with nutraceutical, functional food and cosmetic properties also being identified. All of these properties have been show to depend of the structure of the macromolecule, including the degree of sulphation and branching. The structure of fucoidan has been repeatedly reported to vary according to species, season, location and maturity, however there is little published data to support this at present. Understanding the seasonal variation of fucoidan is important for industrial applications, where a consistent product is required and harvest at the correct time is key. This study explores the seasonal variation in fucoidan of three species of brown macroalgae, Fucus serratus (FS), Fucus vesiculosus (FV) and Ascophyllum nodosum (AN), harvested monthly off the coast of Aberystwyth. Average fucoidan content is 6.0, 9.8 and 8.0 wt% respectively for FS, FV and AN, with highest quantities extracted in autumn and lowest in spring. The fucoidan macromolecule is comprised of a sulphated fucose backbone and often contains small quantities of other sugars such as xylose. These components are important to the functionality of the polysaccharide. Fucose content varied between 18–28, 26-39 and 35-46 wt% and sulphate content between 30-40, 9-35 and 6-22 wt%, and both fluctuate inversely to the total fucoidan. Size exclusion chromatography (SEC) analysis gave some comprehension into the structural differences

between the species. Based on the molecular weight distribution, it is hypothesised that FS has a more complex, branched structure, with a higher degree of associated sulphate ions, while FV and AN have simpler, linear structure with less associated sulphate ions. LC-MS analysis gave further evidence to this.

OR-10-05

Fucoidan and cancer: research and clinical interaction studies

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Fucoidans have previously been identified as potential anti-cancer agents in vitro and in vivo. Here, we discuss new data on two different types of fucoidan on human cancer cell lines in vitro and in vivo, both as sole agents and in combination with common chemotherapy agents. Notable synergy and additive effects were observed with particular types of chemotherapy, indicating potential for future complementary therapy. Fucoidans are ingredients in nutraceuticals used by patients with cancer. Recent research has indicated reductions in fatigue and inflammation in patients undergoing chemotherapy, however patients and physicians require reassurance that oral fucoidan will not interfere adversely with the gold standard of treatment. Here, we will discuss new clinical data on interaction studies with commonly used hormone blocking drugs and standard chemotherapy regimes for patients with active malignancies.

OR-10-06

Seasonal variance in polyphenol and polysaccharide content in brown seaweed

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Seaweeds are a rich source of minerals and vitamins, in addition to bioactive compounds like phlorotannins and polysaccharides. The bioactivity, antioxidative properties and potential utilization of chemicals extracted from seaweed has been extensively studied in the recent years. Phlorotannins and polysaccharides (such as fucoidan and laminarin) have great bioactivity potential and can be used in functional food, nutraceuticals and cosmetics. Examples of bioactivity include antioxidant, anti-inflammatory and anti-diabetic properties. The aim of the present project was to study the effect of environmental factors on polyphenols and polysaccharides in seaweed and thereby be able to better understand how ecology affects chemistry of these species for more effective isolation of biochemical, their further analysis and utilization in bioactive measurements. Samples of Saccharina latissima, Alaria esculenta, Ascophyllum nodosum and Fucus vesiculosus were collected at three locations, Reykjanes, Breiðafjörður and Eskifjörður, from March till October, in total on six occasions. Methods for isolating fucoidan and laminaran polysaccharides were developed. Total polyphenol content (TPC) was measured in all samples and different bioactivities assessed in selected samples applying both chemical and cell based assays. In addition, iodine and contaminants, with main focus on total arsenic and inorganic arsenic, were analyzed in selected samples. TPC was high in F. vesiculosus and A. nodosum but rather low in A. esculenta and S. latissima. Antioxidant activity, measured as oxygen radical absorbance capacity (ORAC) values and in cells, was high in samples containing high amount of TPC. F. vesiculosus and A. esculenta showed anti-inflammatory properties. Total content of arsenic was seasonal depended and the amount of inorganic arsenic was in very low concentration. The results have increased the knowledge about the potential uses of seaweed in Iceland substantially.

OR-11-01

Macrocystis pyrifera prioritizes tissue maintenance in response to nitrogen fertilization

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Our understanding of the response of terrestrial plants to nitrogen addition is advanced and provides the foundation for modern agriculture. In comparison, research on responses of complex marine macroalgae (e.g. Fucales and Laminariales) to increased nitrogen is far less developed. We investigated how in situ pulses of nitrate affected the growth and nitrogen physiology of the giant kelp Macrocystis pyrifera by

adding nitrogen using KNO3 dissolution blocks during a period of low seawater nitrogen concentration. Multiple parameters (e.g. growth, pigments, soluble NO3-) were measured in distinct tissues throughout entire fronds (scimitar, stipe, adult blade, mature blade, sporophyll, and holdfast). Unexpectedly, fertilization did not enhance elongation rates within the frond, but instead biomass (g cm-2) increased in blade tissues; this may have enhanced tissue integrity as fertilized kelp had lower rates of blade erosion. Tissue chemistry also responded to enrichment; pigmentation, soluble NO3-, and %N was higher throughout fertilized fronds. Labelled 15N traced nitrogen uptake and translocation from nitrogen sources in the kelp canopy to sinks in the holdfast (10 meters below). This is the first evidence of long-distance (> 1 m) transport of nitrogen in macroalgae. Patterns in physiological parameters suggest that M. pyrifera displays functional differentiation between canopy and basal tissues that may aid in nutrient tolerance strategies, similar to those seen in higher plants and unlike those seen in more simple algae. This study highlights how little we know about nitrogen additions and nitrogen-use strategies within kelp compared to the wealth of literature available for higher plants.

OR-11-02

Phenology of Chondracanthus tenellus (Rhodophyta) in central Pacific coast of Honshu, Japan

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To probe the potential as raw material for salad or carrageenophyte, phenology, reproductive efforts and types of carrageenan were studied in a common gigartinalean red alga, Chondracanthus tenellus. Field observation and sampling were conducted at Tateyama in the Pacific coast of Japan monthly from August 2014 to July 2015. Growth was monitored by measuring the length and weight of thalli and population density by counting the number of clumps along a subtidal fixed line of 30 m long (3-4 m in depth). Reproductive efforts were evaluated by counting the numbers of cystcarp per thallus and carpospores per cystcarp. Types of carrageenan were identified by NMR analysis in May 2015. Average thallus length sharply dropped in October and gradually increased from November 2014 to record the maximum length (61.6 ± 27.7 mm) in June 2015. Female gametophytes bearing cystocarps were found mainly in April to September and the largest percentage among the collected samples (N = 157-1686) was 50.7% in September. The other thalli did not show any reproductive signs from visible or tissue section. The average number of cystcarps per thallus varied between 1 and 418 depending on the season and individuals. The number of carpspores per cystocarp was 72.81±15.51×103 (N = 4) in January 2015. Population density steadily increased from the beginning of the study, and reached peaks (1.3 clumps /m2) in December and February. Carposporic gametophytes were found in August to September in 2014 and May to July in 2015 with the highest value (20.6 %) in September. From these results, maturation season of gametophytes seems to be May to September. Tetrasporophytes were found only in June 2015. NMR analysis revealed that gametophytes contained kappa/iota hybrid carrageenan. The spectrum from sterile thalli indicated the presence of iota or theta/lambda type carrageenan. Considering the size of thallus, it is preferable to harvest in May to July.

OR-11-03

Genetic and environmental variation of Undaria pinnatifida originating from five sites in Japan

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et al.

Undaria pinnatifida is grown for food and industrial materials worldwide; advanced breeding is needed to meet quality and productivity requirements, and to promote adaptation to site-specific environmental changes. In this study, we selected five cultivation sites in Japan with different environmental conditions: Oga (OGA, northern Sea of Japan coast), Hirota Bay (HRT, north-eastern Pacific coast), Matsushima Bay (MAT, north-eastern Pacific coast), Naruto (NRT, Seto Inland Sea coast), and Shimonoseki (SIM, southern Sea of Japan coast). We first cultivated sporelings originating from the natural population at each site in seawater. Then we cultivated the next generation in a tank under controlled environmental conditions.

We measured the morphological characteristics and nutrient uptake kinetics (Vmax, Ks, and Vmax/Ks) of the plants. Plants from MAT grew faster and those from SIM were smaller than those from other sites, characteristics that were observed in both cultivation stages. Although twice the leaf thickness was observed between HRT and OGA cultivated, there were no significant differences among plants from different sites cultivated in tanks. The nutrient uptake kinetics of NAR plants (Vmax and Ks) and OGA plants (Vmax/Ks) cultivated in seawater were greater than those of plants from other sites. This suggests that NRT and OGA plants are adapted to temporarily high nutrient loading and low nutrient conditions, respectively. In tank cultivation, although the Vmax and Ks values of NRT plants were similar to those of plants from other sites, OGA plants had the greatest Vmax/Ks values, a similar result to that from seawater cultivation. Thus, morphological characteristics of MAT and SIM plants, and nutrient uptake kinetics of OGA plants are likely genetic, and may provide sources of mother plant selection; for example, we can use MAT plants for faster growth and OGA plants in low-nutrient conditions.

OR-11-04

Uptake kinetics and storage capacity of dissolved inorganic phosphorus in Ulva lactuca

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Dissolved inorganic phosphorus (DIP) is one of the essential macronutrients, along with nitrogen (N) and potassium (K), for metabolism and growth in Ulva lactuca (Chlorophyta). It is known that the central North Sea can be N-limited, whereas P-limitation can be effective in coastal areas, the habitat where U. lactuca is present. Little attention has been given to phosphorus-related research and few studies examine DIP-uptake kinetics and storage capacity in macroalgae in general, and U. lactuca in particular. Especially uptake kinetics and storage capacity of DIP in U. lactuca are unknown. Besides its structural employment in biological molecules, as in cellular membranes (phospholipids) or DNA and RNA, phosphorus is needed to transport cellular energy in the form of ATP, hence its availability governs growth rates. The present work is aimed to assess DIP-uptake and DIP-storage capacity as well as N:P-uptake dynamics in U. lactuca. The results show that DIP-uptake kinetics and capacity are directly related to the duration of preceding starvation. Individuals of U. lactuca removed up to 97% of DIP from surrounding medium within one day at 50 µmol l-1 supply after 10 day starvation, with uptake declining to 37% on the next day. When exposed to lower DIP concentrations, the amount of time before it comes to a decline increases proportionally. Exposed to 25 µmol l-1 (12,5 µmol l-1) showed a decline after 2 (4) days, suggesting a threshold for uptake, respectively storage capacity at 0,83 ± 0,05 µmol l-1 cm-2. Thus, U. lactuca efficiently removed DIP from the growth medium, most likely converting it to (storage) polyphosphates, explaining abundant growth during times of DIP depletion. The DIP concentration did not affect the uptake of N-compounds from the medium and high N:P -ratios identify U. lactuca as an efficient bioremediator for eutrophic coastal waters (or salt water waste streams), removing large quantities of N, while requiring minimal DIP uptake.

OR-11-05

Species-specific patterns of induced defenses in Korean macroalgae and herbivores

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Induced defense has been rarely reported in marine macroalgae even though its undebatable benefit in energy-saving strategy to avoid grazing damage. This research is conducted to evaluate two species of common macroalgae (Undaria pinnatifida and Pachymeniopsis elliptica) against two common marine herbivore species (Strongylocentrotus nudus and Chlorostoma lischkei) for their possibility of induced defense and species-specific responses. The experimental procedure to detect an induced defense involves three steps: acclimation, treatment and recovery phases. After grazer-free acclimation phase, each algal species are separated into two groups exposed to each herbivore species for feeding (treatment phase), and then placed in the containers without the grazers (recovery phase). At treatment phase, thalli exposed to grazers in the different regimes as the experimental groups (DC; direct consumption, NC; waterborne cues from nearby comsumed cospecifics, NCH; waterbourne cues from non-consuming herbivores) and the control group are measured for their actual consumption through feeding preference assay. Undaria showed an induced defense against both herbivore species, but there was species-specific difference: Strongylocentrotus (NC in both phases) and Chlorostoma (DC, NC, NCH in treatment phase). The results indicate that Undaria expresses an induced defense when directly eaten and when grazers present nearby and when eaten thallus present nearby (i.e., due to a waterborne cue) for the snails, whereas they express an induced defense only for waterborne cue by eaten Undaria thallus for the case of the sea urchins. Pachymeniopsis did not show an induced defense in all experimental groups for both phases. In conclusion, induced defense in macroalgae can be species-specific depending on algal species and herbivore species in these two pairs of species case.

OR-11-06

Seawater pH, and not inorganic nitrogen source, affects pH at the blade surface of the giant kelp

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Ocean acidification (OA), the ongoing decline in seawater pH, is predicted to have wide-ranging effects on marine organisms. For seaweeds, the pH at the thallus surface, within the diffusion boundary layer (DBL), controls their response to OA. Physiological processes such as photosynthesis and respiration alter the SW chemistry at thallus surface, increasing and reducing the pH, respectively. Other physiological processes as inorganic nitrogen (Ni, NO3– and NH4+) uptake might also alter the pH near to thallus. Using Macrocystis pyrifera, we hypothesized that (1) NO3– uptake will increase the pH within the DBL whereas NH4+ uptake will decrease it, (2) if NO3– is co-transported with H+, increases in pH would be greater under an OA treatment (pH = 7.65) than under an ambient treatment (pH = 8.00), and (3) decreases in pH will be smaller at pH 7.65 than at pH 8.00, as higher external [H+] might affect the strength of the diffusion gradient. Overall, Ni source did not affect the pH within the DBL, with pH increasing under both Ni sources. However, increases in pH within the DBL were always higher at pH 7.65 than at pH 8.00. Overall, carbon acquisition was affected by pH treatments, but not by Ni source. CO2– uptake was higher at pH 7.65 than at pH 8.00, whereas HCO3– uptake was unaffected by the pH treatments. Our findings suggest that photosynthesis control surface pH rather than Ni uptake.

OR-12-01

Toxic trace elements in seaweed – occurrence, analysis and food safety assessment

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There is an increased interest to increase the exploitation of marine macroalgae for commercial purposes including the use in relation to food and feed production. Certain seaweeds have the potential to accumulate various trace elements and contain consequently relatively high levels of both essential and toxic elements. Certain seaweeds can even be used for bioremediation purposes in order to remove toxic trace elements from the environment. There is consequently a need to document the levels of toxic elements in seaweeds and to ensure that the contents do not exceed legal limits or pose a risk to human health upon consumption before they are introduced on the market. Furthermore, a better understanding of how biological and environmental factors, like seaweed type, geography, season etc may affect the levels of trace elements is called upon, in order to be able to select seaweeds with optimum characteristics for commercial use. The present lecture will include: 1) •A presentation of data on the concentration level of toxic elements (Cd, Pb, inorganic As, iodine) in various types of seaweeds obtained in different projects at DTU Food. 2)• A presentation of the current status on food/feed legislation and toxicological guideline values for human exposure for the toxic elements in question. 3)• A discussion of the results obtained for the selected toxic elements in relation to food and feed risk assessment.

OR-12-03

Biological monitoring of Kappaphycus alvarezii pilot farming in Ecuador

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Kappaphycus alvarezii is a species from the Indo-Pacific region has been introduced in several locations outside its natural range as a way to provide alternative livelihoods to coastal communities in developing countries. K. alvarezii has been the main source of raw material for the carrageenan industry in the world during the last 30. In Ecuador, K. alvarezii was has been pilot farmed using floating rafts in a shallow protected bay in the Santa Elena peninsula since June 2015. As part of the current national legislation for aquatic introduced species, the National Fisheries Institute (INP) must conduct a follow up of the different environmental impact assessments in order to verify their feasibility and sustainability. The aim of this study was to analyze the biology and potential risks of invasion of K. alvarezii in order to design public policies to evaluate the environmental risks associated with it cultivation in the sea. The risk analysis study was based mainly on its settlement capacity and dispersion, spore production and grazing. Cultivations cycles varied between 45-60 days. Water temperature varied between 22.2-27.5oC, turbidity was 0.5 – 1.30 m, and salinity remained between 32 – 35 O/OO. Field surveys around the cultivation area also

included local marine flora, meoinfauna, and biofouling on the farmed plants. From the work conducted, there is no apparent evidence of local species displacement and growth on the seabed, although further studies are required to determine its invasive potential in the local ecosystems.

OR-12-04

Iodine content in seaweeds: variability, and implications for dietary nutrition and health risks

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Interest in the use of seaweeds as food and feed in the Western world is undergoing a resurgence. Many seaweed species contain compounds with documented health benefits. While seaweeds are considered a good source of proteins and minerals, an associated risk such as the detriments of high iodine levels, among others (e.g. heavy metals and contaminants), cannot be disregarded. This study provides a quantitative analysis on the variability of seaweed iodine concentration. Cultivated (IMTA vs. monoculture) and wild biomass of Saccharina latissima and Alaria esculenta, and wild Palmaria palmata from two Norwegian locations, France, and Iceland were collected 2-3× in 2015. Sampling, biomass handling and processing were standardized across sites. Freeze-dried and powdered samples were analyzed for iodine content applying a recently developed HPLC method. Species-specific, temporal, and spatial variations in iodine contents will be discussed.

OR-12-05

In situ assessment of Ulva sp. as a biomonitoring tool of metal polluted estuaries

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Seaweeds have been proven to be a valuable bioremediation tool for eutrophic systems, particularly in association with aquaculture operations. However, the potential to use seaweeds for mitigation of other contaminants is less clear. In this study we investigated the use of Ulva, a well known opportunist, for bioremediation in a highly metal polluted estuary (Derwent estuary, Tasmania). Ulva sp is widely distributed throughout the Derwent estuary, including areas with high levels of metal pollution. We transplanted Ulva sp. from unpolluted to polluted sites and 1) evaluated the metal uptake rates and 2) assessed in situ physiological performance of transplanted plants in order to determine the effectiveness of Ulva sp. as an in situ bioremediation tool. Relative growth rate, photosynthetic pigments (Carotenoids, Chlorophyll a and b), cytochemistry (Polysaccharides, proteins, starch granules), fluorescence capacity (Pulse amplitude modulate, PAM), ultrastructure (Transmission electron microscopy) and metal concentration (Inductively Coupled Plasma Atomic Emission Spectroscopy, ICP-AES) were evaluated at three study sites, representing unpolluted as well as low and high pollution levels. The physiological response of Ulva sp. showed the extent to which this "adaptable" species was affected by the environmental stress levels associated with metal pollution, and the results show the conditions under which Ulva was most effective as a bioremediation tool in heavy metal impacted environments such as the Derwent estuary.

OR-13-01

Kelp forest communities at Cape Farewell, Greenland; a quantitative approach and associated food web

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Michael Rasmussen, *Department of Bioscience, Aarhus University, Denmark*
et al.

An investigation on the kelp forest communities at the southernmost tip of Greenland, Cape Farewell, was performed, including sites of different degrees of wind exposure. At 5 sites, three samples were collected at 5, 10 and 15 m's depth. The samples were collected by SCUBA divers within a frame area from which all algal material was collected together with associated fauna by covering and collecting the algal material in a 1 mm mesh net. The collected material was sorted by species, weighed and countered as well as analysed for stable isotopes, δ13C and δ15N. At each site, three depth video transects were performed to the deepest limit of algal cover. The distribution of species along the video transect followed a general pattern. At the lowest depths the kelp forest consisted of a mix of species, including Alaria esculenta (Linnaeus) Greville, Saccharina nigripes (J.Agardh) Lontin & GW Saunders, Saccharina latissima (Linnaeus) C.E.Lane, C.Mayes, Druehl & G.W.Saunders and Sacchorhiza dermatodea Bachelot de la Pylaie, gradually intermixed with Agarum clathratum Dumortier at greater depth until this species became completely dominant at the greatest depth of the algal vegetation. The relationships between the presence / abundance and biomass of algae and fauna, and that of depth and wind exposure, expressed in Relative Exposure Index (REI), were tested using analyse of variance (ANOVA), correlation or regression analyses. For community analysis, Non-Metric Multidimensional Scaling (MDS) was used based on Bray-Curtis dissimilarities as input to the analysis. Stable isotopes signals of δ13C and δ15N were analysed in an attempt to map the food web linked to the kelp forest of Cape Farewell. ANOVAs and correlation analyses were performed to test of relationships between stable isotope signals and sites (protected / exposed to wind) as well as depth. The results will be presented and discussed.

OR-13-02

Contrasting timing of life stages across latitudes – a case of a marine forests forming species

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At low latitudes, Saccorhiza polyschides forests are highly seasonal, with macroscopic sporophytes present only between spring and autumn. At high latitudes, however, these are able to overwinter and survive for longer than a year. This seasonality at lower latitudes is commonly attributed to temperature. To test if this might be the factor leading to such differences across latitudinal ranges, field demographic surveys were combined with controlled culture experiments in two populations with contrasting timing of life stages: a central population in Brittany, France and a southern one in Northern Portugal. Our results did not support the initial hypothesis that such differences were caused by temperature. In the field, we found recruitment to be limited to spring in the south while further north sporophytes recruited year-round. Culture experiments showed that zoospores were able to develop under temperatures between 5 and 20°C, with optimum at 10-15°C, placing Portuguese winter temperatures within the optimum range, and thus indicating that seasonal recruitment is not caused by winter temperatures. Furthermore, zoospores took a maximum of 62 days, at 5°C, to develop into visible sporophytes, and only 20 days at 10°C, excluding the possibility that the absence of recruits through winter was a consequence of synchronized release of zoospores in autumn. While temperature doesn't offer an explanation for the differences between populations at different latitudes, the presence of macroscopic sporophytes in southern populations coincides with the typical upwelling season, which is accompanied by increased nutrient levels. This seasonality of nutrient availability in the south, in contrast with more constant levels in north-central range, led to the alternative hypothesis that nutrient availability, and not temperature, might explain the differences in life stage timing across latitudes. This hypothesis was, however, not initially considered and requires testing.

OR-13-03
The Recruitment Of Ascophyllum nodosum In Easter Canada: Is It Really A Stochastic Event?
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Ascophyllum nodosum (Rockweed) is the dominant perennial brown seaweed in the intertidal zone along the Atlantic coastline of the Maritimes in Canada where it forms extensive beds. This seaweed is also an important economic resource with almost 40,000 tonnes processed into plant bioestimulants and animal feed supplement each year. A. nodosum is probably one of the most studied seaweed in North America, covering a vast array of physiological, biological and ecological aspects. On the biological aspect, studies on recruitment show that this seaweed has a very stochastic recruitment pattern and these finding have been taken as the norm for this macroalgae throughout the range of its distribution. We have carried out diverse studies and observations on the population dynamic of this resource for almost 20 years in eastern Canada and our observations show that recruitment may not be as stochastics as originally thought. Our field observations on A. nodosum beds in the north side of the Bay of Fundy (New Brunswick), show a dense cover of recruits in the canopy understory. Here we have also followed the recruitment pattern of A. nodosum in old and recently installed breakwaters and found that recruitment occurs each time new substrate is available. Contrary, in the south side of the Bay, in Nova Scotia, recruits are significantly less abundant. We hypothesize that these differences are due to the nature of the substrate and herbivores pressure rather than differences in zygotes production and settlement.

OR-13-04
Two Southern African commercial kelps: latitudinal changes in dominance and the environment
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Laminaria pallida and Ecklonia maxima are large, commercially valuable kelps that co-dominate inshore waters of the west coast of southern Africa in a geographically changing pattern. In the south, E. maxima dominates and forms a canopy in shallow waters (< about 5m deep), with L. pallida forming a sub-canopy and extending down to 20 m or more. Northward along the Southern African coast and into Namibia, E. maxima is progressively replaced by L. pallida, which also shows some morphological changes. To explain this change in dominance we examined a range of morphological characters in both kelps (stipe length, stipe weight, stipe outer diameter, stipe inner diameter, length of hollow section in the stipe, and frond weight), and various environmental factors (seawater temperature, seawater turbidity, cloud/fog data, day length, and wave and wind data). Our results, based on measurements at seven sites along 1600 km of coast between Cape Town and Swakopmund (Namibia), quantified and confirmed the change in dominance and the northward increase in stipe-hollowness in L. pallida. The morphology of E. maxima did not change with latitude. Water turbidity, wind speed and wave height differed significantly along the coast. However, only turbidity showed a steady trend, increasing northward in terms of all indicators (Chlorophyll a, Particulate Inorganic Carbon, Particulate Organic Carbon) while wind speed and wave height showed a generally decreasing trend. Our results suggest that L. pallida sporophytes may progressively outcompete E. maxima northward, perhaps because they are more low-light tolerant, and that by developing a hollow stipe the sporophytes may grow faster, potentially increasing their competitive advantage in the shallow water where they would compete with sporophytes of E. maxima.

OR-13-05
Salinity effects on different life history stages of Sargassum hemiphyllum from Hong Kong
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Salinity effects on different life history stages of Sargassum hemiphyllum, a common lower intertidal brown alga in Hong Kong, were examined. These included the holdfast (HFS), slow growing (SGS), rapid growing (RGS), and germling stages. Release of germlings from receptacles under different salinities were also examined. The salinity levels tested ranged from 35 (ambient) to 5psu at 10psu interval for up to one month of exposure. For all the vegetative stages, retarded growth and lower photosynthetic performances were recorded at salinities lower than the ambient. Highest mortality was observed for individuals exposed at the lowest salinity (5psu). Obvious bleaching was observed in the thalli, suggesting loss of photosynthetic pigments as a response to low salinity exposures. Receptacles exposed to 15psu

rarely released their oogonia/zygotes and none was released at salinity of 5psu. Meanwhile, Sargassum germlings displayed adverse growth at salinity of 25psu or lower, and the negative effect was exacerbated with increasing exposure time. The low tolerances of S. hemiphyllum to reduced salinities could have a significant implication on its ability to disperse into or across large estuarine areas along coastal region of northern continental Indo-west Pacific. This research was supported by Hong Kong RGC GRF 460010.

OR-14-01

AN INNOVATIVE APPROACH TO DEVELOP SUSTAINABLE MARINE ACTIVE INGREDIENTS FROM MACROALGAE

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World's Oceans biodiversity is a significant source of new active ingredients. In the last decades microalgae have been of growing interest whereas macroalgae stayed relatively unexploited regarding the large number of species available. 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. We took an interest in the rare and poorly known species by establishing a technique allowing to overcome the main problem by developing a method to cultivate macroalgae cells. This technique consisted in selecting macroalgal cells keeping them at the cell state. This required isolation work to obtain monospecific cultures. Obtained strains were cultured, at first, in small volumes in autotrophic conditions then the main difficulty was to keep cells in good conditions during the scale-up in order to reach industrial scale. Next cultures were modulated to obtain optimal biomass productivity. These first steps were conducted without knowing the name of species in culture so it was necessary to identify studied strains. Identifications were done by microscopic examination and molecular barcoding. Resulting biomass from cultures was analyzed to determine phyto-chemical content by HPLC-MS. Therefore strains were screened to select those which were showing the best phyto-chemical composition. Highlighted components reputed of a cosmetic interest allow us to choose in-vitro tests like transcriptomic and proteomics studies which will give the firsts clues of the activity of the algal cell extract. Conclusive tests were followed up by the development of an in-vivo formula which was tested on a panel of volunteers to evaluate the efficacy of the ingredient. 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.

OR-14-02

Prebiotic potential of brown seaweed by in vitro human gut bacteria fermentation

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Seaweeds are important sources of nutrients, including polysaccharides with diverse structures and functionalities that could potentially be exploited as prebiotics. This study aimed to investigate the prebiotic potential of South Australian brown seaweed using different extraction processes. Seaweed extracts were prepared with enzyme-assisted and conventional acidic and water extraction processes. Significant differences were found in the potentially fermentable components (e.g. fibre, starch, sugar, protein, and polyphenols) in the seaweed extracts from the different extraction processes. Enzyme-assisted and acidic pH could work in synergy to reduce the molecular weight of polysaccharides in the extracts. Six representative extracts with different composition profiles were assessed for their prebiotic potential in an in vitro anaerobic fermentation system containing human fecal inocula. Their ability to generate short chain fatty acids (SCFA; the primary beneficial end-products of fermentation in the human gut) and to promote the growth of selected bacterial types (as assessed by quantitative PCR) were analyzed as indicators of health benefit. Following 24 h fermentation, all seaweed extracts significantly increased ($p<0.05$) the total SCFA production (50.7-72.7 mol.ml-1) and total number of bacteria (log10 10.2-10.4 cells.ml-1) when compared to blank and cellulose controls (17.9-18.6 mol.ml-1 and log10 9.5 cells.ml-1). The extract prepared using Celluclast-assisted extraction showed the greatest potential for improving gut health as these induced significantly higher production of butyrate (9.2 mol.ml-1) and growth of some bacteria regarded as beneficial, including Bifidobacterium (log10 6.6 cells.ml-1) and Lactobacillus (log10 5.3 cells.ml-1). These findings demonstrate that brown seaweed has the potential to be used as a source of dietary supplements with gut health benefits in humans.

OR-14-03
Seaweed as a tool against obesity

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Adipocytes constitute a major part of the fatty tissue and perform key endocrine functions, one of them insulin sensitivity. Accumulating an excess amount of fatty tissue (obesity) can disturb hormone balance and is considered one of the major risk factors for type 2 diabetes. Reducing the rate of fat cell differentiation (adipogenesis) could be one way of minimizing the chances to become obese. The brown algae bladderwrack (Fucus vesiculosus) has been the target of many bioactivity studies due to its high content of secondary compounds. These studies have amongst others revealed antidiabetic, anti-hypertensive and antioxidant properties. The aim of our study was to investigate the effects of different seaweed extracts on differentiation (adipogenesis), proliferation and apoptosis of adipocytes. Undifferentiated murine adipocytes (3T3-L1 cell line) were exposed to 14 seaweed extracts in different concentrations and differentiation quantified using both Oil red O and AdipoRed staining protocols. We found that F. vesiculosus extracts inhibited adipogenesis up 35% at 0,1mg/mL concentration, making it a strong candidate for further studies to regulate adipogenesis through dietary supplementation. Additionally, C57BL/6Ntac diet induced obese mice were fed a high fat diet supplemented with seaweed extracts. To test for benefits of a seaweed supplemented diet we performed histological, protein and gene expression analysis on fatty tissue of these mice.

OR-14-04
Revealing the functional potential of seaweed and mesoherbivore-associated microbiomes

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It is becoming increasingly clear that the microbiomes of marine and terrestrial organisms can add genetic diversity and functions that play important roles influencing host development and ecology. Although the characterization of these communities associated to seaweeds are becoming more common, the drivers and functional roles of these associated microbes are still hardly explored. In terrestrial plants, the associated microbiome performs essential functions for their hosts, such as providing nutrients, defense and growth stimuli. However, another part of that same community also can affect the host negatively by outcompeting beneficial bacteria, causing disease and/or degrading plant products and tissue. In contrast with terrestrial, marine organisms have to cope with and defend themselves against a much higher biofouling pressure on a constant basis. The interactions between microbes and seaweeds may hold great potential for the future of seaweed cultivation and their biotechnological application. By elucidating bacterial community compositions and functions associated to brown and red seaweeds across species, latitudes, oceans and environments as well as under experimental conditions, like ocean acidification and grazing, we hope to contribute to innovative applications. Following a metagenomic approach we provide insights in functional genes present in these microbiomes, including enzymes involved in the production of halogenated compounds. For the seaweed-processing industry we also explored the bacteria associated to the gut microbiome of seaweed consumers under different diets and conditions. Overall, we present innovative insights into the potential of seaweed and mesoherbivore-associated microbiomes for the development of the seaweed industry and novel opportunities for functional food, cosmeceuticals, nutraceuticals and pharmaceuticals.

OR-14-05
Brown seaweed and cancer: melanoma

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Research on the health effects of eating brown seaweed is scattered in a range of scientific journals, and their relevance to cancer prevention and cure are often non-obvious. This review of brown seaweeds and melanoma will tie together many of the diverse threads of current research. Melanoma rates are increasing rapidly, with an estimated 232,000 people diagnosed worldwide each year. It is associated with a burgeoning therapeutics market estimated at $3.6 billion by 2020.

OR-15-01

The Canadian IMTA Network (2010-16): what have we learned regarding the inorganic component?

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"Integrated Multi-Trophic Aquaculture" (IMTA) was created in 2004. Its scope is broad and flexible. It was never conceived as to be reduced to only the cultivation of salmon/kelps/invertebrates, in temperate waters, within existing salmon site limits. There are many variations on the IMTA theme, which can lead to the development of open-water or land-based systems, in marine or freshwater environments and in temperate or tropical climates. Having to deal with different types of nutrients, different spatial and temporal recapturing strategies should be designed. This will certainly trigger changes in regulations, as they were designed without IMTA in mind in most countries. There is a renewed interest in the mariculture of seaweeds for their integrated cultivation, the ecosystem services they provide and novel uses. The value of the ecosystem services provided by IMTA extractive components should be recognized, accounted for and used as financial/regulatory incentive tools (e.g. nutrient trading credits). The IMTA multi-crop diversification approach could be an economic risk mitigation and management option to address climate change impacts. Perceptions should change: nutrients are not necessarily wastes and recycling, encouraged on land and in agriculture, should also be at sea and in aquaculture. Business models should embrace the emerging Integrated Sequential BioRefineries (ISBR) concept to manufacture products for a wide variety of applications. To give IMTA its full value, extractive species will have to be valued for more than just their biomass and food trading values, but also for the services they render and the increase in consumer trust and societal/political license to operate they provide. Humans will soon not be able to continue thinking of mostly land-based agronomic solutions for securing their food/many other derived products, but will have to turn increasingly to responsible aquanomy to manage their aquatic fields.

OR-15-03

An economic analysis of Integrated Multi-Trophic Aquaculture (IMTA) – A Norwegian case study

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By producing more seafood per area, and addressing key environmental problems presented by salmon farming, Integrated Multi-Trophic Aquaculture (IMTA) could be a solution towards improved and sustainable food production. An IMTA production system has been implemented at a test-site Oldervika (Nordland, Norway) to evaluate its efficiency in securing a sustainable growth in the production of Atlantic salmon (Salmo salar) and Bladderlocks (Alaria esculenta). This case study investigates the economic profitability of an IMTA-farm under a period of 11 years. The economic analysis of IMTA as a production method is conducted by following the Norwegian Government Agency for Financial Managements´ (DFØ) economic analysis guide. At the end of the timeframe of the analysis, production under an IMTA has a lower net present value than a traditional production of salmon. Benefits of production under an IMTA system is however recognised to catch the emissions of nitrogen, phosphorus and carbon from the fishfarm. This benefit in capturing of nutrients is valued at NOK 374 553. Further benefits from non-priced effects are seen through an increase in biodiversity. Though, in our study, these environmental benefits do not outweigh the costs of implementing IMTA. To develop an IMTA system that is profitable a different approach must be taken. Three scenarios are identified to create a positive net present value by IMTA production. One is based on the condition that IMTA production system are receiving an eco-label, and prices of products rise as such. The other scenario is dependent on outsourcing the work related to the seedlings to a specialise company that produces larger volume. The third scenario would need the production to be scale-up on the site. In this last scenario, the regulation that determine the maximum biomass authorized (MBA) on a specific site would need to be re-evaluated and adapted specifically for IMTA system that are integrating seaweed culture on salmon farm.

OR-15-04

Macroalgal component of a novel recirculating land-based integrated multi-trophic aquaculture system

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In integrated multi-trophic aquaculture (IMTA), macroalgae may serve as the assimilative component to utilize nutrients from the system's animal wastes. A prototype of a new concept in land-based marine closed-system IMTA has been developed that uses a centralized filtration system to deliver controlled

volumes of selected pretreated waste streams to each system component and potentially resolves water quality and flow distribution issues related to traditional serial closed-system IMTA designs. Critical in this system is the use of macroalgae as "extractive species" to provide biomitigating functions for waste generated by the "fed species" (fish and other animals). To date, we have demonstrated high rates of primary productivity and nutrient removal by two macroalgal species (Gracilaria and Ulva) in our prototype, selected Ulva as the primary species, and refined culture conditions for this species in our IMTA system, most recently optimizing aeration requirements (frequency and duration). A current experiment is focused on determining how pH and inorganic carbon availability affect growth rates of Gracilaria and Ulva to further enhance growth and nutrient removal in the system and lead to more desirable algal products such as human food. This research will provide important data for continued improvement and optimization of the overall HBOI IMTA system, including the development of a new economically viable crop which will increase the probability of transitioning our system to the commercial sector.

OR-16-01

Seaweed aquaculture as a match for agriculture

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Agriculture's 10 GT/y production, led by plants, dwarfs aquaculture by 100:1 (farm gate basis). This is absurd in a world covered by ocean. Rectifying the imbalance requires a x-100 growth in mariculture, led by algae. Several cultivable seaweed species can feed humans and animals. Proposed huge scale seaweed farming on the ocean can use seawater's intrinsic nutrients, fishfarm effluents, urban wastewater and coastal runoff (green tides). Several GT/y of seaweeds can cost-effectively supply food and feed, produce free oxygen, reduce ocean acidification and capture GHG. This panacea can happen with minimal engineering, allowing nature to facilitate much of the work. Engineering and managing the production of 10 GT/y of algae on the ocean surface requires teams of experts on aquaculture, algae culture, ecological marine engineering, oceanography, climatology, economics, governance and others. Ideas (e.g., J Isaacs, S Maruyama, J Ryther, H Stommel, C Zener) and projects (the US OTEC and the Japanese TAKUMI) have considered the feeding of huge floating seaweed farms in mid ocean by upwelling of nutrient-rich Pacific Ocean water. M Notoya and co-workers have considered 10 x 10 km seaweed culture rafts, each producing 10 MT/y. Thousands such rafts, covering < 1 % of the global ocean area, may be sufficient. Fish cages in huge IMTA farms can feed by their nutrient-rich plumes more seaweed production. Plumes of wastewater, properly placed, could also supply nutrients to seaweed farms. This new industry will be rather harmless environmentally, compared with doubling agriculture on land. It will support as a byproduct huge natural production of fish, and will provide many jobs. Whether 'mariculture', 'sea ranching' or anything else – these approaches represent man-made production of seafood on the High Seas. Involvement of governments and international organizations is necessary to make it happen, due to the huge scale and international law considerations.

OR-16-03

Farming of agarophytes in India

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In India, Gelidiella acerosa and Gracilaria edulis are the two principal source of agarophytes. Food grade agar is obtained from G. edulis while pharmacological grade agar is extracted from G. acerosa. India produces annually 90 tons of agar, (50 tones of food grade agar and 40 tons of pharmacological grade agar) which is very meagre when compared with world production of 12,000 tons of agar. Currently, there are 21 agar industries but not functioning upto their rated capacity, as there has been a short supply of raw materials. The indiscriminate harvesting of wild stock has resulted in depletion of its precious resource especially from Gulf of Mannar, southeast coast of India. In India, the entire quantum of biomass for agar production is coming from natural harvest. Feasible cultivation technologies have been developed for G. edulis and G. acerosa. G. edulis cultivation has been initially started with long line rope method which gave biomass yield of 20 tons dry wt. ha-1.y-1 in 3 harvests. Recently, bamboo raft method has been developed. The plants were harvested at 60 day intervals. 4 harvests in a year are possible with biomass yield of 26.4 tons dry wt. ha-1.y.-1 G. acerosa cultivation was tried with bottom-stone culture method in which G. acerosa was seeded on coral stones and kept in lower intertidal region. Two harvests were made

in a year and a crop yield of 4.0 tons dry.ha.-1year-1 was obtained. Recently, suspended stone method was used for G. acerosa cultivation. 2 harvests were achieved in a year with biomass yield of 18.225 dry tones ha-1 year-1. Efforts are being initiated recently for commercial cultivation of these 2 algae along the Indian coast.

OR-16-04

Institutional innovation and the emergence of sustainable seaweed aquaculture industries

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Seaweed aquaculture represents a promising opportunity for aligning commercial production with environmental and social objectives. Environmentally, the cultivation of seaweeds on ropes in the ocean requires no fresh water, arable land, or fertilizer. Seaweed crops absorb carbon and provide other locally beneficial ecosystem services. Socially, seaweed farming can provide an avenue for economic diversification in coastal communities and at the household level basic farms can often be built easily and inexpensively. With increasing global demand for these versatile crops, a seaweed aquaculture boom is beginning despite major gaps in identifying best management practices, understanding implications of global change, and creating appropriate environmental and social frameworks. Successful emergence of environmentally sound regional seaweed industries will require thoughtfully customized and innovatively structured support to navigate a mix of scientific, farming, entrepreneurial, market, and policy challenges. As a collection of dynamic social-ecological systems, the seaweed aquaculture sector represents a form of industry that could catalyze transitions toward a more sustainable future. The sector thus provides opportunities to study how the formation of novel institutions - defined as structures and rules of a social system - can be channeled to foster sustainable development. Using a mixed methods approach, the research presented examines the roles of social networks, leaders, and policy design in shaping the evolution of an innovative new industry in Panama. Drawing on social science and organizational management theory, the findings presented contribute to understanding the impacts of individuals and communities on the creation, emergence, and evolution of institutional structures. Lessons have broad applicability across a range of natural resource-dependent industries and geographic contexts within the Americas and around the world.

OR-16-05

European production of kelps - an overview

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The global agenda of Blue Growth is embrasing a European kelp production as a sustainable resource for food, feed and biomolecules, and as an instrument for circular nutrient management. The European production of kelps constituted less than 0.1% of the global production, however according to FAO, the European aquaculture production more than doubled from 20 to 41.5 wet tons of kelp from 2000 to 2013. In contrast, the production based on wild harvest of European kelps declined by 35% from 0.3 million wet tons to 0.2 million wet tons from 2000 to 2012. The European production is still based on few commercial seaweed farmers and experimental trials driven by research institutes. The species most commonly cultivated in Europe are the kelp species Alaria esculenta, Saccharina latissima, Laminaria digitata, L. hyperborea, Undaria pinnitifida and the pseudokelp Sacchorhiza polyschides. The production and harvesting systems are evolving from manually handled Asian type longline systems over systems designed for mussel farming to unique systems of two-dimensional specially designed textiles, and from coastal waters towards larger-scale off-shore sites. The reported production yields span a factor of 35 between 0.5 kg m-1 in the German Baltic and 17 kg m-1 in Scotland. Direct and in-direct effects of large-scale environmental factors, such as salinity, temperature, exposure and eutrophication, predominantly explain the large span in productivity. Potentially also genetic diversity plays a role. The need for using common methods, procedures and terminology in order to for standardising data and presentation of results through Europe is discussed, since this is of utmost importance for supporting the expanding seaweed industry and policy makers.

OR-17-01
Evolution of size in large seaweeds: an empirical test of "universal" biomass scaling relationships
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As plants fix carbon, they must distribute newly fixed photosynthate among various organs in order to maintain physiological processes and to ensure that they will develop into adults that are well suited to their environment. Ontogeny may interact with environmental constraints to generate specific biomass allocation patterns that produce plants of given sizes and structures. While biomass allocation patterns have received substantial attention among embryophytes, providing evidence of several "universal" scaling relationships associated with increasing body size, biomass scaling of plant-like marine macroalgae has never been comprehensively examined. The kelps (Laminariales) are the largest marine algae and allocate photosynthate among three organs (blade, stipe and holdfast) superficially analogous to those of land plants (leaves, stem and roots). In this study, we use an allometric approach to quantify developmental (intraspecific) and evolutionary (interspecific) biomass partitioning patterns in kelps. We assess (1) whether embryophyte-based derivations of biomass partitioning can be applied to large marine macroalgae and (2) whether the evolution of increased body size is accomplished by means of a predictable change in developmental biomass allocation. We demonstrate that biomass allocation patterns in kelps differ substantially from those of land plants and present evidence that larger kelp species have evolved increased investment in holdfast and stipe throughout development. Like embryophytes, increased stipe investment could be a response to increased light competition. However , in contrast to embryophytes, increased holdfast mass is likely associated with resistance to dislodgement.

OR-17-02
The importance of chimeric holdfasts as genetic reservoirs for kelp resilience and management
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In Chile, kelps are dominant organisms with considerable ecological and economic importance, providing resources for alginates, biofuels, and feed for abalone rearing. Their frequent harvesting results in population reduction, fragmentation and isolation. Increased demand for kelps has led to the introduction of management plans, including re-colonization strategies. A key factor for the management and restoration of threatened and endangered species (terrestrial and aquatic ecosystems) is the conservation of genetic diversity at the individual, population and regional levels. However, in Chile the genetic diversity of kelps at any of these levels remains unknown. Moreover, kelps can coalesce, forming chimeric holdfasts. In this study, we used 8 microsatellites to evaluate the frequency of chimeric holdfasts in three populations of the kelp Lessonia spicata. In addition, to evaluate the impact of chimerism on fertility and reproduction, we assessed whether genotypic heterogeneity in the coalescing holdfasts is similar to that of the erect axes where plants produce reproductive structures. We evidenced chimeric holdfasts in all populations, without any latitudinal pattern, ranging from 27 to 53% of the studied plants. Their genetic diversity (allelic richness, number of different alleles, Shannon index, polymorphic loci, private alleles, Ho, and He) was found to be high at the holdfast, decreasing towards the apical portions of the axes, irrespective of their population origin. This suggests that holdfasts are reservoirs of genetic diversity, adding to their ecological importance as a nursery ground for invertebrates. Chilean kelp management should therefore consider conservation at four levels of genetic diversity: holdfast, individual, population and regional, in order to maximize the long-term population sustainability. Future kelp managers should evaluate the significance of holdfasts as genetic reservoirs during postharvest and recovery time.

OR-17-03
Phylogeographical study revealed instability of annual kelp Ecklonia radicosa population
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Recently, warm temperate kelp forests have drastically changed their distribution and biomass in Japan. Ecklonia in Lessoniaceae and Undaria in Alariaceae are the two representative genera distributing down to Kyushu. Undaria includes 3 annual species: a common species U. pinnatifida with a variety of haplotypes (15) and closely related species U. peterseniana and U. undarioides with fewer haplotypes (3 for each).

On the contrary, Ecklonia includes only one annual species, E. radicosa, though five perennial species are also included. E. radicosa, which has been located in the genus Eckloniopsis for a long time, distributes from Kyushu to central Pacific and southern Sea of Japan coasts of Honshu. In the last decades, E. radicosa has exhibited interesting biogeographical events such as extinction of southernmost population at Mage Island, northward expansion to Cape Manazuru on the central Pacific coast and invasion (or reestablishment) at Ojika Island in northwest of Kyushu. The present phylogeographical study explored the genetic diversity, population connectivity and demographic events in E. radicosa using mitochondrial cox3. In total, 276 individuals (20-30 individuals/ population) were collected from twelve populations. Sequence comparisons of 561-bp segment revealed the presence of 6 segregating sites and 5 haplotypes (Hd: 0.036 ± 0.016) in this kelp. The dominant haplotype H1 accounted for 98% and pairwise estimation (Fst) never showed genetic break. Demographic analysis (mismatch distribution) detected recent expansion of the population (Unimodal, τ: 0.25 ± 0.86, $\theta 0$: 0, $\theta 1$: 0, SSD: 0.00281, HRag: 0.4699). In comparison with the above Undarian species, haplotype diversity was significantly low in E. radicosa. Previous studies show divergence of Ecklonia was earlier than Undaria by 10 Ma; haplotype diversity is higher in population persisting for a long term. Therefore, it is likely that E. radicosa has repeated rapid expansion and reduction of population.

OR-17-04

Germplasm banking of the giant kelp: our biological insurance in a changing environment

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The giant kelp forms vast underwater forests and is a key functioning species in marine systems from both hemispheres. But this species is also a commodity product. Macrocystis pyrifera is harvested for feedstock (e.g. abalone aquaculture) and for its chemical compounds (e.g. alginates). In Chile, the abalone aquaculture industry is growing at a face pace and with it, the harvesting of the giant kelp. Erosion of natural kelp beds can happen as a consequence of poorly managed harvesting practices and, there is now a great interest in farming the giant kelp. But food security is just one of the drivers - aquaculture sustainability and fuel security are key factors too. In the past 5 years several research consortiums in collaboration with companies tried new farming techniques to boost biomass production mainly for biofuel. But a lack of sustainable management can lead to genetic erosion, lack of resilience and degradation of livelihoods. One solution for this problem is the implementation of gene bank as resource insurance. This has been recognized for farmed fish, terrestrial animals, and plants. But so far genetic resource management has not been fully recognized for seaweed species. Aiming to alert and prevent this situation we developed a germplasm bank based on three different genetic populations of M. pyrifera from Chile. We developed and tested a non-cryopreservation technique. We preserved female and male gametophytes in separate, from 3 different genetic populations in low light, at 10^{o}C, in Provasoli media but without cryoprotective agents. We show for the first time gametophyte viability up to 89% after 5 years in cold storage. This is also the first work to show differences in cold storage viability between genetic populations in a macroalgae species. We advocate genetic resource management of the giant kelp and seaweeds in general and offer a solution.

OR-17-05

Characterization of newly developed EST-derived SSR markers specific to kelp Saccharina latissima

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The kelp Saccharina latissima is a species of high ecological and economic importance. We developed a novel set of S. latissima-specific genetic markers that will find applications in conservation biology, biodiversity assessment, and commercial exploitation of this macroalga. Thirty two expressed sequence tag (EST)-derived microsatellite markers were developed and characterized in this study. The 32 loci harboured moderate levels of polymorphism with 2-13 alleles per locus (mean 5.4) within a sample of 96 S. latissima sporophytes collected from six localities distributed along the European coast from Southern Brittany (France) to Spitzbergen (Norway). The 25 loci that were retained for population genetic analyses revealed substantial genetic differentiation among the European populations that did not follow any pattern of isolation by distance. In addition, within-population genetic diversity was generally low (Hs < 0.323). Two non-mutually exclusive hypotheses were proposed to explain this low diversity pattern: (1) lower variability of the EST-derived microsatellites compared to the random distribution of SSRs developed from genomic DNA since the former are frequently located in coding regions, which are generally less variable, or (2)

reduced effective population size due to the patchy distribution of small and disconnected populations of this species along the coast. The particularly high genetic differentiation between the French and Scandinavian S. latissima populations is in agreement with the reported ecotypic differentiation, which may reflect an important resource for genetic improvement. The pattern of genetic diversity revealed in this study thus suggests that care should be taken to avoid the transfer of strains between different geographic regions.

OR-18-01

Bioactive Compounds from Seaweeds: Cosmetic Applications and Perspectives

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Marine macroalgae are often used for the production of ingredients or extracts in cosmetics. These ingredients can have one of the three main functions: (1) they are considered as additives which contribute to the organoleptic properties; (2) they are used for stabilization and preservation of the product; (3) or finally, they are bioactive compounds which fulfil a real cosmetic function and activity. This presentation describes the bioactivities of molecules or extracts used for cosmetic applications, and discusses some perspectives for the development of new compounds using specific extraction methods and bioactivity assessment. Metabolites derived from seaweeds have been shown to be active in antiaging skin care, anticellulite treatment and slimming, as well as having antioxidant, photoprotective, moisturising, and whitening properties. Among the various classes of seaweed components, sulphated polysaccharides, peptides, carotenoids, fatty acids, and phytohormones exhibit antiaging and antioxidant properties, while mycosporine-like amino acids, flavonoids have an antiphotoaging activity. Flavonoids (i.e. phlorotannins) are lipolytic agents which are isolated from macroalgae and which also inhibit melanogenesis. A better knowledge of algae genetics and the improvement of algae cultivation or co-cultivation will provide new opportunities for the development of bioactive compounds.

OR-18-02

The natural variation of phlorotannin profiles in Irish commercially valuable brown seaweeds

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The potential of highly bioactive polyphenols, phlorotannins, for commercial application has long been recognised within nutraceutical research, with particular attention given to brown algae. Phlorotannins can constitute up to 5-12% of dry weight in particular species providing protection against several oxidative stresses. Associated health benefits include; anti-oxidant, anti-HIV, anti-inflammatory, radio-protective, and anti-diabetic activity, making them highly attractive compounds for industrial extraction. However, phlorotannins possess a high degree of phenotypic plasticity with seasonal and temporal variability in levels, structural profiles and associated bioactivity. Until recently, spectrophotometric assays have been the primary method for phlorotannin analysis. However, these methods provide no qualitative information on the phlorotannin composition in regard to molecular weight or isomer production - two factors fundamental to their bioactivity. This project aims to characterise the effect of environmental variations on phlorotannin profiles utilising mass-spectrometric techniques. Five commercially valuable Irish brown algae were collected from two sites along the west coast of Ireland over six seasons and analysed for their natural phlorotannin content and composition. Through molecular weight cut off (MWCO) dialysis and reverse-phase flash chromatography, <3.5 kDa purified phlorotannin fractions were achieved and analysed using a UPLC-TQD-MS/MS. Unique metabolic profiles were obtained for each species for both temporal and spatial variation with corresponding variations in their bioactivity levels. For a successful future integration of phlorotannin extracts into novel commercial applications, particularly within the food sector, a sound scientific comprehension of the driving factors behind their production and structural variability is essential.

OR-18-03

Polyphenolic compounds from Fucus vesiculosus and their antioxidant activity

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Natural antioxidants derived from marine algae have the potential for improving oxidative stability of lipids in food systems. Recent studies showed that extracts from Icelandic Fucus vesiculosus reduced

lipid oxidation in fish-oil-enriched foods, such as milk, mayonnaise and granola bars. This was found as an increased lag phase in development of unwanted flavours and odours related to lipid oxidation. Hence, high antioxidant efficacy of these extracts was mainly related to a high content of phenolic compounds. Previously, a high in vitro antioxidant activity, mainly radical scavenging activity, of F. vesiculosus has been related to a high phenolic content. Since F. vesiculosus are rich in phlorotannins, the major group of polyphenolic compounds in brown algae, it is hypothesised that the in vitro radical scavenging activity of F. vesiculosus extracts is related to the phlorotannin content. However, the clarification of how the different phlorotannins contributed to the overall antioxidant activity is lacking. The aim of the present study was to identify phlorotannins contributing to the antioxidant activity of F. vesiculosus extracts. An 80% (v/v) aqueous ethanol extract (EE) was obtained and further the phlorotannins were purified by ethyl acetate partitioning to obtain a solvent fraction EAF. The total phenolic content of both EE and EAF was determined and the in vitro antioxidant properties were evaluated. Furthermore, separation and characterization of phlorotannins from EAF with respect to composition and antioxidant activity were determined with applied on-line analysis technique. This was done using high performance liquid chromatography coupled to an on-line electro chemical detector and the compounds were characterised by mass spectrometry (HPLC-DAD-ECD-QTOFMSn). Phlorotannin compounds were identified according to the fragmentation pattern and their antioxidant contribution was evaluated.

OR-18-04

Seasonal variations of antioxidants in the brown seaweed Saccharina latissima

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Mainly the brown seaweeds are known for their high antioxidative capacity within the specific compounds such as phlorotannins, polyphenols, flavonoids, pigments, and these natural antioxidants are of high industrial interest. Previous studies have shown large seasonal variations in biomass composition. The aim of this study was to see if there was a seasonal variation in the antioxidant content of sugar kelp (Saccharina latissima), compare two cultivation sites, REF and IMTA, and test different solvents applied for extractions, methanol or ethyl acetate. Rope cultivated sugar kelp were sampled both in close proximity to a blue mussel and fish farm (IMTA) and at a reference/control site (REF), both outside Horsens fjord in Denmark. Sugar kelp biomass was measured (n=3) at 2 m depth in 2013-2014, and freeze dried and stored frozen for further analyses. In relation to the extraction, two solvents with different polarities were applied. Methanol was generally a better solvent for extracting the more polar compounds i.e. phenolics, whereas ethyl acetate tended more efficient for flavonoid extraction. There was no significant variation in the TAC between the two cultivation sites, ranging between 1,531-5,135 µg GA/g DW, and with no clear pattern of seasonal variation. Within the phenolic content no significant difference was seen (258-3,594 µg GA/g DW), and for IMTA the flavonoid concentration for September 2013 (4,830±1,048 µg rutin/g DW) was significantly higher than the other months. The biological variability had a high impact revealed by large standard deviation. The pigment specimens did not change during the year, however the concentration did, and with fucoxanthin as the most interesting. No clear correlation was found between pigments and the antioxidants. This study showed high concentration of antioxidant in sugar kelp and in 100 times higher range than e.g. microalgae. However, the large variations should be taken into account when aiming for industrial use.

OR-18-05

Total phenolic content and biological activity of Sargassum muticum enzymatic hydrolysates

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Brown seaweeds are known as a potent source of phlorotannins. However, the presence of complex polysaccharides in their cell wall strongly reduced the extraction efficiency. Thus, the degradation of their cell wall by enzymes is an important step in releasing the active components. In this study, enzymatic extracts of Sargassum muticum phlorotannins were prepared with eight commercial enzymes; two proteases and six carbohydrases. Then, the antioxidant, antibacterial, antiviral, anti-tyrosinase, anti-elastase activities and total phenolic content (TPC) of S. muticum enzymatic hydrolysates (SmEH) were evaluated. Soluble TPC of SmEH digested with Viscozyme was the highest – 5.15%, and the insoluble TPC was 0.9%. Celluclast and Viscozyme had the lowest value of IC50 indicating a strong antiradical activity – 578.5 and 624.0 µg/ml. The IC50 of BHA (Butylated hydroxyanisol) and BHT (Butylated hydroxytoluene) as standard were 12.6 and 23.3 µg/ml. The ferric reducing antioxidant power of SmEH ranged between 1.1

mg Fe2+/g – digested with Viscozyme, and 2.0 mg Fe2+/g – digested with AMG. The tyrosinase inhibition activity of Viscozyme was 97.4% higher compared to Kojic acid, 86% and other enzymes. Then, the elastase inhibition activity, Celluclast had highest activity (31.1%). However, this activity is still lower than the Trypsin Inhibitor – 50.0%. IR (Infra-Red) Spectroscopy showed a distinguished heterogeneity in the biochemical compositions of SmEH which it might be related to their phlorotannins or other components. Based on the HPLC (High Performance Liquid Chromatography), the highest peak was detected in 260-280 nm with retention time between 17-18 min. The retention time of phloroglucinol as standard was also detected at 18 min in 280 nm. It is assumed that the phlorotannins in SmEH has the same characteristic as phloroglucinol. This study reveals that enzymatic extraction can be applied as an alternative method in extracting phlorotannins of brown seaweed.

OR-19-01

Optimizing high-value compounds in a land-based IMTA system: protein and natural dyes from seaweed

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The demand for high quality, traceable, standardized, safe and sustainable ingredients is generalized, from food to higher value markets. In land-based IMTA systems, it is possible to balance biomass yields and chemical composition according to the market sought; also, these systems offer the possibility to select and grow algal species not adaptable to the long-line systems used at sea. Protein levels are affected by the nutrient availability in the water and the seaweeds' ability to uptake and store nitrogen. Red and green seaweed species generally have higher protein content (10-47%) and are excellent candidates for land-based cultivation operations. In the project SEACOLORS, the textile industry challenged seaweed (and microalgae) producers to evaluate the potential of specific algal pigments to be used as natural dyes. The rationale behind it is to reduce the highly harmful environmental impact of current synthetic textile dyes. After a first phase of species selection, small-scale lab trials followed by outdoor cultivation work in the commercial system at ALGAplus (Portugal), were conducted evaluating the combined effect of specific production factors (e.g. nutrient input, stocking densities) on the final pigment yields of Gracilaria, Porphyra and Ulva species. Pigments were extracted and tested as dyes in different textile fibres evaluating intensity and maintenance of target colours. Phycobilliproteins, chlorophylls and carotenoids were optimized, extracted and tested as dyes but are also high-value compounds in the food, nutraceutical and cosmetic markets. A two-fold increase in total protein content was achieved and maintained through time in highly sought species in the food and feed markets. These results demonstrate the value and feasibility of IMTA land-based systems and confirm the potential for differentiation in western seaweed farming operations.

OR-19-02

Nutrient compensation as management tool– Sugar kelp production in sustainable aquaculture

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Integrated multi-trophic aquaculture (IMTA) is theoretically a sustainable production form, which minimizes waste products from e.g. fish farms, by the co-production of bivalves or/and seaweed. For the Danish fish farmers the extractive organisms could be the solution for increasing fish production, but do the principles of IMTA fully mitigate the nutrient impact from open net-pen fish production at realistic production scales?
In this project, commercial scale cultivation of sugar kelp (Saccharina latissima) was investigated with regard to operation, yield, biofilter capacity and mapping the biomass composition for one year incl. protein content, amino acid profiles, lipids and fatty acid composition, minerals and vitamins. Results were obtained from an IMTA site and compared to a reference site with no impact from the fish (175 t year−1) and mussel farm, both located just outside Horsens Fjord, Denmark. The nitrogen content in sugar kelp varied between 0.5-3.7% of dw with the highest concentration in September 2013 with an estimated maximum yield of 5.1-7.1 tons ww ha-1 year-1. Potentially, a cultivation area of 204-340 ha would be needed to achieve 100% N recovery, based on the tonnage of the specific fish farm. The harvest contained

protein (10%), lipids (3%) and vitamin A (34 mg/kg per dw), however with large seasonal variations. Sugar kelp increased the biodiversity by functioning as hanging reefs, but did not significantly affect the sediment by shading (5% in a scenario of 5 kg/meter dropper rope). During the project a number of improvements of the existing techniques for producing seaweed on suspended line systems were developed, however, further optimization of techniques for deployment, production as well as harvest is needed. This would also allow sugar kelp production as a viable and robust mitigation tool for nitrogen removal and hopefully allow for future expansion of sustainable marine fish production in Denmark.

OR-19-03

The ecological processes and bioremendiation effects of Gracilaria lemaneiformis cultivation

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Chinese mariculture production ranks No. 1 in the world, seaweed cultivation makes important contribution. Gracilaria lemaneiformis has become one of the most important cultivation seaweeds in Chinese coastal waters since 2003. Production of Gracilaria (dry weight) increased from 50,536 t in 2003 to 197,000 t in 2012, and now ranks second only to the kelp Saccharina (formerly Laminaria). Gracilaria cultivation areas form special ecosystems that are artificially controllable and produce huge biomass in a short time with tremendous impact on aquatic environments and structures of biological communities. Author study some key biogeochemical processes of C, N, P and plankton communities in the Gracilaria cultivation ecosystems. Results have shown that Gracilaria is environmentally beneficial because it has the capacity to improve water quality by mitigating eutrophication, controlling harmful algal blooms, remediating contaminants, changing plankton community structure in the cultivation areas, and sequestering CO2. Large-scale cultivation of Gracialria provides an effective approach for bioremediation in the eutrophic coastal waters in China.

OR-19-04

Nutrient bioextraction and bioenergy recovery from ocean outfalls of treatment works

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Nutrient management at wastewater treatment plants is capital intensive, requires space for expansion, and has significant operational costs associated with removing nutrients. As an alternative to tertiary treatment processes, the kelp, Saccharina latissima, is being explored as a nutrient bioextractant from the plumes of outfalls of secondary sewage treatment systems. S. latissima contains high sugar content, and is a valuable food, feed, and biomass feedstock for platform chemicals and biofuels. In this work, we explored use of S. latissima as a third-generation biofuel when anaerobically digested. Digested material retains nutrient value and can be land-applied as a fertilizer, off-setting chemical fertilizer use for land-based agriculture. Field measurements were used to identify growth rates of S. latissima farmed in Boothbay Harbor, Maine, USA. Based on measurements of growth rate and macroalgae nitrogen contents, a farm size of 16 hectares would be needed for each mg/L N removed per million gallons per day wastewater treatment plant flowrate. Laboratory-scale measurements were used to determine biomethane potential (BMP; 180 L/kg VS) and gross heat of combustion (9.8 MJ/kg DW) of S. latissima. Increasing salinity from 2ppt to 17ppt decreased BMP linearly from 180 L/kg VS to 105 L/kg VS. Salinities above 17ppt were toxic, ceasing methane production after 20 hours. Full-scale simulations of anaerobic digestion for kelp fields sized to meet nutrient reduction requirements were completed using the BioWin simulation software and best-fit model coefficients derived from laboratory-scale simulations. Full-scale anaerobic digester models indicated that 40% VS reduction can be achieved with a hydraulic retention time (HRT) of 13d. Continuing work investigates the economic and lifecycle impacts of kelp-based nutrient bioextraction versus engineered nutrient management scenarios at wastewater treatment plants.

OR-20-01

Effects of floating macroalga masses and farms on climate change and related issues

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Macroalgae, naturally-occurring or farmed, provide valuable ecosystem services. As farming for biomass expands these services are being characterized and quantified. Bioremediation of water through the uptake of excess nutrients is perhaps the more thoroughly studied and widely used one. Biomass accumulation is clearly a carbon sink, yet it is only recently gaining relevance as farmed product approaches 30 million tons per year. Other potential ecosystem services, however, are just being studied beyond initial considerations, such as biodiversity enrichment and fisheries enhancement; the uptake of nitrogenous compounds from water before they become nitrous oxide, a potent greenhouse gas; oxygenation of hypoxic areas; and, a

reduction in ocean acidification by the uptake of dissolved CO2. Additionally, we are assessing through direct measurements and satellite imagery analysis the role of macroalga farms and of the Sargasso Sea and drifting Sargassum masses in altering solar radiation and energy balances. As determined, surfaces covered by macroalgae significantly differ from the surrounding sea both in decreasing penetration of radiation into the water, perhaps aiding to decrease ocean warming, and in reflecting more radiation than the water surface alone, increasing the commonly very low ocean albedo, something that eventually may positively affect global energy balance. After presenting results from this radiation and energy analysis and its foreseeable implications, these are integrated in a preliminary quantitative view with other known ecosystem services, as they feedback onto climate change and related issues. The argument is presented that large scale floating macroalga masses and farms can become a tool of extraordinary potential to mitigate climate change and to adapt to it through both products and services, including climate change intervention, in this case by the potential alteration of ocean solar radiation and energy balances.

OR-20-03

Pilot scale cultivation of Sarcothalia crispata in southern Chile

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After long time and efforts to cultivate Chilean carrageenophytic species, new public and private projects have arisen to turn this into reality. This work describes the drivers behind this trend, recent progresses in the cultivation of Sarcothalia crispata (Bory) Leister, the main species used worldwide for the production of kappa II and lambda carrageenan. Preceded by an extensive review of previous work, the paper describes the consensus and remaining gaps of knowledge. Trying to fill the last ones and proposing a cultivation system to be implemented in the south of Chile. Hatchery stage is well known and give consistent results through the different studies performed so far, making the production of sporelings highly efficient and allowing the start of cultivation at the sea. Experiments were carried out in 6 different localities of the 10th and 11th regions of Chile with different results. Attempts to understand this findings drives to herbivory, fouling and epiphytes associated to local regimes of water movement as the main factors to pay attention for site selection. The study also covers the differential growth of gametophytic and sporophytic plants which have an impact on the availability of raw material for Kappa II and Lambda carrageenan production, respectively. A review of the economics of the proposed cultivation system is included as well as a projection of the potential influence of this breakthrough in the global carrageenan industry.

OR-20-04

Drones for monitoring of seaweed farms

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Efficient monitoring of seaweed farms is a both challenging and laborious task using manned aircraft. A substantial improvement in monitoring may be achieved using unmanned systems or drones for the job. Drones are able to fly much lower than manned aircraft providing better data quality with multi- or hyper-spectral camera systems. Drones may also be programmed to follow a GNSS-guided track for data collection ensuring consistant data sampling. Finally, drones are likely the most cost efficient method for efficient monitoring of seaweed farms allowing for frequent data collection runs yielding more and higher quality information about the status of the farms.

OR-21-01

Subtidal benthic macroalgae from Easter Island obtained by germling emergence

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Easter Island, one of the most isolated portions of land, belongs to the Nazca-Desventuradas Marine Protected Area, a vast, recently-established marine reserve. In spite of its remote location between South America and Polynesia it is not considered a biogeographic zone, as much of its biodiversity can also be found either in the South-Eastern Pacific or in Polynesia. However, its marine flora has been the matter of only eight investigations that mainly included records of conspicuous macroscopic seaweeds from the intertidal and upper subtidal. The present study aims to examine the cryptic subtidal marine vegetation present in this locality through i) the germling emergence method for their isolation from small substratum

samples obtained by diving and ii) DNA barcoding for their subsequent molecular identification. From in total five substratum samples collected in April 2014, we isolated 40 algal strains, comprising 29 different species. The majority of them (72%) were brown algae, whereas red and green algae were represented by 17% and 10 % respectively. Morphological and molecular identification using the markers COI-5P, rbcL, psaA and psbC showed that most of the brown algal isolates belonged to the Ectocarpales but did not match any previously sequenced taxa. We also isolated members of the Dictyotales and Sphacelariales and two putative new species of Discosporangium and Verosphacela.

OR-21-02

Spatial and Temporal Patterns of Seaweeds in Macao SAR, PRC

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This paper presents a part a baseline assessment of seaweeds in Macao SAR, a coastal city situated in the southern coast of China, west of the heavily industrialized Pearl River Delta region. The seasonal and zonation patterns of seaweeds in a rocky intertidal shore in Coloane Island was investigated from May 2011 to June 2012. A distinct seasonal pattern was observed with majority of the species exhibiting higher abundance during the winter seasons (November to February) when mean seawater temperatures and precipitation were significanty lower. Reproduction in Prionitis sp. was apparent during the winter months. A distinct zonation pattern was also observed, with Ulva sp. dominating the upper intertidal zone while a mixture of Prionitis, Gelidium and Gelidiopsis dominated the lower intertidal zone. Seasonal patterns on the occurrence/growth of these species are likely to be caused by changes in temperature and salinity over the seasons while the limited geographical distribution of red seaweeds in the rocky shores are likely to be caused by the type of substrate and strength of wave action and water movement. The wider geographic distribution and observed bloom of Ulva sp. at certain periods of the year along the coastline of Macao may be an indication of a high degree of eutrophication in the area.

OR-21-03

Population fitness at the southern edge of species distribution

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The factors that determine species range boundaries have been the focus of many recent studies, but empirical data showing evidences of differentiation in population related traits along distributional borders are still scarce. In this work the patterns of interpopulation variation in phenotypic and ecophysiological traits along the southern distribution limit of an intertidal structuring seaweed genera (Fucus sp-), were studied at two biogeographical borders. F. serratus and F. gardneri were the model species used at the Atlantic and Pacific biogeographical transition areas, respectively. The patterns of variation in population structure and abundance were characterized along a coastal stretch of approximately 600km, across the southern distributional limit of each species. Based on the abundance patterns found, five populations were chosen, at each biogeographical boundary, to study their ecophysiological tolerances to different thermal disturbance intensities. The vegetative growth and photosynthetic efficiency of vegetative tips were the response variables estimated. The results of the study showed no consistent evidences of decreased fitness towards the edge of species distribution supported by biomass, density or relative frequency of life-stages distribution patterns. This study also showed variable ecophysiological tolerances to thermal disturbance of Fucus sp. populations along the southern distributional border, at both biogeographical transition areas. These results highlight the variable patterns in populations phenotypic traits at range margins, possibly related to the specific factors determining the borders of distribution of each species at each location.

OR-21-04

The variable routes of rafting: dynamics of floating bull-kelp Durvillaea antarctica

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Rafting is an important dispersal mechanism for seaweeds and associated organisms wherever floating seaweeds are available and survive sufficiently long at the sea surface. The bull kelp Durvillaea antarctica represents one of the most ubiquitous floating seaweeds in the southern hemisphere, but molecular phylogeographic studies had suggested that successful rafting dispersal varies along the continental coast of Chile. Herein we determined the biomass and demography of bull kelps stranded on 33 beaches along the Chilean coast in order to examine whether rafting is restricted to certain regions and seasons (winter or summer). Stranded kelps were found on all beaches and during both study seasons. While the

majority of stranded kelps had only one stipe (one individual), at most study sites we also found coalesced holdfasts that contained mature males and females, especially during the winter season, which would facilitate successful rafting dispersal. Biomass of stranded kelps varied regionally, with high biomasses in the northern (29°S to 33°S) and the southern region (39°S to 42°S), and substantially lower biomasses on the beaches of the central region (34°S to 38°S). This pattern was maintained between seasons (winter and summer) and years (2013, 2014, 2015). Pelagic barnacles (Lepas spp.), which only colonize floating kelps, were found primarily in the northern and southern regions. Similarly, the largest sizes (capitulum length, mm) of epibionts Lepas spp. on stranded kelps were observed at sites from the northern and southern regions, indicating prolonged floating periods. Based on these results we conclude that rafting dispersal is more common in the northern and southern regions, most likely due to local supply of kelps and regional hydrodynamics. These findings show that rafting dispersal via floating seaweeds can vary regionally, depending on intrinsic (seaweed biology) and extrinsic factors (shore morphology and oceanography). Funding: FONDECYT 1131082

OR-21-05

Coralline diversity along a kelp forest density gradient: how barren are urchin barrens?

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According to the classic otter-urchin-kelp trophic cascade, when sea otters are removed from kelp forests, urchins increase in abundance, grazing down the kelps and ultimately creating “urchin barrens.” These denuded habitats represent an alternative state dominated by coralline algae, whose calcified thalli resist urchin grazing, and generally lead to declines in species diversity across all trophic levels. However, changes in coralline algal diversity across gradients of kelp density are often overlooked and have never been properly characterized. Moreover, recent studies have shown that morphological species concepts of coralline algae are deeply flawed and that we are significantly underestimating coralline diversity worldwide. Using DNA barcode identifications, we describe for the first time the species diversity of subtidal coralline algae at four sites along the central coast of British Columbia, Canada, representing a gradient of otter occupation, urchin abundance, and kelp forest density. As expected, coralline abundance increased as kelp forests thinned. Coralline communities were surprisingly rich with 10-12 distinct species identified in kelp forests and 8-9 species identified in urchin barrens; several of these species are new to science and require taxonomic attention. However, coralline communities within urchin barrens showed reduced Shannon-Wiener diversity and evenness; a few coralline species, which were also present in kelp forests, significantly increased in abundance when kelps were removed. This mismatch between increased coralline abundance and decreased coralline diversity likely reflects grazer-mediated shifts in space or light competition, broadening our understanding of kelp forest dynamics.

OR-21-06

Distribution, phenology and dominant carrageenan type of Chondrus elatus endemic to Japan

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Chondrous elatus Holmes is a carragenophyte endemic to Japan. This species is distributed on the middle to north Pacific coasts of Honshu Island (Mie to Aomori Prefectures), and is utilized as a source of food gel called ‘kaiso’ or ‘kaiso-konnyaku’ in the center (Ibaragi, Chiba and Kanagawa Prefectures) of its distribution; dried materials or processed gel products are locally commercialized. Probably because the populations of C. elatus are formed in the intertidal zone on the exposed rocky coasts, little has been known on its ecology. Therefore, the author visited Enoshima Island, Fujisawa City in Sagami Bay (type locality) at an ebb tide every month from December 2007 for two years and additional density survey was conducted in March 2010. Furthermore, carrageenan type was determined on the commercial dried materials sold at Choshi, Chiba Prefecture in May 2014. C. elatus was found only in the lower intertidal zone of the outer coast of the island; the density was about 7 clumps / m2 and each clump was comprised of 30 to 300 uprights. A total of 6 clumps (2 tetrasporophytes, male and female gametophytes in each) of C. elatus were collected; total length, wet weight and maturation of all uprights were examined. Uprights were present and dry / wet weight ratio was around 20 % all through the year; weight per upright increased in summer. Fertile uprights accounted for >20 % in sporophytes from June to December and >25 % in female gametophytes from May to August, respectively but small numbers were always reproductive. When uprights were pruned at the height of 1 or 5 cm from its basal crust, the regrowth rate (1.1 cm per month) was larger than the growth rate (0.4 cm per month) of the intact uprights. The commercial dried materials of this species contained kappa carrageenan as the main polysaccharide and smaller amount of lambda carrageenan that could be solubilized in cold water.

OR-21-07

Phylogenetic systematics and diversity of Seaweeds from Indian Coast

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Seven GPS-aided research expeditions in Western and Eastern Indian rocky intertidal coasts covering ca 3000 km stretch of shoreline were carried out and approximately 3000 individual algal specimen of unique morphological features that belong to ca 60 known and unknown species were sampled. Expeditions covered the following coasts: West (Maharashtra, Goa, Karnataka and Kerala Coasts), East (West Bengal, Andhra Pradesh and Tamil Nadu), and Andaman & Nicobar Islands. Phylogenetic analysis using ITS, trnL, COX, RPS, 18S and rbcL sequences were conducted that revealed existence of a number of new species. Majority of the species identified belong to red algae and the states Kerala and Tamilnadu were the richest in terms of species diversity. The following two new algal species were discovered: Ulva paschima Bast and Cladophora goensis Bast. The study also revealed existence of endophytic algae for the first time in Indian Ocean. Study also generated ca 2000 unique DNA barcodes curated at NCBI-GenBank. Existence of following algal species for the first time in India were revealed by this study: Dichotomaria Sp. Nov,. Sirodotia Sp. Nov,., Ulvella leptochete, Acanthophora spicifera, Dilsea socialis, Sargassum zhangii, Boergesenia forbesii, Galaxaura rugosa, Padina testrastromatica, Hydropuntia Sp. Nov., Grateloupia Sp. Nov. and Porphyra Sp. Nov. The results were made available in the form of a comprehensive database on Indian algae, db-IndAlgae, first such database ever. This is the first DNA barcode-based comprehensive assessment of the phylogenetic diversity of seaweeds from Indian coastal region conducted till date, and is supported by DST-INSPIRE Faculty Award from Government of India.

OR-22-01

Seaweeds and the human brain

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Eighty percent of the content of the human cranium is brain matter. The brain functions as the epicenter of not only our physical existence, but also of our sense of well-being and the manifestation of human consciousness. This precious and complex organ increases in mass from 350-400 g in the human infant to 1.3-1.4 kg in an adult, and it is comprised of approximately 78% water, 12% lipids, 8% protein and 1% carbohydrate. Significant progress in behavioural and analytical sciences is accelerating our understanding of the multifaceted functions and responses of the brain to various stimuli, whether it be to the break-down products of food, the influences of environment, or in relation to our genetic predisposition. The science of seaweeds, and particularly their broad range of applications is also gathering momentum as studies regarding this marine resource repeatedly underscore the natural health and nutritional benefits of dietary macroalgae. This work reviews research highlighting the potential impact of consumption of a variety of seaweeds on brain health, with major emphasis on diet and the gut/microbe/brain axis, the importance of polyunsaturated fatty acids and the impact of antioxidant activities in neuro-protection. These elements have the capacity to help in the defence of humans from cognitive disorders such as dementia, Alzheimer's disease, and adverse conditions characterized by progressive neuro-degeneration. Such pathologies triggered by neuro-inflammation, oxidative/nitrosative damage, and synaptic loss are examined in the context of nutritional neuro-protection and the roles various seaweeds may play. Psychological benefits associated with consuming a diet fortified with macroalgae are also discussed in terms of reduced depressive symptoms and improvements in human sexual function.

OR-22-02

Nutrient Composition, Antioxidant and Antiobesity Properties of Sabah Red and Brown Seaweeds

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Obesity has reached epidemic proportions in many countries around the world. Preventing and treating obesity is becoming an increasing priority due to dissatisfaction with high costs and hazardous side-effects of antiobesity drugs. This study was conducted to investigate the nutrient composition, antioxidant activities and antiobesity properties of Sabah red seaweed (Kappaphycus alvarezii) and brown seaweed (Sargassum polycystum) powder in rats fed high fat diet. Male Sprague Dawley rats were divided into five groups, each representing control negative (CN), control positive (CP), low, medium and high seaweed dosage group (LDG, MDG and HDG). The study duration was eight weeks. Effects of seaweeds in preventing antiobesity and peroxidation in rats were studied via assessing the plasma lipids and, plasma and organs malondialdehyde (MDA) concentrations. Likewise, activities of antioxidant enzymes such as superoxide dismutase (SOD), glutathione peroxidase (GSH-Px) and catalase (CAT) were accessed as indices of oxidative stress. These seaweeds were found to be high in dietary fiber and contained 12.01-15.53% macro-minerals (Na, K, Ca

and Mg), 7.53-71.53 mg/100g trace elements (Fe, Zn, Cu, Se and I), significant vitamins, B1, B2, C, E (alpha-tocopherol), total carotenoids (beta-carotene, lutein, zeaxanthin) and flavonoids (quarcetin, kaempferol, epicatechin, epigallocatechin). Rats fed with HDG diet showed the greatest effect in suppressing weight gain. By comparing with CP group, throughout the study, it was found that HDG group (10.0% seaweed treatment diet) showed the most supporting effect in suppressing weight gain, followed by MDG group (5.0% seaweed treatment diet) and LDG group (2.5% seaweed treatment diet). HDG group decreased the levels of plasma total cholesterol and plasma total triglycerides. These findings found that seaweed powder treatment had positive effect in inhibiting weight gain and has promising value in preventing obesity.

OR-22-03
Biobased plastics from Seaweed – Seabioplas EU project

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SEABIOPLAS fits EU 2020 strategy regarding biodegradable polymers. Major market drivers for biodegradable polymers include legislation, depleting landfill capacity, pressure from retailers, growing consumer interest in sustainable plastic solutions, a quest for fossil oil and gas independence and the reduction of greenhouse gas emissions. The industry defines biopolymers, or bioplastics, as polymers that are either bio-based and/or biodegradable - PLA is biobased and biodegradable under industrial conditions. The production of PLA and other biopolymers is now based in natural resources like corn, wheat, sugar beets and sugar cane. There is an increasing concern that the use of those raw materials will compete with food, feed or energy production, with consequent escalation of raw material costs and negative environmental effects. The dependence of those feedstocks is a limitation to a wider application of biopolymers in the plastic industry; thus the interest in alternative sustainable resources. SEABIOPLAS proposes seaweeds: offering many advantages, including higher productivities, no competition for land use, minimal water consumption while having similar sugar. SEABIOPLAS offers a complete integrated solution to the plastic SMEs stakeholders through the scientific knowledge provided by the RTDs, from the production of the feedstock in sustainable Integrated Multi Trophic Aquaculture systems, to the development of the biopolymers using innovative technologies of reduced environmental impact until the validation test of the seaweed-based polymers in greener plastic products. There are 6 business partners involved in the project, 4 of which are SMEs interested in seaweed production and plastic production. Seabioplas project terminated at the end of 2015. This communication gives an overview of major results in term of technical development for PLA and polysaccharide based plastics, LCA analysis and economical viability.

OR-22-04
Alginate gels with new crosslinkers

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Alginate is a polysaccharide present as a structural component of brown algae (Phaeophyceae), comprising up to 40% of the dry matter. The exploitation of brown algae in Europe is based on the commercial value of alginates, which are used as thickening and gelling agents. The alginate molecule is composed of two building units, i.e β-D-mannuronic acid (M-unit) and its C5-epimer, α-L-guluronic acid, which are linked through (1→4) glycosidic linkages. Alginate hydrogels crosslinked with divalent ions, e.g. calcium, have been extensively studied, and such gels have found numerous applications also for high-value applications, e.g. immobilization of cells and tissue engineering. For certain applications of alginate gels, high calcium concentrations can lead to complications. We recently reported on the use of chito-oligosaccharides (CHOS) as crosslinkers in alginate gels (Biomacromolecules (2013) 14, 2765), and we now report on combinations of CHOS and calcium ions to crosslink two commercial alginates, one with a relatively high content of M-units and the other with a lower content of M-units. Both gels were found to form weak gels with only CHOS, i.e. without calcium. The gel strength of both alginates increased with increasing concentration of CHOS and upon lowering the pH by adding increasing amounts of the slowly proton-donating lactone D-glucono-delta-lactone (GDL), as previously found for an alginate containing only M-units. Combined CHOS-calcium

alginate gels were prepared through internal gel setting by using solid calcium-carbonate and neutral CHOS, followed by lowering the pH with GDL. Gel strengths of pure CHOS-alginate gels were lower than pure calcium-alginate gels for both alginates. However, up to 50% of the calcium could be substituted with CHOS without decrease in the gel strength, and in gels prepared from both type of alginates, a substantial amount of calcium could be substituted with CHOS without significant reduction in gel strength.

OR-22-05
Seaweed compost for agricultural crop production

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This study manipulated the carbon-to-nitrogen ratio (C:N) of seaweed composts by varying the proportion of high N seaweed (Ulva ohnoi) and high C sugarcane bagasse to assess their quality and suitability for use in agricultural crop production. Seaweed-bagasse mixes that had an initial C:N ratio greater than 18:1(up to 50:1) could be transformed into a mature compost within 16 weeks. However, only composts with a high seaweed content and therefore low initial C:N (18 and 22:1) supported a consistently high rate of plant growth, even at low application rates. Sugarcane grown in these high seaweed composts had a 7-fold higher total above-ground biomass than low seaweed composts and a 4-fold higher total above ground biomass than sugarcane grown in commercial compost that did not contain seaweed. Overall, the optimal initial C:N ratio for seaweed-based compost was 22:1 which corresponds to 82% seaweed on a fresh weight basis. This ratio will produce a high quality mature compost whilst also ensuring that a high proportion of the nitrogen (>90%) in the Ulva biomass is retained through the composting process.

OR-22-06
Ascophyllum nodosum extracts mediated salinity tolerance in Arabidopsis

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Ascophyllum nodosum, a brown algae, is a source of biostimulant involved in imparting growth promotion and stress tolerance in different agricultural crops. The molecular mechanism of A. nodosum extract (ANE) mediated stress tolerance, however, remains largely unknown. In this study, we show that methanolic sub-fractions of ANE improved growth of Arabidopsis under NaCl-stress; biomass increased by approximately 50% at 100 and 150 mM NaCl relative to controls. Bioassay guided fractionation revealed the ethyl acetate sub-fraction of ANE (ESA) had the majority of stress alleviating bioactive components. ESA elicited a substantial global transcriptome changes on day one and day five after treatment. On day one, 184 genes were up-regulated while, this number increased to 257 genes on day 5. On the other hand, 91 and 262 genes were down-regulated on day 1 and day 5, respectively. On day 1, 2.2% of the genes altered were abiotic stress regulated and this increased to 6% on day 5. A number of stress inducible genes LEA, Di21, ADH, DREB 1C, DREB 1A and rd29B and a number of ABA inducible genes were upregulated. Additionally, ESA treatment reduced Na+ accumulation in the shoot. There was a significant reduction in Na+ uptake in Arabidopsis grown hydroponically in the presence of NaCl and the bioactive component of A. nodosum. Thus, bioactive components in the ethyl acetate fraction of A. nodosum induce salinity tolerance in Arabidopsis by regulating the expression of stress responsive genes, and thus proves to be an important candidate for improving sustainable agriculture in harsh environmental conditions.

OR-22-07
Effect of Seaweeds on Vegetables Growth Under Glasshouse Condition

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Seaweeds have long been used to increase plant productivity and food production in the world via their beneficial effects. The effect of wild seaweed on plant growth and development were studied under glass house conditions. Some the observed parameters on eggplant, mustard, and onion indicated that some wild seaweeds performed better over control. The result here indicated that organic compound present in seaweeds can improve plant growth in glasshouse conditions. Results presented illustrate that all seaweeds can increase crop performance compate to control, especially that seaweed Sargassum sp (treatment B) and Caulerpa sp (treatment D).

OR-23-01

A brown epi-endophyte, Mikrosyphar zosterae, produces galls on Chondrus ocellatus fronds

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The filamentous brown alga, Mikrosyphar zosterae was first isolated from Chondrus ocellatus in Asia and is identified using molecular analysis and morphological features in this study. Mikrosyphar was discovered as the causative agent of galls on Chondrus fronds, which was confirmed in a mixed culture of the two species. Mikrosyphar appears as black spots on Chondrus fronds and grows as and epi-endophyte. Galls are produced in the tissues of Chondrus between the cortex and the medullar zone by Mikrosyphar sporophyte formation. No hypertrophy or hyperplasia of Chondrus cells was found, which is different from galls in other species. In laboratory culture, three different morphological types of Mikrosyphar were observed: diploid sporophyte thalli, haploid vegetative thalli, and very small gametophyte thalli. In culture experiment using Mikrosyph, hyaline hair, endogenous hair, and reproductive organs (both unilocular and plurilocular sporangia) were observed. In conclusion, the brown alga Mikrosyphar zosterae has a diphasic, heteromorphic life history undergoes isogamic sexual reproduction, and the species is a causative agent of galls on Chondrus fronds, which may reduce carrageenan production.

OR-23-02

The response of Chondrus ocellatus to two endophytes, Mikrosyphar zosterae and Ulvella ramosa

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To examine the effects of two endophytic algae, Mikrosyphar zosterae (brown) and Ulvella ramosa (green) on the host Chondrus ocellatus, culture experiments were conducted for 5 weeks in culture, at 10° C and 20 °C. Four treatments were made: control (Chondrus monoculture), MC (Mikrosyphar and Chondrus mixture), UC (Ulvella and Chondrus mixture), and MUC (Mikrosyphar, Ulvella and Chondrus mixture). After 3 weeks, the relative growth rates (RGRs) for frond weight and branch length (main and lateral) were estimated and the number of newly produced branches was counted. Mikrosyphar produced galls showing black dots on Chondrus fronds, whereas Ulvella made dark spots. The RGRs of the frond weights and main frond lengths of Chondrus were significantly greater in the control and MC treatments than in the UC and MUC treatments, indicating that the growth of host Chondrus was inhibited more by green Ulvella than brown Mikrosyphar endophyte. However, RGRs for total lateral branch lengths were the other way around: 12.96 (UC), 9.29 (MUC), 5.48 (Control) and 4.99 %day-1 (MC treatments). Similarly, the number of newly produced lateral branches was greater in the UC and MUC (2 – 2.66 branches per frond) than in the control and MC (0.66 – 0.83 branches) treatments. The present results indicate that the two endophytes inhibit the growth of the host Chondrus and the negative effects on growth by Ulvella are more severe than those caused by Mikrosyphar. Furthermore, Ulvella destroyed the apical meristems of Chondrus but Mikrosyphar did not. On the other hand, Chondrus showed compensatory growth in the form of lateral branch production as Ulvella attacked its apical meristems.

OR-23-03

Convergence of mechanism(s) of action of bioactives of Ascophyllum nodosum

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The brown seaweed Ascophyllum nodosum is one of the most studied species, largely due to its long term, extensive use in plant and animal agriculture and also industrial applications. However, the nature of bioactive compounds present in this seaweed, it's commercial extracts and the molecular mechanism(s) of action of these compounds have only recently attracted the interest of researchers. The most common activities elicited by extracts and compounds isolated from A. nodosum include anti-stress activity, especially against abiotic stresses, i.e. extreme temperatures, osmotic stress and salinity and also induction of immune responses in plants and animals. In addition, A. nodosum also exerts differential effects on microbes, in general, favouring the growth of microbes which improve plant and animal health, while suppressing pathogenic forms. Studies conducted in our laboratory and others suggests that compounds present in A. nodosum commercial extract perturbs similar biochemical pathways across multiple groups of organisms. In this paper we will discuss the effect of A. nodosum and its extracts on plant, animal and microbe systems while developing a unifying model to relating bioactivity of A. nodosum to it applications.

OR-23-04

Bacteria isolated from brown seaweed impart salinity tolerance in land plants

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Soil salinity is one of the major abiotic stresses that affects plant growth and productivity. Mechanism(s) of plant tolerance to salinity is complex and is mediated by multiple biochemical pathways. Seaweeds survive in harsh environmental conditions, such as high salt concentration, temperature extremes and strong tidal forces in the intertidal zones. There is growing evidence that microbes that inhabit the surface of seaweeds protect them against harsh environmental stresses. Thus, there might be a potential to impart salinity tolerance in land plants by applying these seaweed inhabiting bacteria. In this study bacteria isolated from brown seaweeds were screened for its potential to mitigate salinity stress in plants. A number of strains of bacteria were isolated, cultured and inoculated in the root zone of Arabidopsis thaliana challenged with 200mM NaCl. Two strains of bacteria isolated from Fucus vesiculosis imparted significant salinity tolerance to Arabidopsis. It was observed that plants inoculated with bacteria accumulated less sodium and had more potassium in the leaf tissues as compared to control plants. Moreover, the stress responsive genes such as RD29A, RD22 and, proline biosynthetic genes such as, P5CS1 and P5CS2 were significantly upregulated in bacteria inoculated plants at 24, 48 and 72 hrs after 200mM NaCl treatment as compared to control plants. Taken together, these results suggest that seaweed microbes could mitigate salinity stress in land plants.

OR-23-05

Glycomics in brown algae: enzymatic profiling off cell-wall polysaccharides for population screening

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Brown algae have a carbohydrate-rich cell-wall which is essential for many processes in algal physiology and development. The main components are the cellulose, sulfated fucans and alginates. We recently provided a global snapshot of their macromolecular configurations within the wall. For each polysaccharide, major ideal motifs have been described but a vast continuum of intermediate structures can be found. This chemical diversity has been largely ignored so far, mainly because the chemical analyses are fastidious and time-consuming. We are currently developing biochemical fingerprinting methods to allow the rapid cell-wall phenotyping of large populations of brown algae. Part of those methods are enzymatically-based and use specific recombinant proteins from bacterial origins. Those enzymes have been biochemically, and sometimes structurally, characterized (i.e. fucanases, alginates lyases). Additional methods use monosaccharide composition and linkage analyses, and glycoarrays probed with specific anti-alginates and anti-fucans antibodies. Distinct populations are fingerprinted including: i) harvested species having distinct distributions on the shore, and ii) microscopic Ectocarpus strains routinely cultivated in the laboratory. For the latest the results will be correlated to the genomic data to explore further the biosynthetic routes. This work is taking place within the French program 'IdeAlg' (http://www.idealg.ueb.eu), dedicated to Seaweed Biotechnology and Bioressources.

OR-23-06

Monoclonal antibodies generated against plant cell wall components bind to epitopes present in algae

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Over 200 monoclonal antibodies have been generated against land plant cell wall components; many are commercially available. Monoclonal antibodies enable the precise localisation of specific epitopes, the part of the wall component recognised by the monoclonal antibody, at tissue, cellular and sub-cellular level. As a tool monoclonal antibodies have greatly facilitated our understanding of plant cell wall composition, metabolism and function. However, although several monoclonal antibodies were generated against algal cell walls by researchers ~30 years ago, in the majority of cases, for various reasons, they are no longer available. More recently researchers have begun to generate useful new seaweed-directed monoclonal antibodies, particularly toward commercially important polysaccharides. Applying a different strategy

we decided to investigate the potential of the existing wide range of monoclonal antibodies that were generated against land plants to recognise epitopes present in algae. We have found that several of these monoclonal antibodies are able to recognise and bind to glycan epitopes present in algal cell walls and had specific and differing immunolocalisation patterns. This substantially expands the range of tools that can be used to investigate algal cell wall processes.

OR-23-07

Reversible cell wall swelling controls sieve tube transport in Laminariales

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Kelps, brown algae of the order Laminariales, possess sieve tubes for the symplasmic long-distance transport of photoassimilates that are evolutionarily unrelated but structurally similar to the tubes in the phloem of vascular plants. In contrast to land plants, sieve tubes of kelps are embedded in a gelatinous extracellular matrix which isolates them from neighbouring cells. Therefore we hypothesized that kelp sieve tubes might tolerate invasive experimentation better than their analogs in higher plants. Using fluorescent dyes, we visualized sieve tube structure, bulk translocation, and wound responses in fully functional, intact Bull Kelp (Nereocystis luetkeana). Micro-injection into sieve elements proved comparatively easy. Pulsed dye injection enabled the determination of flow velocity in individual sieve elements, and the visualization of pressure induced reversals of flow direction across sieve plates, which conclusively demonstrated that a critical requirement of the Münch theory is satisfied in kelp. In injured tubes, slime plugs formed but were unlikely to cause sieve tube occlusion as they assembled at the downstream side of sieve plates. Cell walls expanded massively in the radial direction, reducing the volume of the wounded sieve elements by up to 90%. Ultrastructural examination showed that a layer of the immediate cell wall characterized by circumferential cellulose fibrils was responsible for swelling, and suggested that alginates, abundant gelatinous polymers of the cell wall matrix, were involved. Wall swelling was rapid, reversible, and depended on intracellular pressure, as demonstrated by pressure injection of silicon oil. As sieve tube transport is pressure-driven and controlled by tube diameter, a regulatory role of wall swelling in photoassimilate distribution is implied in kelps. More generally, our results revive the concept of turgor generation and buffering by swelling cell walls, which had fallen into oblivion over the last century.

OR-24-01

Transcriptome analysis on the pathogen responsive genes in a red alga Pyropia tenera

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Pyropia seafarms are suffering from various diseases, ranging from spectacular outbreaks in natural populations, down to chronic diseases which cause downgrade of crop quality. Oomycete pathogens, Olpidiopsis pyropiae and Pythium porphyrae causes economic loss about 10-15 million dollar to sea farmers every year. The recent development of intensive and dense mariculture practices have made some new diseases spread much easier than before. Transcriptomic study revealed there are innate immnunity in Pyropia tenera towards the oomycete diseases. Host plants intensively use cell wall hydrolase proteins for defense against oomycete infections.. We isolated pathogenerecognition related genes which are highly upregulated during infection process. Metagenomic studies on Pyropia and its epiphytic bacteria showed that some epiphytic bacteria are involved in fungal infection to Pyropia. The evolutionary warfare between Pyropia and its pathogens left many traces in the genomes of both sides. Therefore, proteomic and transcriptomic studies on Pyropia and its pathogens are crucial to develop a disease-resistant Pyropia strain. The pros and cons of mutation breeding of disease-resistant Pyropia strain will be presented.

OR-24-02

Pythium porphyrae, the agent of the red seaweed rot disease: a reformed plant pathogen?

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The red alga Pyropia (formerly Porphyra) sp.is the most valuable seaweed worldwide, underpinning a global industry in excess of $ 1 billion. Pythium porphyrae, the agent of red rot disease is responsible for devastating outbreaks in seaweed farms. Here, we investigated the gene repertoire of P. porphyrae

and its transcriptional regulation using next-generation sequencing EST libraries obtained during a time course of infection. We focussed our annotation on the genes potentially involved in pathogenicity such as secreted proteins, toxins, and homologues of known oomycete pathogenicity effectors. In agreement with the general view that Pythium pathogens are opportunistic, necrotrophic pathogens less specialised than other biotrophic oomycetes, P. porphyrae contains a gene repertoire very similar to the one described in other Pythium species. Strikingly however, we could not identify any enzyme specifically involved in the degradation of red algal- cell wall components. Instead, the presence of cellulases, CBEL proteins and of a cutinase hints to P. porphyrae tracing its roots to a pathogen of higher plants (Embryophyta).

OR-24-03

Back to basics: global shortage of bacteriological and technical agars

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At present laboratory reagent companies are suspending supply of specialised agar products due to low availability of raw material. These bacteriological/technical agars used in laboratories around the world are predominantly obtained from species of a single red algal genus, Gelidium. Harvesting of natural populations is the only source of feedstock as cultivation has never been feasible. Here we analyse historical landings data since the 1920s in all countries where natural Gelidium resources have been harvested. Up to WWII Japan was the only source of agar but then other countries like Spain, Portugal, Morocco, Mexico, and South Africa began to survey and exploit local Gelidium resources. Gelidium landings peaked in the 1960's, while Japan lost market dominance. A sustained decrease in landings to less than 50% of peak annual values has occurred since. This trend was accompanied by concentration of feedstock production in just one country, Morocco, which contributed over 70% of world supply in the last two decades. A sudden decline in this country's landings will have a disproportionate effect on world availability of Gelidium. This is actually the present situation when landing and export quotas were recently implemented in Morocco in order to safeguard the natural resources. Thus Gelidium agar is now undersupplied and priced itself out of the food industry but the increasing demand of bacteriological and technical agars will probably create an opportunity for historical producers, where production has declined, to get back into the market. If an interest in Gelidium resource exploitation is renewed adequate scientific management practices should be implemented. For this, simple harvest statistics such as daily harvest yields and harvest effort need to be collected by harvest area. Estimates of both the standing stock and the exploitation rate of the resource can then be calculated, without the need for time and space extensive, high cost sampling assessments.

OR-24-04

Extraction and characterization of alginate from Ghanaian brown seaweed

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Alginate was extracted from the wild Ghanaian brown seaweeds Sargassum spp. and Padina spp. The chemical characteristics and rheological properties were investigated and compared with a commercial alginates in order to evaluate the potential of Ghanaian brown seaweed as alginate sources. Biomass composition analyses showed that the seaweeds contain significant amounts of the two uronic acids mannuronic – and guluronic acids the main components of alginate, namely 17-30 % of dry material, along with lower amounts of i.a. fucose and glucose. Alginate extraction yields ranged from 16-29 % by weight of the dry material depending on seaweed source and HPAEC-PAD analysis revealed that the majority of the extracted material contained mannuronic and guluronic acids (65-87 % of dry material). The formation and properties of fluid alginate gels produced using CaCO3 were investigated using oscillatory rheology by monitoring the development of the elastic modulus G'. Results showed that the two Padina spp. hold alginates that outstand the commercial alginates and produce gels reaching a G´ value on approximately 400 Pa after 4 hrs. at 20 °C with 15 mM CaCO3. The alginate gels from Sargassum spp. had poor gelling properties with G' values close to 0 Pa. The current work demonstrated that the Ghanaian Padina spp. contain alginate comparable to commercially available alginates and could be considered as future sources for alginate production.

OR-24-05

Novel algae degrading enzymes for the production of bioactive oligosaccharides

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Bioactive compounds from algae possess industrial application potentials in nutraceuticals and pharmaceuticals. Cell walls of both red and brown macroalgae are highly complex and contain special sulfated polysaccharides. Oligosaccharides derived from sulfated algal cell wall polysaccharides have been found to contain a range of health beneficial bioactive properties. Novel enzymes capable of specifically hydrolysing algal polysaccharides into oligosaccharides may be used to generate defined biomolecules and help unveil the complex structures of these cell wall components. Bacteria associated with algae may produce enzymes that decompose algal cell wall polysaccharides. In order to identify such bacteria, we have used a combination of traditional cultivation and isolation methods, sequence based approaches and functional screening. We have recently isolated a novel agarolytic bacterium and we have obtained the genome sequence. Genome analysis revealed several putative genes with proposed function against agar and carrageenans. Likewise, we have searched metagenomic data and identified several predicted genes coding for fucoidanases. In order to confirm the function of these putative polysaccharidases we cloned the genes into E.coli and produced recombinant enzyme. In this way we have discovered several novel enzymes including agarases, carrageenases and fucoidanases.

OR-24-06

Novel seaweed-degrading-microorganisms and enzymes technology for bioenergy production

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Biorefining of the native macroalgae seaweed species in Ghana could enable a new type of green growth. The carbohydrate contents reported for different types of red, brown, and green seaweeds may be up to 50-70% by weight. The lack of lignin in seaweed simplifies seaweed processing as compared to lignocellulosic biomass by eliminating the requirement for hydrothermal or other pretreatment allowing direct enzymatic treatment to obtain fermentable sugars. The enzymatic conversion ratio of seaweed biomass carbohydrates to monosaccharides may be up to 90% depending on the type of seaweed, and notably the type of enzymes employed, but there is scope for enzyme discovery to target the biocatalytic decomposition of the unique types of carbohydrates in seaweeds. Direct inoculation of the seaweed-decomposing bacterial strain Saccharophagus species (Myt-1) and a microbial consortium including lactic acid bacteria such as Lactobacillus brevis, and yeasts, Debaryomyces hansenii and a Candida zeylanoides-related specimen, can e.g. promote the degradation of seaweed biomass and has been shown to induce fermentation of various kinds of seaweeds. In this review, we will outline the recent development of enzyme technology for bioenergy production from seaweed biomass as well as highlight the recent progress and discoveries for saccharification and fermentation of seaweed. Direct inoculation of microorganisms that promotes saccharification and fermentation of seaweed is an option for biorefining and bioenergy production from seaweeds, particularly in low-economy countries such as Ghana.

OR-25-02

Towards the description of a new species of Phytomyxid parasite infecting Durvillaea (Phaeophyceae)

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Durvillaea is a brown algal genus that comprises large brown seaweeds in the southern hemisphere, with both economic and ecological roles in local communities. Over the last years several outbreaks of brown algal endophytes and fungal-like parasites has been reported along its populations. An obligate parasite is described infecting D. antarctica populations from the South-Eastern Pacific (Chiloe Island, Chile) and South-Western Atlantic (Falkland Islands, UK). The pathogen can be found between the cortical and medullar zone and causes hypertrophy, forming characteristic galls throughout the thalli. Cross sections and electron microspcopy observations revealed the prevalence of un-walled plasmodia within the host cells that lead in the formation of hundreds of individual resting spores. 18S phlyogenies place these pathogens within the Phytomyxida (Rhizaria), as a distinct species that is sister species of the marine parasite Maullinia ectocarpii, which is also a parasite of brown algae. In contrast to M. ectocarpii, Maullinia braseltonii nom. prov. does have the sporogenic part of the phytomyxid life cycle which makes it the first marine phytomyxid infecting stramenopile hosts of which resting spores are known. Therefore this species will allow for a further understanding of the phytomyxid - brown algae symbiosis.

OR-25-03

Taxonomy of Amphiroa Lamouroux, 1812 (Corallinales, Rhodophyta) from the Southern Mexican Pacific

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The Amphiroa genus is highly represented in species number in tropical regions around the world. Until now 200 species and varieties have been described, nevertheless just for a few of them is recognized a valid taxonomic status. For the Southern Mexican Pacific the number and names of the species have not been reviewed and according to the actual taxonomic concepts, and then the real biodiversity of the genus is unknown. The aim of this study was evaluate the taxonomy of the genus based on the analysis of published vegetative and reproductive characters in both fresh and historical material. For the last, plants were collected in the northern, center and southern of the Southern Mexican Pacific, as also during the rainy and drying seasons from 2011-2014. The fronds were collected both, at the intertidal and subtidal areas. Also we reviewed historical and type material housed in national (ENCB, FCME and UMAR) and international herbaria (UC and US). In total 32 characters were evaluated, 14 morphological vegetative, 3 morphological reproductive, 9 anatomical vegetative and 6 anatomical reproductive. The anatomical characters were evaluated from permanent histological preparations. The meristic characters were evaluated using Axio Vision Microscopy software Rel. 4.8 and Leica LAZ EZ 3.0. The data were analyzing using a discriminant analysis for tested hypothesis between different morphotypes. According to the stability and persistence of each character we selected the diagnostic ones and determined the phenotypic units. The phenotypic units were contrasted with taxonomic information of valid Amphiroa species, and finally the species names were determined. According to our results the taxonomic diversity of the genus has been overestimated and as consequence of the historical use of variable morphological vegetative characters.

OR-25-04

Taxonomic Revision And Reproduction Of The green Algal Family Ulvaceae From Taiwan

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The green algal family Ulvaceae contains many cosmopolitan and opportunistic species. In the past decade, some foliose species have been proposed to be alternative energy source for producing bio-ethanol in Taiwan. However, the species diversity and seasonal changes of the Ulvaceae along the coasts and neighboring islands are not well documented. In this study, the taxonomy of the Ulvaceae is revised based on comparative anatomy and the inter-specific relationships are inferred using rbcL sequence analyses.

The molecular analyses identified thirteen species, which are grouped into three evolutionary clades: a tubular-type clade containing seven species (U. prolifera and U. linza and five undetermined species), a blade-type clade including three species (U. fasciata, U. ohnoi and U. spinulosa) and a clade with tubular- and blade-types including three species currently placed in Ulva and Umbraulva. The previous records U. prolifera, U. linza and U. fasciata from Taiwan are confirmed, whereas the record of U. "lactuca" from Taiwan is a mixture of U. ohnoi and U. spinulosa. In this presentation, the reproductive pattern of some Ulva species will be discussed as well as their seasonal changes in a monitoring site in northern Taiwan.

OR-25-05

Diversity and molecular phylogeny of Hydroclathrus (Phaeophyceae) from the Western Pacific

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Members of the alginate-producing algal genus Hydroclathrus, distinguished by their clathrate ('net-like') appearance, are widespread in tropical to warm temperate coastal waters. However, compared to other closely related taxa, studies dedicated to the diversity of Hydroclathrus are few, spanning decades in interval, while information on the molecular phylogenetic relationships of the species within the genus are still scarce. Herein, we attempt to bridge these gaps by describing the diversity and molecular phylogeny of the genus Hydroclathrus from the Western Pacific based on genetic (mitochondrial cox1 and plastid rbcL genes) and morphological data. We delineated six species lineages, four of which represent all known Hydroclathrus: H. clathratus, H. stephanosorus, H. tenuis, and H. tumulis. The other two lineages may represent putative new and/or cryptic species. Moreover, this report extends the distribution range of H. stephanosorus and H. tumulis to the Western Pacific, particularly in Japan where both species occurs extensively. Finally, our study highlights the information gap on the diversity of widespread yet often overlooked taxon and underscores the need to conduct a more thorough inventory of our seaweed resources in general.

OR-25-06

Sargassum species from the Yucatan coast: morphological and chemical characterization

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Around twelve species of Sargassum have been reported for the Yucatan peninsula coast, some of which end up as beach cast material and accumulate on the coast during cold months. The great phenotypic plasticity in Sargassum makes difficult to identify benthic and pelagic specimens. In this study we used two approaches using traditional taxonomic characters and chemical characterization analysis to corroborate the identity of the most abundant species. During the winter of 2014 fresh material of several species of Sargassum were collected in the Yucatan coast. The Sargassum species were identified using morphological characters such as presence or absence of criptostomata, blades shape, length and width, and the form, presence or absence of floating vesicles. Eight species were identified: S. fluitans, S. natans, S. filipendula, S. vulgare, S. hystrix, S. buxifolium, S. ramifolium and S. furcatum. For all species their cell wall polysaccharides, alginic acid and fucoidan were extracted, quantified and characterized. For the three species with higher biomass found in the area, S. buxifolium, S. hystrix and S. fluitans organic extracts were prepared and GC-MS analyzes were performed looking for species specific compounds. Analysis identified specific compounds and by using a PCA we shown their species occurrence. For all three species ubiquitous compounds were obtained. In S. buxifolium dichloromethane fraction Hexanoic acid, 2-ethyl- was obtained whereas in S. hystrix Benzyl Benzoate and Epistephamiersine were found. For the last species in the hexane fraction Cholesta-4,6-dien-3-ol, (á)- was found whereas in S. fluitans 2,2'-Ethyldenebis(4,6-di-tert-butylphenol) and 2-Pentadecanone, 6,10,14-trimethyl- was present. We discuss on the applicability of usefulness of this method to aid on taxonomic identification of Sargassum species.

OR-26-01

Effects of the humidity and glass transition on the shrinkage of sugar kelp during drying

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Sugar kelp (Saccharina latissima) is a large brown marine macro-algae species cultivated in the state of Maine, USA for several years. Harvested sugar kelp is dehydrated by the sun or convective drying to produce a

shelf-stable product. We investigated the relationship between the glass transition and shrinkage of sugar kelp during convective drying. Initial moisture content of the freshly harvested sugar kelp was 92.2% (wet basis, wb). The moisture content was reduced to 5.5% wb after freeze drying. Moisture sorption isotherm was obtained by isopiestic method in which freeze dried samples are equilibrated against standard salt solutions. MSI data was fitted non-linearly to monolayer moisture content based BET and GAB models. The model constants in BET model were Mb = 0.161 kg H2O/kg dry sugar kelp solids, B = 2.27 and R2 = 0.986; whereas in GAB model the constants were Mg = 0.23 kg H2O/kg dry sugar kelp solids, C = 1.11 and K = 0.977 and R2 = 0.996. Based on MSI data, in the lower range of water activity (0.5) it absorbs moisture nearly twice the dry mass. Fick's diffusion model was applied to drying kinetics that helps to estimate the best drying parameters (temperature and humidity) for reducing drying time, energy efficiency and nutrient preservation. It parameters were estimated by drying fresh sugar kelp at different set of air temperature in the range of 40 – 70 oC with relative humidity of 25 – 80% at an air velocity of 2.0 m/s. It was observed that the drying time was reduced by nearly 2-2.5 hours when the humidity was reduced to 25% from 80% for the same temperature. Water diffusion in food creates void space and stress leading to shrinkage during drying, which will be measured using an image processing algorithm developed in MATLAB. Results of this study will help in understanding the storage shelf life and drying mechanism of sugar kelp.

OR-26-02
PROMAC - Energy-efficient processing of macroalgae in blue-green value chains
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PROMAC is a research project investigating seaweeds as novel raw materials for human food and domestic animal feed applications. Three different species of seaweed (Alaria esculenta, Saccharina latissima and Palmaria palmata), all with significant potential for commercial cultivation in Norway as well as distinct raw material qualities, are being evaluated as alternative sources of proteins and energy in animal feed, and for their health benefits as human food. The project (i) assesses variation of raw material composition and quality from both harvested and cultured seaweed biomass in relation to environmental and biological factors, (ii) develops primary processes (washing / dehydration, maturation) which will enhance desired raw material properties, (iii) establishes fractionation and extraction methods best suited to enrich beneficial proteins or remove undesirable anti-nutrients and (iv) evaluates nutritional and health values of processed macroalgal ingredients for various animal groups and in relation to their distinct digestive systems. PROMAC also addresses the high energy requirements associated with processing (especially drying, but also secondary processing) of macroalgae as an aquatic raw material. We use the case study of a waste incinerator located on the coast as a model for utilising excess energy from industrial plants in marine bio-based value chains. PROMAC will evaluate benefits and costs of macroalgal products along such value chains (from raw material to market and consumer) through product-based Life Cycle Assessments (LCA) and business model evaluations). The project started in 2015, and first results, integrated across work packages and subject fields, will be presented.

OR-26-03
Evaluation of minerals and vitamins in the Danish cultivated sugar kelp
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Seaweeds are known for their nutraceutical applications, but also the ability to accumulate e.g. very high iodine concentrations and toxic heavy metals. In this study, cultivated Saccharina latissima (sugar kelp) harvested year-round was analysed for minerals (incl. heavy metals) and vitamins (vit A and E) to evaluate the nutritional value, possible risks and harvest time for optimized value and application. Rope cultivated sugar kelp was sampled both in close proximity to a blue mussel and fish farm (IMTA) and in a reference/control site, both outside Horsens fjord in Denmark, and freeze dried and stored frozen for further analyses. Sugar kelp biomass was sampled (n=3) at 2 m depth in 2013-2014. Surprisingly high concentrations of K and Ca (up to more than 100 and 150 g/kg DW, respectively) were found, along with other trace metals: Cr, Fe, Mn, Co, Cu, Na, Zn, and Se. Undesirable elements such as Pb, Hg, and inorganic As were below legislative threshold values for edible seaweed in France and food supplements in EU, whereas Cd concentrations in some seasons were above the French limits. However, a 70 kg person would need an intake of 0.77-2.0 kg DW of sugar kelp to reach the provisional tolerable weekly intake limit set for Cd. The iodine was found in so high levels (up to 5 g/kg) that this will be the limiting element for intake

of sugar kelp. Moreover, the concentrations of total As found from September to March were above the EU regulatory levels for feed ingredients (40 mg/kg DW. Pb and Cd concentrations were below threshold values. The vitamin E (alpha-tocopherol) concentrations (6-25 mg/kg DW) were similar to what is found in broccoli. Generally the year-round variations were due season, and not between the two locations (reference and IMTA), so harvest time is important for optimized use, and may be conflicting with highest yields of sugar kelp. High concentrations of iodine and total As may be of concern regarding food and feed regulations, respectively.

OR-26-04
Seaweed as Food and Feed - a future potential for Greenland

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Seaweed in Greenland is a rapidly expanding business and part of the future economics and occupation. Greenland is big and along the coastline as well as in the fjords there are endless possibilities for harvesting and collecing all different kinds of seaweed. Seaweed has been harvested, collected and used by the indigenous people for many years, but only in recent years this has been done commercially. Within the extensive intertidal zone all kinds of seaweed is to be found and it is mostly here that seaweed is harvested sustainably using the right tools. Harvesting seaweed commercially is carried out in Qaqortoq in South-Greenland and in Nuuk, Sisimiut and Ikerasaarsuk on the West-Coast of Greenland. During the month of September 2015 a Seaweed Event was being held in Nuuk and this was financed by the Nordic Ministeries. The event was arranged by The Department of Fisheries, Hunting and Agriculture and turned out successfully with participants from Denmark, Faroe Islands and Greenland. The future of Seaweed in and from Greenland looks bright and the market as well as the demand for seaweed from this pristine part of the world will most likely increase in the future.

OR-26-05
Seaweeds as a protein source for mono-gastric livestock

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Seaweeds are often cited as alternative feed ingredients for livestock due to a perception of being highly nutritious with the added attraction of being globally distributed and an ability to complement rather than compete with terrestrial crop production. We critically appraised the nutritional benefits of seaweeds as a protein source in livestock feeds by assembling a database of amino acid data for 121 seaweed species. This database enabled us to compare the quality and quantity of protein in seaweeds to traditional protein sources (soybean meal and fishmeal) and the amino acid requirements of mono-gastric livestock (chicken, swine and fish). The quality of protein (% of essential amino acids in total amino acids) of many seaweeds is similar to, if not better than, traditional protein sources, with red and green seaweeds having a higher quality of protein compared to brown. Protein quantity (on a whole biomass basis, % dw) is also higher for red and green seaweeds compared to brown and higher in cultivated seaweeds compared to wild harvested. However, these categories are unnecessary at higher levels of nutritional assessment as seaweeds, without exception, have substantially lower quantities of total essential amino acids, methionine and lysine (on a whole biomass basis, % dw), than traditional protein sources. Correspondingly, seaweeds contain an insufficient quantity of protein to meet the essential amino acid requirements of mono-gastric livestock in the whole form. The use of seaweeds as alternative sources of protein for mono-gastric livestock will rely on the concentration or extraction of protein.

OR-26-06
Cultivated S. latissima and A. esculenta as feed protein source

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et al.

The kelp species Saccharina latissima and Alaria esculenta are attractive for cultivation in Northern coastal areas due to high growth rates and large biomass production in cold water. In this study the content of protein and amino acids were analysed to evaluate the adequacy for using the biomass as a source for feed protein. The effect of cultivation depth and the effect of harvesting time was studied, the latter also compared with wild samples. Wild Palmaria palmata from four locations (Bretagne, Iceland, Mid-

and North-Norway) was also included in this comparative study as this species is recognized as protein rich. Significant differences between cultivated and wild samples (A. esculenta) and between species (A. esculenta > S. latissima > P. palmata) were revealed. The study shows that cultivated kelp is a realistic source for amino acids and cultivation and processing technology need to be optimised to enable exploitation of seaweed protein in the expanding aquaculture industry.

OR-27-01

The circular economy of seaweed as nutrient management instrument for biobased production

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A comparative analysis of the environmental and economic performance of seaweed production and biorefinery systems were modelled within the project MAB3 (www.mab3.dk). A framework for integrated sustainability modelling of the circular economy of offshore seaweed production and biorefinery systems using excess aquatic nutrients and atmospheric CO2 emissions as a resource for biobased production is proposed. The seaweed production system was pilot tested at two Danish coastal areas achieving relatively low productivities of 1 to 2 ton dry weight seaweed per hectare. Biorefinery systems producing ethanol and proteins (EP) or biogas and fertilizers (BF) as main products were compared. Results show that seaweed cultivation and biorefinery systems contributes to mitigation of climate change as well as water quality restoration. Improvements in the productivity (cultivation technology) and product portfolio (processing and cascade utilization) are needed for a seaweed biorefinery industry to become economically viable.
The break-even point for the MAB3 EP biorefinery system is obtained by an increase in the seaweed productivity of a factor 2 to 4. Development of seaweed cultivation technology is ongoing and requires expanding the scale of production. Regarding the product portfolio, especially use of seaweed for pharmaceuticals and cosmetics will increase the profitability of the seaweed utilization compared to use for energy, feed and fertilizers.
There are not synergies between the economic and environmental performance of the modelled systems in all aspects. The revenue of the EP biorefinery system was higher than the revenue from BF system, while BF production delivered larger mitigation of climate change, i.e. GHG emission reductions. Mitigation of aquatic eutrophication was highest for the EP system. The welfare economic value of the services delivered by the seaweed cultivation and biorefinery systems ranges between 5 and 20% of the raw seaweed production costs.

OR-27-02

Kappaphycus farming a source of livelihood for the Fishers in Tamilnadu, Southeast coast of India

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Kappaphycus plays a major role on the application of its phycocolloid, kappa carrageenan in pharmaceutical and food industries, as is evident of its recent production of 183000 tons dry through cultivation. Major carrageenan seaweed producing countries include Indonesia (60.5%), Philippines (31.9%), Malaysia (3.7%), United Republic of Tanzania (2.3%), China (1.1%) and Indian contribution is only 4240 tons wet. The commercial cultivation of this seaweed in India has picked up around 2006 after the introduction of Self Help Groups (SHGs) by Aquaculture Foundation of India (AFI) although its cultivation has been introduced by Dr P.V.Subba Rao, CSMCRI-MARS (CSIR) and Scientists during the last quarter of 1995 near Pamban bridge (Thonithurai, Mandapam, Tamilnadu) in Gulf of Mannar waters of Bay of Bengal, Southeast coast of India. Subsequently Kappaphycus cultivation training has been conducted by CAS in Marine Biology, Annamalai University in five coastal districts (Ramanathapuram, Pudukkottai, Tanjore, Nagapattinam and Cuddalore) of Tamilnadu involving 400 fisher folk and 100 officials to expand seaweed cultivation to the other coastal districts of Tamilnadu and this has resulted in providing regular income of Rs 15200/- during loan period and Rs 17,200/- after loan settlement. This is in contrast to tens of hundreds of fisher folk (women) who depend on wild collection of seaweeds (species of Sargassum, Turbinaria, Gracilaria and Gelidiella) just to earn their daily bread getting around 3500/ - per person per month only for four months (November to February) in year and coupled with uneconomical fishing. Poor earning through seaweed collection and uneconomical fishing coupled with escalation of day to day essential commodities led nowadays tens of thousands of people exclusively to depend on Kappaphycus cultivation in Tamilnadu as an alternative employment that provides a sustainable regular income.

OR-27-03
Preliminary assessment of Kappaphycus alvarezii cultivation in Ecuador

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Kappaphycus alvarezii var. tambalang Doty (Doty) was introduced in Ecuador to evaluate its feasibility as alternative livelihood to coastal communities and a source of raw material for the carrageenan industry. A pilot program started in April 2015 using floating rafts in a shallow protected bay located in Salinas, Santa Elena peninsula. Preliminary results have shown mean daily growth rates between 4.5-8% during a period of nine (9) months with productivities of 50-65 MT/Ha/year. Water quality, salinity and temperature ranges have allowed the plants to grow vigorously with cultivation cycles of 45-60 days. An environmental impact assessment program along with a socioeconomically feasibility study have given the insights to determine the sustainability of K. alvarezii farming as potential source of self-employment and income to coastal communities who have traditionally relied on artisan fisheries for their livelihood. Water rights and permits are part of the government policies to support and promote seaweed mariculture as novel activity, creating a new value chain for the food industry in the region.

OR-27-04
Socio-economic status of seaweed farming in the Philippines

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Seaweed farming primarily in the cultivation of Kappaphycus and Eucheuma species in the Philippines has grown during the past three decades. Due to its low requirements of capital and materials, short-production cycles and simple farming techniques, seaweed farming has generated socio-economic benefits to the marginalized coastal communities in the country. However, various natural and anthropogenic barriers pose a challenge to the progress of the seaweed industry. These barriers include disease outbreaks, changing seasons, onset of typhoons, fluctuating market conditions, lack of value-added activities and implemented financial support from the local government units. This document attempts to discuss the socio-economic problems faced by the different seaweed production areas in the Philippines. Series of information and knowledge gaps will also be highlighted to pave the way for future development of the seaweed industry and facilitate evidence-based policy decision-making in the different government sectors.

OR-27-05
Seaweed Culture Techniques and Practices in Eastern Visayas and NorthWestern Mindanao

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Seaweed farms in the Eastern Visayas and Northwestern Mindanao, Philippines were surveyed in 2015. Focus group discussion and key informant interview were conducted in each surveyed farms. From the data gathered, seasonal calendar, historical profile, list of variety and diseases, market chain, farming methods, common problems and issues, upgrades, and assistance were generated. Results of the analyses were plotted in the map to generate a situationer profile to determine patterns and variations in practices and techniques used by the farmers. A total of 19 and 38 municipalities were surveyed in Eastern Visayas and Western Mindanao, respectively. Seaweed farming practices generally differ across geographical locations due to weather and physical conditions. Several varieties of seaweeds are farmed mostly represented by Kappaphycus alvarezii and Eucheuma denticulatum. The type of disease occurring in most seaweed farms is ice-ice followed by epiphytes, while the siganids or rabbitfish is the most common pest affecting seaweed farms. Farmers do not sell dry products directly to processor. Mostly sell to trader, to consolidator then, to processor. Regarding price, both fresh and dry, Eucheuma is cheaper than Kappaphycus. Between regions, Northwestern Mindanao sell lower price of dry seaweeds compared to Eastern Visayas. Single floating monoline is the most common method of farming used in both regions. However, there are some farming methods and materials used for farming that differ. Northwestern Mindanao tends to be more innovative in their design and culture practice resulting to at least 25 different culture methods. Several problems associated with seaweed farming were listed in both regions, including interventions. In most seaweed farms, the Bureau of Fisheries and Aquatic Resources is the most common agency who assisted through provision of seedlings and materials for farming.

OR-27-06
Phycomorph, a European COST network on macroalgal growth and development
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Phycomorph is a European COST Action (FA1406; 2015-2019). Its objectives are to increase the basic knowledge in macroalgal growth and development, and to promote transfer to the aquaculture sectors. It is an ope network, currently includes 17 European countries and 5 international partners, from both the academic and applied phycological fields. Meetings, workshop, staff exchange and training schools allow to coordinate and develop further research in this field. http://www.phycomorph.org/ . Countries with interest in seaweed cultivation are welcome to join Phycomorph.

OR-28-01
Semi-exposed large-scale seaweed cultivation pilot: results and lessons learnt
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Seaweed Energy Solutions AS (SES) started activities in 2009 with a long term vision to cultivate seaweed for the production of bioenergy. As this requires very low unit costs and vast quantities to be economically feasible, cultivation at smaller scale for higher-value products must bridge the gap. The growing demand for seaweed as resource for food, feed, cosmetics, pharmaceutics and chemical industry has been recognised as an opportunity to gradually scale up seaweed cultivation with realistic near term economic viability. SES has therefore shifted focus to benchmark the near-future commercial prospects and successfully installed, maintained and harvested a pilot cultivation of Saccharina latissima, offshore Frøya, Sør-Trøndelag, Norway. The harvest target was 100 tons wet, distributed over 16 long lines with carrier structures especially adapted to the relatively rough sea conditions. The planning, seeding, deployment, maintenance and harvest of the pilot were conducted with a rather limited budget and short time span, and as such, provided SES with valuable learning experience and benchmarks for all involved processes on the value chain from spores to wet product. Among the lessons learnt was that productivity targets have been exceeded, and the cultivation chain demonstration from spore production to wet product can be considered as well achieved. This contribution gives an insight into this experience, and an evaluation of the results concerning productivity, technology status and up-scaling process. In addition, we will present some important lessons that have been learnt in terms of the downstream process of seaweed farming. Once the wet product is harvested, a number of constraints and important timing and logistics issues appear, which were out of scope of the original pilot project.

OR-28-02
Yield optimization strategy of Macrocystis pyrifera aquafarming in Chile.
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Global utilization of products obtained from macroalgae is a multi-billion dollar industry. Current uses include human and animal foods, cosmetics and phycocolloids among others. Worldwide, several species are known to be exploited, however the majority of algal biomass comes from few species: Saccharina, Undaria, Kappaphycus, Eucheuma, Porphyra/Pyropia and Gracilaria. Macroalgae has been harvested for centuries, and the world production of farmed seaweeds more than doubled from 2000 to 2012, because of the increasing demand. Chile is one of the main producers of seaweeds in the world, however most of the production comes from harvesting natural seabeds (97.6%) and only 2.4% from cultures. One of the most exploited resources is the giant kelp Macrocystis pyrifera, which is sell fresh for abalone feed and dry for alginate extraction. Recently, new possible markets are under development for this species, like human consumption and biofuel/chemicals production that could increase the demand and justify the development of a commercial cultivation system. The objective of this work is to present the recent development of the aquafarming of M. pyrifera in Chile, focusing on the fundamental determinants of productivity in cultivated systems and identify the binding constraints to productivity. Three experimental plots (up to 21 Ha) were designed and deployed in three study areas (Caldera in northern Chile; Quenac and Ancud in southern Chile) to test different environmental conditions. During a period of 1 year, plants produced in an indoor hatchery were deployed monthly, at different densities, and followed until harvested. Environmental parameters and biomass was monitored on a monthly basis. Our findings demonstrate the feasibility of the Macrocystis aquafarming in Chilean coasts. Important difference in yield were observed between the study areas, our best production cycle reached 38.8 DMT/Ha in one southern site and 4.24 DMT/Ha in the northern site.

OR-28-03
Variation in growth and quality of Saccharina latissima cultivated in the Faroe Islands

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Macroalgal cultivation is a developing industry in the western part of the world, and in the Faroe Islands experimental cultivation including Alaria esculenta, Laminaria hyperborea and Saccharina latissima, has been carried out since 2005. The cultivation experiments with A. esculenta and S. latissima have shown promising results with regard to growth and yield, but the quality and composition of the cultivated biomass has not been investigated. Protein level and amino acid composition are essential factors when estimating the quality of the produced biomass for food and/or feed, but how does e.g. seasonality, exposure and nutrient levels affect these factors. Current work investigated growth and yield in cultivated S. latissima in a sound in the Faroe Islands, and studied the variation in total Kjeldal nitrogen, nitrate and protein content and changes in amino acid composition with regard to season (spring and summer), and exposure (current exposed, wave exposed and sheltered). To enable comparison we also investigated the variation in total Kjeldal nitrogen, nitrate and protein content and changes in amino acid compositon in wild S. latissima populations. In the cultivated biomass there was a significantly lower yield at the current exposed site (5.2 ± 0.4 kg m-1) compared to the sheltered (9.9 ± 1.3 kg m-1) and the wave exposed (8.0 ± 1.5 kg m-1). The growth rate (SGR) did not differ with regard to exposure, however the weight of the individuals at the current exposed site was significantly higher compared to the individuals at the sheltered and wave exposed sites through out the cultivation period. In both the cultivated biomass and the natural populations a significant seasonal differences was observed in the total Kjeldal nitrogen, nitrate and protein levels and amino acid composition. A significant difference related to exposure degree was observed in total Kjeldal nitrogen and nitrogen, but this was not observed for protein and amino acid composition.

OR-28-04
Regrowth and biofouling in two species of cultivated kelp

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The meristem of the kelps Laminaria digitata and Saccharina latissima is located at the base of the blade, therefore growth can continue when the distal blade is damaged or removed. For this reason, cropping the blade above the meristem when harvesting natural kelp stands is thought to facilitate regrowth and minimise habitat disturbance. The aim of the study was to determine the regrowth potential of cultivated kelp in the Shetland Islands (UK) within one growing season. L. digitata and S. latissima grown on long lines at sea were harvested 10 cm above the stipe-blade transition zone in May – June and sampled monthly until the end of August. Each sample was photographed and the image analysed to estimate growth rates and levels of biofouling. The rate of growth remained stable for both species whether cropped or whole, S. latissima exhibited greater growth in length than L. digitata between May and August. In late summer, severe biofouling by ascidians made up 32% and 15% of the wet biomass at two sites, however, S. latissima appeared less severely affected than L. digitata. Consequently, S. latissima shows the greatest potential for the application of cropping to improve cultivated yields. However, the period for regrowth is limited by low yields in early spring and blade degradation in late summer. The results of this study also lend support to the use of cropping as a more sustainable harvesting method facilitating regrowth in natural kelp stands.

OR-28-05
Cultivation period elongation of Saccharina japonica for abalone feed industry in Korea

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The brown seaweed, Saccharina japonica is highly valued in Korea for food and for abalone feed. Dasima (S. japonica) cultivation was largely developed, promoted, and industrialized in Korea in the 1970's and production continues to increase with approximately 372,311 tones wet weight harvested in 2014. Recently, an abalone industry has been successfully developed in Korea, making use of the stable production of seaweed. The abalone is a highly sought-after delicacy in Korea. Korean famers prefer to feed their stock on the locally cultured S. japonica. Therefore, seaweed for abalone feed is required during the

whole year. However, between August and November production of farmed seaweed species is limited by environmental conditions. To elongate cultivation period of S. japonica, we set up a trail whereby the initiation of S. japonica cultures was delayed for differing periods of time between December 2013 and March 2015. Delaying the initiation of cultivation resulted in delayed maximum growth compared to control cultures. Strain selection was then undertaken using late maturing thalli to produce a F2 generation. In F2 generation the cultivation period of S. japonica was found to be increased by up to 3 months. Furthermore the mean length and biomass of the F2 generation were larger than for the parents stock. Our trials therefore indicate that the use of the F2 generation selected for a longer growing period, can contribute to ensuring a stable year round algal feed supply for abalone industry in Korea.

OR-28-06

The inner Danish waters as suitable seaweed cultivation area- evaluation of abiotic factors

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Increased production of macroalgae may contribute to solving e.g. the demand for food globally. Palmaria palmata and Saccharina latissima are at present demanded and cultivated in European waters, and can potentially be cultivated at even larger scale. The present study investigated suitable cultivation areas in Danish waters for these two algal species in regard to a variation in the abiotic conditions: light, temperature, and the unusual salinity gradient through the inner Danish waters towards the Baltic Sea. Published tolerance levels of the abiotic conditions of the species were reviewed and compared to surveillance data on presence of the species and to empiric abiotic data at five sites in Denmark. Furthermore, in situ experiments were conducted at the locations by deployed vertical ropes with inserted adults of P. palmata and S. latissima at 1-6 m depth. The analysis of the abiotic conditions showed, that light conditions are sufficient to meet the light saturation level of both algae, but large seasonal and a site specific variations in light attenuation determine optimal cultivation depth. Water temperatures were found to exceed the tolerance level for P. palmata in July, August, and September and for S. latissima in August at some sites. A large geographical variation in salinity was seen between sites, with salinities below the tolerance level of P. palmata at most sites. The results the in situ experiments showed increased biomass over a seven months cultivation period for both species at salinities down to 21±3 PSU, and at the low salinity site (17±5 PSU) P. palmata turned green while continuing growing. This most likely due to stress such as low salinity and light. Cultivation of P. palmata near Fredericia provided the highest specific growth rate of 0.038 d-1 which was significant from the other sites. These findings were further discussed and the inner Danish waters evaluated as suitable location for cultivation of the assessed species.

OR-29-01

Evidence of a natural F1 Macrocystis x Lessonia (Phaeophyceae, Laminariales) hybrid from Chile

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Macrocystis pyrifera and Lessonia nigrescens are economically and ecologically important large brown seaweeds. Here we describe for the first time the presence of a Macrocystis pyrifera x Lessonia nigrescens hybrid in Chiloe Island (Chile, Southeastern Pacific), where populations of the two parents coexist. Externally, the F1 hybrid exhibited typical features of its parents M. pyrifera (cylindrical and flexible distal stipes, serrate frond margins and presence of sporophylls) and L. nigrescens (rigid and flat main stipe and first bifurcation), as well as intermediate features between them (thick unfused haptera in the holdfast). Histological sections revealed the prevalence of mucilage ducts within stipes and fronds (absent in Lessonia) and fully developed unilocular sporangia in the sporophylls. Molecular analyses confirmed the presence of the two parental genotypes for ITS1 nrDNA and the M. pyrifera genotype for two maternally inherited cytoplasmic markers (COI and rbcL). Meiospores from fertile sori developed into competent gametophytes, which at fertility gave rise to F2 sporophytes that reached several millimeters in length in 27 weeks. This was the first sighting of an interfamilial Macrocystis-Lessonia hybrid in 25 years visiting the study area. It remains open how often such individuals occur in nature.

OR-29-02

The genome sequence of the brown alga, Cladosiphon okamuranus: Novel evolutionary insights

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The brown algae (Phaeophyta) are relatively large phycobionts, and are important components of coastal ecosystems. Some species are edible while others serve as industrial, biomass and medical materials. Despite the ecological and economical importance of brown algae, genetic information about them is limited. Here, we focused on the brown alga, Cladosiphon okamuranus (Chordariaceae), one of the most important seaweeds in Japan. This alga, called “Okinawa mozuku” in Japanese, is an edible seaweed, and is cultivated in Okinawa. Since establishment of the cultivation technology in the 1970s, several strains of this species have been discovered in Okinawa Prefecture. They have different viscosities, growth rates, and flavors. C. okamuranus is rich in fucoidan, a sulfated polysaccharide and a key constituent of brown algae. For that reason, C. okamuranus is a good species for investigating biological mechanisms of brown algae. We sequenced DNAs and RNAs that were extracted from three different strains of C. okamuranus. In addition, the genome and transcriptome of Nemacystus decipiens (Spermatochanaceae) was also sequenced in order to use this species as an outgroup. The estimated genome size of C. okamuranus was 154 Mb, and the assembled DNA sequences were 183 Mb, in which scaffold N50 and GC content were 328 kb and 54%, respectively. Some strain-specific transcripts were found by RNA-seq data analysis. Furthermore, we found 7.3 Mb of bacteria-like sequences in the genome assembly. Our results suggest that some bacteria are essential for the growth of C. okamuranus. These findings may benefit the cultivation of this algal holobiont and should offer insights into phaeophyte evolution.

OR-29-03

Genome assembly and metagenomic analysis of the green alga, Caulerpa lentillifera

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Green algae exhibit diverse structural arrangements and modes of alternation of generations. Chlamydomonas and Chlorella are typical systems for photosynthesis research. However, green algae can also be used as models of more complex phenomena, e.g., the study of interactions between microbes and eukaryotic hosts. Caulerpa lentillifera, an important aquacultural species in Okinawa, is a coenocytic marine green alga. It has spherical structures at the tips of its branches; hence, its common name: “sea grapes.” Some marine green algae require compounds synthesized by bacteria. In this project, we are attempting to identify metabolic pathways involved in the exchange of substances between Caulerpa and associated bacteria. Here, we report progress on the genome assembly of C. lentillifera and its metagenomic analysis. The genome size was estimated at ~30 Mb by k-mer frequency analysis. 16S rRNA binning analysis of highly diverged coverage data revealed the presence of at least 80 operational taxonomic units of 16S rRNA fragments on the surface and/or in C. lentillifera tissues. Transcriptomic data and binning of organellar sequences also revealed the complexity of this green algal holobiont. Our results demonstrate the feasibility of using C. lentillifera as model system for the study of eukaryote–microbe symbiosis.

OR-29-04

Distribution and Morphology of Gracilaria spp. in Selected Coastal Areas in the Philippines

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Gracilaria is considered the next economically important seaweed in the Philippines because of its similar uses as Kappaphycus and its potential in the international market. Gracilaria is a good source of “agar” which is the highest priced phycocolloid in the world (Bixler and Porse 2011). However, the taxonomists are having problems with the identification of species because of high variability in the morphology of Gracilaria and its rampant phenotypic plasticity. The identification of species through its morphology is not sufficient to address this concern. Robba et al (2006) believed that the diversity in this genus can be clarified through DNA Barcoding using cytochrome oxidase subunit I (COI) as marker. Hence, this project was conceptualized to generate information on the distribution and diversity of Gracilaria spp. based on morphological examination and molecular analysis using DNA barcoding. Collected healthy and complete

thalli of fresh samples and voucher specimens Gracilaria spp were A total of 86 COI sequences were obtained from 38 coastal areas, including mangrove areas and ponds, from Luzon and the Visayas regions. The COI sequences belong to 13 species of genera Hydropuntia, Gracilariopsis, and Gracilaria. Most of the COI sequences obtained in this study have corresponding sequences in GenBank, and comparison via computation of their evolutionary distances resulted in values lower than the identified 2% K2P threshold which verified that the sequences belong to the same species. The presumptive IDs assigned to our collection, which was mainly based on morphological characters, were verified via DNA barcoding. This study verified three species under the genus Gracilaria, namely, G. arcuata, G. blodgettii, and, G. salicornia.

OR-29-05

Species Diversity And Phylogeny Of Crustose Coralline Algae From Algal Reefs In Northern Taiwan

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Crustose coralline algae (CCA) are red algae including many reef-building species and marine producers that play a critical role in the marine ecosystem. CCA are characterized by thallus composed of thin cellular layers firmly attached on rocks, having calcareous deposits within the cell walls as well as all reproductive structures confined in conceptacles or pits. They are commonly found in the algal reefs in northern Taiwan but their species diversity is largely unknown. Due to their simple thallus structure, many CCA species sharing similar morphology are difficult to be separated one another based on the morphological anatomy alone. In this study, more than 300 samples of CCA from the algal reefs in northern Taiwan were collected and their phylogenetic relationships were inferred based on psbA and SSU sequence analyses. The CCA collections were clustered into seven large clades (= genera) and fifteen subclades (= species) including four "Hydrolithon", four Lithophyllum, three Phymatolithon, and a single species of Mesophyllum, Pneophyllum, Spongites, and Sporolithon. The significance of morphological characters will be tested based on molecular analyses and their biogeographic patterns in the western Pacific Ocean will be discussed in order to understand their evolutionary histories.

OR-30-01

Development of an alternative food for juvenile culture of green abalone from brown algae

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The use of seaweed has food for abalone cultivation has some disadvantages, such as: variation in the availability of seaweeds, lower nutritional value and high harvesting cost. Currently is seek to improve nutrition in culture through the development of balanced meals. The objective of this research was to development a production process of balanced feed for abalone juveniles from two species of brown algae Macrocystis pyrifera and Eisenia arborea. Three food formulations were calculated using the program Zootec 3. The process to obtaining the nutritional bars, was developed using an orthogonal design including the following parameters: minimum water volume for rehydration of algae, temperature and extraction time. Response parameters were viscosity and toughness of the resulting paste. The best combination was: rehydration with 200 mL of water, extraction at 75 °C at pH 10, for 1 hour, to give a paste with viscosity higher than 500,000 mPa.s and a texture of 24 g cm-2. To prepare the nutritional bars a concentration of 0.5% polymethyl carbamide was used as binder. Stability tests, toughness, attractability, palatability and consumption were experimented in a commercial culture abalone facility. The nutritional bars in culture presented an average toughness of 619 g cm-2 and an average stability of 82.2%, also, all formulations were palatable. Regarding the attractability and consumption it was determined that the food bars produced with Eisenia arborea (ABEA) presented higher attractability and consumption among all formulated bars with 15.3% attraction and 52.1% consumption after 24 hours, surpassing the conventional food, which is fresh E. arborea and was similar to the commercial feed Brand ABKELP. We concluded that the ABEA food is highly recommended to use it as feed for abalone.

OR-30-02

Synbiotic effects of Tasco, an Ascophyllum nodosum product used for animal feed applications.

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Seaweeds contain a unique suite of complex polysaccharides and bioactive constituents that have been shown to promote Gastro-Intestinal (GI) health in a wide variety of animal models. Tasco®, an animal feed

supplement produced from the macroalga, Ascophyllum nodosum, has been used in animal agriculture to increase stress resistance, improve immune competence and increase health, welfare and productivity of animals. Early work has shown that the prebiotic effect of Tasco® is about five times the potency of the standard prebiotic, inulin (FOS) in promoting GI tract health. It is thought that important to the prebiotic effect is the natural mixture of complex polysaccharides contained within Tasco® (fucoidans, laminarin, alginate, mannitol, etc.) coupled with the antimicrobial effects of phlorotannins acting in a differential manner on beneficial versus endogenous pathogenic microorganisms. Results of research using a variety of animal models from our laboratory, including Caenorhabditis elegans, will be reviewed to show how the prebiotic action of Tasco® works in synergy with the actions of probiotic bacteria to overcome the negative effects of a bacterial pathogen such as Pseudomonas aeruginosa (PA-14). Trials show that Tasco® induces in the probiotic bacteria (Lactobacillus acidophilus) production of a heat stable molecule that reduces growth of the pathogen, PA-14. Results will be shown on how Tasco® can be used in poultry rations as an alternative to sub-therapeutic antibiotic use to achieve the same growth promotion effect, but without commercial antibiotic use. Keywords: GI tract health, prebiotic, probiotic, pathogen, polysaccharides, phlorotannin.

OR-30-03

Brown seaweeds dietary supplementation for white-leg shrimp

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The white-leg shrimp Litopenaeus vannamei were fed with diets contained 0.5%, 2% and 4% of brown seaweeds Undaria pinnatifida or Sargassum filipendula (dry mass). The resistance to high temperature stress as well as the immunological parameters and midgut microbiology were evaluated. Shrimp cultivation was made in clear water system for two weeks in seven 800 L tanks with constant aeration (O>5mg/L), temperature of 29°C ± 1°C and 80% of daily water exchange. Each tank had 100 shrimps (mean weight of 7g), and they were fed four times per day according to the treatment. The amount of feed was calculated based on 6% initial biomass of shrimp in each tank and adjusted daily according to the consumption. After the experimental period, the phenoloxidase activity in animals fed with 4% U. pinnatifida showed significant increasing in relation to control. No significant differences were observed in agglutinating activity and total hemocyte counts in the serum of shrimps fed with seaweeds supplementation and control. Animals fed with 0.5% and 4% U. pinnatifida had lower concentration of Vibrio spp. in midgut. After thermal shock, shrimps fed with 0.5% and 2% S. filipendula showed a survival rate of 96.67%, higher than control (43.33%) and those fed with 4% of S. filipendula (26.67%). In this last case, probably the low survival rate is related to the low consumption of the feed. Shrimps of all treatments with U. pinnatifida showed lower survival rate in relation to control. Based on these results, we concluded that supplementations with 0.5 and 2% of S. filipendula improve the resistance to high temperature stress and supplementation 0.5% and 4% of U. pinnatifida decrease the concentration of Vibrio in shrimp midgut.

OR-30-04

The use of stable isotopes to track the incorporation of Ulva from aquafeed into sea urchin gonads

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This study used stable carbon and nitrogen isotope analysis to investigate the incorporation of specific dietary ingredients from 4 artificially formulated feeds containing varying amounts (0%, 5%, 15% & 20%) of the seaweed Ulva, into commercially valuable gonads of T. gratilla, over a 20 week period. By analysing the isotopic signals of sampled gonads and individual dietary ingredients with IsoSource, a mixing and mass balance model, it was possible to estimate the relative contribution of each dietary ingredient to gonad production. Ulva was shown to be an important isotopic source for gonad production, accounting for an average of 33% of the isotopic signal across all Ulva-containing diets at the end of the trial. This is significantly more than fish meal and maize, which only contributed an average of 11 and 9%, respectively, of the isotopic signal of the gonads. These findings support previous data on the importance of Ulva in urchin diets and demonstrate the value of stable isotope analysis for assessing the contribution of specific dietary ingredients in new feed formulations, particularly where growth of specific tissues are being investigated. The data also indicate the importance of macroalgae in gonad production, as a diet without Ulva was shown to rely heavily on dietary carbon and nitrogen obtained from kelp (Ecklonia maxima), even though kelp was only fed prior to experimentation. Stable isotope analysis can be extremely useful in assessing the effectiveness of particular dietary ingredients, particularly in cases where growth of specific

organs is being investigated. In general, feeding trials cannot assess the incorporation of specific dietary ingredients, but through the use of stable isotope analysis and mixing and mass balance models such as IsoSource, it is possible to estimate their relative contributions to production, which can help to improve diet formulations.

OR-30-05

Macroalgae in the swine industry; do we have the answer to antibiotic replacement?

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The Swine Industry is still the biggest food producing industry in the world with a modest growth of a 2-3% a year producing well over 100 million tonnes of pork of which half takes place in China. However, the disease issues and environmental pressure has led to an overuse and abuse of growth promotors and antibiotics. This has had detrimental effects for human health as more and more bacteria have become resistant to commonly used antibiotics. Recently the WHO have issued a warning on overuse of antibiotics in animal feed and that a drastic reduction or phasing out of antibiotics in animal feed and in particularly swine feed should take place with immediate effect. Therefore it has become urgent to find alternative sustainable feed ingredients for animal feed to address the antibiotic issues. Macroalgae have been used for many years in animal feed based on their anecdotal health properties. However biochemical composition of these algae has received limited attention; nevertheless several studies have demonstrated that algae can be used to boost immune health and act as growth promotor and antibiotic replacers. Over the last decade scientific evidence has surfaced on the effects of many bioactive compounds in macroalgae and their use for a variety of health applications. Ocean Harvest Technology has developed a specific swine feed ingredient from macroalgae for the swine industry, to replace antibiotics and growth promotors. This presentation will evaluate the use of macroalgae in the swine industry and discuss the company's results of recent trials in the Philippines, Vietnam, China and USA and the future consequences this may have for the Swine Industry.

OR-31-01

Utilization and exploitation of red seaweeds in Chile: Opportunities and challenges

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Red seaweeds that produce carrageenan and agar are usually exploited in central and southern Chile and exported as commodities to worldwide markets. Increased market demand for algal raw materials and for direct consumption has stimulated research and development of new cultivation techniques. Sarcothalia crispata, Gigartina skottsbergii, Chondracanthus chamissoi, Mazzaella laminariodes, Mastocarpus papillatus, species of Gelidium and edible species are commonly harvest from wild beds while Gracilaria chilensis has been cultivated for almost 30 years. Efforts have been made to increase production of biomass through farming but little success has been obtained since there is open access to wild beds. In this review we address technical, social, and economical perspective on the status of the management and cultivation of the most valuable red seaweeds in Chile. Problems, opportunities and challenges under new regulation policies are discussed in this paper. Financial support: Project Fondef IT 14I10126

OR-31-02

Development of a joint MSC-ASC standard for seaweed eco-labelling

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With global seaweed production increasing alongside demand for certification, the MSC and ASC are collaborating to create a joint standard for certifying seaweed operations. The Standard will apply globally to all scales, including both wild harvest and aquaculture production systems. The draft of the Standard comprises five core principles: Principle 1, Harvesting & farming of seaweeds are conducted in a manner that does not lead to depletion of the exploited wild populations and, for those populations that are depleted, harvesting operations should lead to their recovery; 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 performance of the harvesting system or farm is scored against thirty-three Performance Indicators, each of which has one or more Scoring Issues (seventy in total).The ASC and MSC standards enable producers to verify the good status and responsible management of their resources by using a credible, independent third-party assessment process. Certified harvesters and farms can be recognised and rewarded in the marketplace, with an assurance to consumers that their products come from a well-managed and sustainable sources. Public consultations on the draft standard take place over 2016 prior to an expected full release in mid-2017.

OR-31-03

Tools for managing seaweed farming

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Seaweed farming is a major economic activity for Indonesia. More than 10 million of seaweed have been produced in 2014. With 54 716 km of coastline, Indonesia can further increase this production. The goal is to do it in a sustainable way and integrated in a global coastal management plan. In the frame of the INDESO (Infrastructure Development Of Space Oceanography), tools for managing seaweed farming have been developed. The combination of satellite images, numerical modelling and GIS processing permitted to develop methodologies to: (1) Define new suitable areas for seaweed farming (2) Predict the algal production. Accuracy of the results highly depends on the quality and the frequency of in situ data. This work is also useful to make recommendations concerning data acquisition of physicochemical parameters in the coastal environment and ecophysiological parameters related to the cultivated seaweeds.

OR-31-04

Challenges Of The Ecosystem Approach In The Harvest Of Ascophyllum nodosum In Eastern Canada

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Ascophyllum nodosum (Rockweed) has been traditionally harvested since the mid-forties in eastern Canada, providing jobs for hundreds of local residents in coastal communities. The management of this resource has varied considerably during the last 50 years. Previous to 1994, and under The Fisheries Act, the marine plant management was either “laissez faire” or based only on single species resource sustainability. Competition for the resource among companies and lack of clear regulations created irregular landings and overharvesting situations in some areas. The collapse of the groundfish fisheries in Atlantic Canada in the early 90’s created a strong public concern regarding management policies and a precautionary approach was established for the harvest of these resources under the Ocean Act in 1994. A. nodosum plays an important role as a habitat for invertebrates and vertebrates thus, strict regulations such as low exploitation rates, changes in harvesting gear and protected areas, have been actively imposed since the establishment of the new Act. The consequences of this new approach on both the resource and the industry are analysed here.

OR-31-05

Design and prototype of Kappaphycus alvarezii mechanical harvester

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A mechanical harvester for K. alvarezii cultivated in Brazil is described. It was based on the same principle of mussels harvesting machines used in continuous system production farms in New Zealand, Australia, the USA and the UK. The mechanical design was done in four stages: specification, conception, basic design and detailed design. The first stage dealt with the establishment of necessary technical specifications for design and evaluation of the next stages. Physical solutions were proposed at the second conception step to fulfill the design specifications. At the basic design, prototype dimensions and shapes were defined as well as materials and manufacture process. Necessary prototype parts and assemblies drawings for the prototype production were produced at the final detailed design stage. Extractors were adapted in design revision to Perna perna mussels and K. alvarezii (cultivated in tubular nets) farmed in Brazil to

provide lighter and compact structure and manufacturing costs reduction without compromising their robustness. Comparing design specifications and the final built mechanical harvester prototype, only mass and manufacturing costs target values were extrapolated (30.5% and 26.1%, respectively). Field trials will be performed for the prototype performance evaluation to assess the effects of mechanization in K. alvarezii harvesting productivity.

OR-32-01
Year-round storage of cultivated seaweed biomass through ensilage

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Cultivated european phaeophyte macroalgae, display a seasonally variable composition and biomass. For the conversion of this biomass to bioenergy and/or the extraction of specific chemical components, a seasonal harvesting optima will exist. This creates a seasonal glut of biomass and so preservation/storage is essential to allow year-round processing. Drying or chemical preservation can be very expensive and so ensilage is being investigated as a cheap and simple method of storage as wet biomass. Saccharina latissima was harvested from an experimental seaweed farm in june 2015. This were packed tightly into 60l food-safe barrels and destructively sampled every 3 months over 12 month. The effects of: chopping seaweed, adding an inoculum of previously ensiled seaweed and the influence of immediate vs. 2 hour delayed barrel packing were investigated. A seasonal experiment was also carried out, to examine the difference in ensilage quality from cultivated harvested in june, august, october or january. In all cases, the ph and temperature of the silage was recorded as well as a suite of compositional analysis including: water/organic/ash content, c:n and protein content, as well as changes in carbohydrates (alginate, mannitol, cellulose and laminarin) and ensilage products, including lactic acid, ethanol, propanol, acetic acid, propanoic acid and butyric acid. These experiments will be used to determine whether year-round ensilage of seaweed is a feasible storage option for this type of biomass, depending on the final use. It will also provide recommended conditions for the ensilage of cultivated s. latissima. In 2015-2016, a 100x100m grid will be used to grow an estimated 20-25 tonnes of seaweed for further large scale trials.

OR-32-02
Processing of brown macroalgae to fish feed

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For the production of protein-rich feed, Norway imports large amounts of soya bean meal from South America. This import is not sustainable and Norway has established a research center called “Foods of Norway” which will develop novel processing technology to produce feed from Norwegian biomass resources such as seaweed. Saccharina latissima is a brown seaweed found in Norwegian waters that is rich in carbohydrates, and could act as a source for fermentable sugars. Additionally, seaweed contains phosphorus, nitrogen and minerals that could be used as important components of microbial growth media. In this work S. latissima was enzymatically hydrolyzed and used as a fermentation medium, alone or in combination with a lignocellulosic hydrolysate. Different fermentation media were designed and used to aerobically produce yeast cells that were applied as a protein source in fish feed. The seaweed processing was carried out as a separate hydrolysis and fermentation (SHF) process, or as a simultaneous saccharification and fermentation (SSF) process. Saccharification of seaweed was optimized using a blend of a cellulase cocktail and an alginate lyase. Lignocellulosic hydrolysates were prepared by enzymatic saccharification of steam exploded birch. Different yeast strains were screened for growth in blends of seaweed and birch hydrolysates. Furthermore, selected yeasts and optimized processes were scaled up for production of larger amounts of single cell protein. The produced yeast cells were characterized and used an ingredient in fish feed.

OR-32-03
Fermentation studies for wise utilization of seaweeds

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Fermentation has over 10000-years history. However, few studies are conducted on this topic for obtaining food and related products from seaweeds. This paper introduces following three topics on seaweed fermentation study.
1) Seaweed sauce: Origin of fermented sauce is high-salt content gravy products, which was described for the first time over 3000-years ago in Chine. Fermented sauce products are usually produced from soy and fish, but that from seaweed have not been developed. This study report seaweed sauce prepared from

nori, Pyropia yezoensis using enzymatic degradation and fermentation processes.
2) Seaweed bio-ethanol: 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 low concentration (usually, ca. 1% v/v) of ethanol can be produced. The author produced 16.5% v/v concentration of ethanol from seagrass seeds. The ethanol products are more expected to be utilized as alcohol beverages rather than biofuel.
3) Marine silage: The fermented products obtained from seaweed are also expected to be utilized as a diet for terrestrial and aquatic animals, and I named this type of diet as 'marine silage (MS)'. The MS was prepared from blooming algae, Ulva spp. (UMS) by enzymatic degradation and lactic acid fermentation processes. The UMS is one–cell product of Ulva and has a size of ca. 6µm in diameter and, therefore, suitable for ingestion by suspension feeders such as bivalves.
The author believe that fermentation of seaweeds will open new marine fermentation industries and contribute to a wise utilization of seaweed resources.

OR-32-04
Sugar kelp as feedstock for fermentation-based succinic acid production in a biorefinery approach

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This study aimed to evaluate the potential of the macroalga Saccharina latissima (sugar kelp) as novel feedstock for fermentation-based succinic acid production in a biorefinery approach. Seasonal variations in the content of carbohydrates, and fermentable sugars, had a significant impact on the succinic acid yield and titer. A maximum succinic acid yield of 91.9% (g g-1 of total sugars) corresponding to 70.5% of the theoretical maximum yield was achieved when a blend of macroalgal biomass cultivated over two growing seasons and harvested in July and August was used as feedstock. A succinic acid titer of 36.8 g L-1 with a maximum productivity of 3.9 g L-1 h-1 was achieved. The high content of total phenolic compounds (TPC) in the macroalgal biomass (July-August: 5-1% DM), and high concentration of macro- (Ca, K, Na, Mg, P, N and Fe) and micronutrients in the solid residue recovered after enzymatic hydrolysis, makes co-production of antioxidants (i.e. phenolics) and fertilizer very attractive. Finally, a simplified economic assessment showed that for the analyzed scenarios the main product selling price (succinic acid) can be lowered significantly by coproducing added value products (fertilizers) and high added value-lower volume products (antioxidants).

OR-32-05
Seaweed salt from Ulva: developing the biorefinery concept

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The high salt content of seaweed biomass can pose a problem for seaweed based fertilizer; animal feed supplements and fuels by increasing soil salinity, decreasing feed digestibility, and increasing corrosion in processing equipment. However, this problem can be resolved in a biorefinery approach using a preliminary washing step with the waste being delivered as a co-product. We compared post-harvest processing of two species of Ulva (chlorophyta) using different washing time-by-temperature combinations. We quantified the yield of crystallized salt after evaporation of the water as a target product. We also characterized the composition of salts and processed biomass, with the aim of improving the composition of the processed biomass for production of fertilizer, animal feed or fuels. Washing of U. ohnoi and U. sapora effectively reduced the mineral (ash) content of the biomass with concomitant production of crystalline salts with Na:K ratios of 1.1 – 2.2 and a maximum of 19% soluble fibre (ulvan). The maximum yield of salt was 29% of the biomass for U. ohnoi and 36% for U. sapora. Salts from both species have potential for human health applications and functional foods. The processed biomass had increased contents of energy by 20-50% for both species to a maximum of 18 MJ kg-1 and protein by 11-24% to a maximum of 27.4% of dry weight. The production of seaweed salt is therefore an innovative first step in a cascading biorefinery model for the utilization of macroalgal biomass which simultaneously improves the quality of the processed biomass for production of fertilizer, feed or fuel.

OR-33-01
Characterization of the GGPS responsible for carotenoid biosynthesis in Pyropia umbilicalis

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Carotenoid metabolism in red algae is not well understood. Geranylgeranyl diphosphate (GGPP), synthesized by GGPP synthase (GGPS), is a precursor for the biosynthesis of many biologically important metabolites,

including carotenoids and chlorophylls. GGPSs have been functionally characterized in many organisms, but not in species of the primitive red algal order Bangiales. Here, we cloned and characterized the gene encoding GGPS (PuGGPS) in Pyropia umbilicalis (Bangiales). PuGGPS encodes a protein of 345 amino acids with an N-terminal transit peptide. The catalytic activity of PuGGPS for the production of GGPP was verified by a color complementation assay in Escherichia coli and subsequent high-performance liquid chromatography analysis. Homology modeling of PuGGPS showed that its tertiary structure resembles that of other known GGPSs and that this structure allows for the precise docking of the enzymatic product of PuGGPS, GGPP. When leafy thalli of P. umbilicalis were treated with norflurazon, an inhibitor of the key carotenoid metabolism enzyme phytoene desaturase, the expression of PuGGPS increased by twofold compared with that of the control in the first 2 h, suggesting a prompt response to metabolic perturbation. Prolonged norflurazon treatment failed to increase PuGGPS expression. Sequence analysis showed that PuGGPS shares seven conserved motifs with other previously identified GGPSs from different organisms, including two aspartate-rich GGPS signature motifs. Phylogenetic analysis also indicated that PuGGPS is a member of the type II GGPSs found in eubacteria and plants

OR-33-02

Characterization and physical mapping of the rRNA genes and telomere sequence in Saccharina japonica

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The chromosomes of Saccharina japonica are characterized by small size and almost homomorphy. Fluorescence in situ hybridization (FISH) technique is a powerful tool for the mapping of DNA sequences onto such homomorphic chromosomes. The ribosomal RNA genes (45S and 5S rDNA), organized in a tandem repeat pattern and located in one or more cluster, are generally accepted as excellent cytological markers for karyotype analysis of many higher plants using FISH. In the present study, 45S rDNA sequence was cloned from the S. japonica gametophytes based on the partial sequences of two screened clones from a bacterial artificial chromosome (BAC) library. It was found that the coding region of 45S rDNA was composed of approximately 5,300 bp in length, including a 1,824-bp 18S rDNA, a 643-bp or 436-bp fragment containing internal transcribed spacer-1 (ITS-1), 5.8S rDNA and ITS-2, and a 2891-bp 26S rDNA. Each repetitive unit of 5S rDNA includes a 120-bp coding region, which was separated by a diverse non-transcribed spacer (NTS). Southern blot profiles with 18S or 5S rDNA as a probe demonstrated that they were uni-locus genes. Absolute quantification of real-time PCR was used to estimate the copy numbers of the 45S and 5S rDNA, and the copy number of the 45S rDNA was 40 or 45 per haploid genome, while it was 2590 or 2650 for 5S rDNA. FISH patterns illustrated that 45S rDNA was localized on the terminal regions of Chromosome 23 possibly being confined to the nucleolus organizer regions (NORs), whereas 5S rDNA was near the telomere of Chromosome 27.

OR-33-03

The evolution and maternal inheritance of chloroplast genome in Saccharina japonica

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The chloroplast genome sequence of one brown seaweed, Saccharina japonica, was fully determined. It is characterized by 130,584base pairs (bp) with a large and a small single-copy region (LSC and SSC), separated by two copies of inverted repeats (IR1 and IR2). The inverted repeat is 5015bp long, and the sizes of SSC and LSC are 43,174bp and 77,378bp, respectively. The chloroplast genome of S. japonica consists of 139 protein-coding genes, 29 tRNA genes, and 3 ribosomal RNA genes. One intron was found in one tRNA-Leu gene in the chloroplast genome of S. japonica. Four types of overlapping genes were identified, ycf24 overlapped with ycf16 by 4 nucleotides (nt), ftrB overlapped with ycf12 by 6 nt, rpl4 and rpl23 overlapped by 8 nt, finally, psbC overlapped with psbD by 53 nt. With concatenated plastid protein data, the chloroplast phylogenetic relationship among S. japonica and the other photosynthetic species was evaluated. Two simple sequence repeats from chloroplast DNA (cpSSRs) were developed and used to investigate inheritance patterns of chloroplast DNA in Saccharina japonica.

OR-33-04

Organellar genomes of Ulva spp. and phylogenomics of the "Core Chlorophyta"

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Next generation sequencing of green algal chloroplast and mitochondrial genomes has begun to allow for a better understanding of organellar evolution and phylogenetic histories. Unfortunately, only

limited genomic data were previously available for the class Ulvophyceae, and questions involving the monophyly of this group still remain. Here, we present insights into the organellar genome evolution of the green macroalgal genus Ulva and perform phylogenomic analyses to investigate the monophyly of the Ulvophyceae. Our data showed that gene and AT content of the chloroplast and mitochondrial genomes of Ulva spp. were similar; however, these genomes differed in size and intronic content. An inverted repeat (IR) that had previously been found in other ulvophycean chloroplast genomes (i.e. Pseudendoclonium akinetum and Oltmannsiellopsis viridis) was absent in the Ulva spp. chloroplast genomes. The mitochondrial genomes of Ulva spp. followed an "expanded-derived" pattern through increases in intergenic space and intron content, which had also been identified in other ulvophyceans. A syntenic comparison of green algal organellar genomes reiterates their highly rearranged nature and showed intrageneric rearrangements in the chloroplast genomes of Ulva spp. Furthermore, separate phylogenomic analyses of chloroplast and mitochondrial protein-coding genes showed no support for a monophyletic Ulvophyceae sensu lato.

OR-33-05

Comparative genomics of chloroplasts and mitochondria in brown algae

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The Phaeophyceae (brown algae) are multicellular photosynthetic marine organisms and display great morphological and physiological diversity. After their own independent evolution for more than 200 million years, the current brown algal group consists of a multitude of taxa including 19 orders, 62 families, 473 genera, and more than 2000 species. However, the data on their chloroplast and mitochondrial genomes are limited so far. The known brown algal chloroplast genomes are 124.1-140.0 kb in size, and contain 173-185 genes including 6 rRNA, 28-31 tRNA, and 139-148 protein-coding genes (PCGs), and appear to be highly rearranged in genome architectures among the different orders but be highly conserved in order Fucales and Laminariales. Brown algal chloroplast genomes contain multiple small inverted repeats (SIRs) and tandem repeats (TRs). The mitogenome sizes of brown algae are 31.6-58.5 kb, and harbor 65-79 genes including 3 rRNA, 24-26 tRNA, and 37-52 PCGs. The mitogenome organization in order Ectocarpales, Laminariales, Desmarestiales, and Fucales (ELDF) has high similarity only varying in ORF number and one or two tRNA position, which are apparently different from that in Dictyotales representing a more ancestral brown algal lineage. The total spacer size is positively correlated with brown algal genome size. The chloroplast and mitochondrial genomes obtained provide important information for us to understand plastid and mitochondria evolution as well as phylogeny in brown algae.

OR-34-01

Analysis of nutritional quality of Grateloupia sp. from Indian coast

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Land resources are depleting day by day, as the population is growing alarmingly. This ever increasing population is exerting great pressure on arable land, water and biological resources to provide adequate supply of food while maintaining the integrity of our ecosystem. During the last seven to eight years food prices have increased many times in India pushing millions of people into poverty. In order to, avoid future food scarcity there is a need to look for alternative and more affordable food supply. A new food source is needed that not only provides complete nutrition for healthy and active lives, but is also produced sustainably. India has a vast coastline of about 7000Km and with approximately 770 sp. of seaweeds reported so far from different parts of Indian coast. Although many seaweed species are available in abundance in India, still they are not practised as a food resource. People depend on conventional land food resources and there is a need to generate awareness in them regarding potential application of seaweeds as food. Grateloupia (Halymeniaceae) which has 20 genera and approximately 160 species dispersed worldwide is the largest genus in the family. In India, it is represented by six species G. comorinii, G. filicina, G. furcata, G. indica, G. lithophila and G. watii out of which, five species are endemic to India except G. filicina distributed all around the world. In the present study it has been found that Grateloupia is not only nutritionally very rich but also is a good source of λ carrageenan. Although, 6 species of Grateloupia have been reported from different parts of the Indian coast, not much information is available on their nutritional and carrageenan content and quality. Therefore, in the present work an attempt has been made to analyze the various species of Grateloupia lithophila as a source of food and carrageenan. Various physical and chemical characteristics have been analyzed and the same will be presented.

OR-34-02
Effects of washing treatments on the nutritional value of edible seaweeds

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Washing of macroalgae is a standard initial pre-treatment step after harvest of the biomass in order to remove particulate matter. In the context of using macroalgae in human food and feed applications, such treatments may have either adverse effects by removing nutritional water-soluble compounds, or positive effects by washing-off or reducing anti-nutritional substances and potential toxins. This study compares the influence of soaking treatments of winged kelp (Alaria esculenta) and sugar kelp (Saccharina latissima) under various conditions (fresh water vs. seawater at several temperatures), quantifying the effects of treatment duration on seaweed biomass, considering relevant parameters. The measured variables include the evolution of mineral, carbohydrate, protein, polyphenol and pigment content, as well as changes in the biomass surface colour throughout treatments. Levels of undesired elements such as cadmium (Cd) and inorganic arsenic (In As) are also monitored. A higher loss of dry matter content was observed in both species washed in fresh water compared to seawater reflecting a general reduction of the biomass' nutritional value. Losses were generally higher in S. latissima than in A. esculenta. Hot fresh water treatments greatly affected iodine, as well as pigment content and colour surface whereas Cd, In As and most carbohydrates remained stable. There is a growing interest for using seaweeds as raw material in food and feed applications, where harvested biomass is often washed, and then stabilized by drying. Understanding the influence of the various processing steps on the biomass composition will allow predictable results in terms of nutritional value and organoleptic quality of the products. These results will contribute to establishing optimized processing protocols for specific products, and are also relevant in the context of biorefinery systems which seek for a complete exploitation of the desired compounds from the raw material.

OR-34-03
Cultivated seaweed for tasty and healthier "traditional" foods

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According to the 2012 World Hunger map, 12.5% of the world's population is undernourished. On the other hand, hypercaloric westernized diets are important causes of chronic degenerative diseases that significantly impact life quality and health care costs: obesity, hypertension, coronary heart disease and type 2 diabetes. In recent years, western consumers started seeking convenient foods, but preferably local sourced, environmentally sustainable and that contribute for a healthier lifestyle. Seaweeds are a rich and balanced source of nutrients, being characterized by high contents of protein, fibres, certain vitamins and minerals coupled with a low fat and sald content. Moreover, their health benefits appear to go beyond their nutrient profile, as has been recognized for centuries in South Asian countries. Recently, that knowledge has been transferred for the western consumer and new seaweed-based products are launched every year. However, despite the acknowledgment that seaweeds are a very healthy addition to one's diet, there is a generalized lack of culinary knowledge on seaweed usage and most western consumers still see seaweeds as an exotic food and/or associate them to specific diets (e.g. vegetarian, vegan, macrobiotic). Changing food habits can be a long journey. One way to overcome this mind-set is through good marketing and educational tools and by seeking to develop products with flavours close to the traditional ones. The project SHARP (Seaweed for healthier traditional foods) intends to widen the consumption of seaweed-based products. It brought together nutrionists, seaweed farmers, traditional food producers and chefs to develop cost-effective products that are palatable for the consumer, nutritionally balanced and with potential positive impact on human health validated by scientific evidences. Initial results of this project, including a consumer study perception on the use of seaweed grown in aquaculture (namely IMTA) systems will be presented.

OR-34-04
Cultivated seaweed: An emerging seafood market in Quebec (Canada)

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Quebec possesses an important natural resource of edible seaweeds which is unexploited and could lead to the development of a new seafood industry. The Quebec shellfish farmers interested in diversifying their production through kelp culture could feed those markets with a high quality biomass. To favor the development of this new industry, different high-value food applications need to be developed in order to interest various sectors of the food-processing industry. In this context, Merinov initiated a research project that aimed to characterize the nutritional value, identify potential food safety concerns and obtain the sensory profile of two species of macroalgae, Saccharina longicruris and Alaria esculenta, in order to find appropriate food applications. Through this project, several conservation methods were also tested to identify the best strategy for transportation, storage and marketing of algae. In order to validate the general interest for seaweed consumption and evaluate the chances of success of the developed food applications on the market, a group of consumers were subjected to sensory evaluation tests. In light of the results achieved, the nutritional properties of the studied seaweeds are generally comparable to those of vegetables, but are richer in fiber and in polysaccharides, such as alginates or fucoidans. However, it is advised that people with health problems related to the consumption of sodium and iodine limit their consumption of seaweed. Despite their limited knowledge on the edible seaweeds, the Québec consumers showed a particular interest for seaweeds as a nutritious local food product. This is why, many food products incorporating algae will be developed with the help of specialists at Merinov and the expert sensory panel.

OR-34-05
Seaweed as a gourmet ingredient in gourmet products

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Nordisk Tang (Nordic Seaweed) is a significant player in Scandinavia in terms of implementing seaweed into gourmet products. Our philosophy and dedicated aim is to put seaweed back on the table in Scandinavia and Europe. We do this through disruption, which means that we take an existing product and alter/ improve it by adding seaweed. Not only to create great taste, but also to explore and exploit the health benefits of seaweed. As such our products can be described as “gourmet products with a strong focus on health”. By using seaweed in our products we also believe that we can reduce the usage of salt (NaCL) and a variety of emulsifiers, thus all our products are “clean label” products. Today our products are widely known in Denmark, and we are starting to gain foothold in Germany, Norway and Sweden. As our seaweed products contain a great variety of natural salts; minerals; vitamins and proteins they are widely popular amongst vegetarians and vegans. We try to be as innovative as possible and we currently have a product portfolio of 16 unique products with 20 more in the pipeline. All our products are carefully developed by using only ingredients we have near by (with only one or two exceptions). Therefore we also see our company as highly sustainable in all aspects of the word. We use the unexplored resources, which are close to us; we only use organic ingredients and the wastewater and waste seaweed we apply on the farmlands as fertilizer. Finally we have a financially sustainable company with a large customer base, which makes all of our activity possible. Apart from making seaweed common in Scandinavia and Europe again, our aim is to be able to make a clean and pure Nordic version of sushi plates, seaweed salads etc. which are interesting for the Asian (and European) markets. We are very far with getting the texture and taste right through a specially developed process and with help from some of the most diligent educational institutions in Denmark.

OR-34-06

Deciphering the lipidome of the seaweed Gracilaria sp. from the IMTA system in the lagoon of Aveiro

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Gracilaria sp. is one of the world's most cultivated and valuable edible red seaweeds. It is considered a rich food, with health beneficial effects associated with the longevity of Asian population and a multi product source with several biological activities. Concerning lipids from Gracilaria sp., phospholipids and glycolipids were only scarcely addressed. They are potential high value metabolites displaying several commercial applications in food and cosmetic industries. Gracilaria sp. thrives in Ria de Aveiro lagoon, Portugal, and is being cultivated in an integrated multi-trophic aquaculture system (IMTA). Aiming to fully explore its nutritional properties and biotechnological applications, in the present work we intended to characterize the full lipidome, accessed for the first time by hydrophilic interaction liquid chromatography-electrospray ionization mass spectrometry approach. It was found to contain glycolipids (sulfoquinovosyl diacyl- and monoacylglycerols, di- and monogalactosyl diacylglycerols), glycerophospholipids (lyso- and phosphatidylcholines (PCs), lyso- and phosphatidylglycerols and phosphatidyletanolamines) and di- and monoacyl betaine lipids. Glycolipids are the predominant category of lipids while betaine lipids are the less extent compounds. The phospholipidome was found to contain high number of PCs species. As other red algae, Gracilaria mainly contains glycolipids species and C18 and C20 polyunsaturated fatty acids, such as linolenic and arachidonic acids. Several of these lipids were reported to have nutritional and health benefits as anti-inflammatory, antimicrobial and antitumor promoters, supporting the potential of Gracilaria sp. from IMTA as an edible product for human wellbeing and prevention of disease.

OR-35-01

The bad, the good and the not so ugly: disease and restoration in Phyllospora comosa.

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Key species of macroalgae are declining worldwide. The fucoid Phyllospora comosa was once common on shallow subtidal reefs around metropolitan Sydney, Australia, but disappeared in the 1980's, coincident with peaks in heavy sewage outfall discharges. We are interested in the potential causes of this decline, as well as the potential to restore this species and its associated biodiversity back to Sydney. Broad-scale spatial sampling revealed that putative disease phenotypes of Phyllospora are more common near urbanized areas along its distribution, suggesting disease may have been associated with its decline. One of the disease phenotypes investigated, 'stipe rot', was confirmed as a fungal disease that significantly increases mortality of infected individuals, and may have contributed to Phyllospora's decline from Sydney's coastline. Encouragingly, water quality in Sydney is now much improved due to the installation of deepwater offshore sewage outfalls. However, Phyllospora has not recolonized. To test whether this species could now survive on the coast of Sydney, we transplanted Phyllospora from outside Sydney back onto Sydney's reefs. These transplants survived, grew and reproduced at rates comparable to those in reference populations. In some 'restored' locations, these populations appear to have become self-sustaining, with adult individuals established up to 100 m from initial transplants. The distinct biodiversity associated with Phyllospora forests is also returning, though initial results suggest that restoring associated biodiversity (including commercially important species) can be a complex and long-term process. Our research also suggests that even following major engineering projects to enhance habitat quality, active restoration of key (habitat-forming) species may still be needed for successful recovery of degraded natural ecosystems.

OR-35-02

Tropical seaweed beds as habitats for juvenile fish

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Tropical shallow habitats such as seagrass and mangrove are commonly considered as important nurseries for several species of coral reef fish. However, there are indications that structure per se may be more important for the juvenile fish community than previously realized, which implies that also other shallow habitats with high structural complexity should be explored. Tropical seaweed beds is one such habitat that has received little attention, and despite that seagrass meadows in East Africa has been shown to be utilized by juvenile coral reef fish, no studies have been performed on the juvenile fish utilization of the seaweed beds in these same areas. This study investigated fish assemblages of the shallow seaweed habitat in the Western Indian Ocean, and compared them to the assemblages of the closely situated seagrass beds. Fish assemblages were assessed with visual census transects, in which all fish were identified to lowest taxonomical level, counted and length was estimated. Comparisons between the habitats were made regarding fish abundance, abundance of age categories, functional groups and species richness. Our results show that fish abundance were similar between seaweed and seagrass habitats, but that the abundance of juvenile fish were higher in seaweed beds than in seagrass meadows, while no differences were found for subadult and adult fish. Additionally, macroalgal beds had a higher juvenile abundance of commercial and coral reef associated fish species than did seagrass meadows. These results highlight that tropical macroalgal beds can be more important as juvenile habitats than previously believed, which underscores the need of widening the view of the tropical seascape.

OR-35-03

Inhibition of marine harmful algal bloom species by Gracilaria lemaneiformis

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While harmful algal blooms (HABs) have become a threat to fisheries, environmental and public health, and economies worldwide. We report on experiments examining the effects of the macroalga, Gracilaria lemaneiformis on the growth of two common HAB species: Scrippsiella trochoidea and Akashiwo sanguinea. The fresh thalli (FT), extraction of fresh thalli (EFT) and extraction of dried and powdered thalli (EDPT) were capable of lysing or strongly inhibiting the growth of all two HAB species in a dose-dependent manner within controlled laboratory experiments during which high nutrient levels, low bacterial levels, and common pH levels among treatments and controls. The EFT showed the strongest inhibition effects, and EDFP is next, the FT inhibition effect was the weakest relatively. Our findings combined with the well-known nutrient removal capacity of seaweeds collectively suggest that the use of macroalgae may be a promising mitigation strategy for HABs in coastal ecosystems.

OR-35-04

Impacts of cultivation of seaweeds on plankton and benthos populations on open sea environment

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The present study was conducted in seaweed culture sites at Tuticorin and Mandapam coast along the Gulf of Mannar region. Monthly collections of sediment, water and plankton samples were made routinely from May 2015 to October 2015 at seaweed cultivation stations of Tuticorin and Mandapam coast. The total plankton biomass density varied from 27250-372000/m3. A total of 44 species of marine phytoplankton and 49 species of zooplankton were recorded in Tuticorin coast. Among the phytoplankton species, it varied from10-28 species were recorded in seaweed culture site. Among the zooplankton it varied from 10-27 species. Maximum was recorded in control site. In Mandapam site, a total of 42 marine phytoplankton and 45 zooplankton species were recorded during the study period. The total plankton density varied from 27500 to 381900/m3 was recorded in seaweed culture and control site. In Mandapam and Tuticorin coast the total plankton density is low in seaweed culture site than compare to control site. In seaweed culture and control sites, the plankton density varied from 1132-95000(no/m2) and 1096-110066 (no/m2) respectively. Macro benthos density varied from 904-383333 and 1096-110066 (no/m2) in Tuticorin and Mandapam respectively. Meio benthos varied from 83000-1015000 and 816- 348666(nos/m2) in Tuticorin and Mandapam respectively. In Mandapam coast, the phytoplankton

density is low in seaweed culture site than control site whereas in Tuticorin coast the zooplankton density is low in seaweed culture site than control site. But In Mandapam site, the zooplankton density is higher in seaweed culture site than compare to control site where as in Tuticorin site the phytoplankton density is higher in seaweed culture site than compare to control site. Hence this fluctuation is determined by physicochemical parameters of seawater, nutrient competition, sewage and industrial effluents discharging in direct and indirect activities.

OR-35-05

Carbon dioxide mitigation potential of seaweed aquaculture beds (SABs)

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Seaweed aquaculture beds (SABs) that support the production of seaweeds and their diverse products cover extensive coastal areas, especially in the Asian Pacific region, and provide many ecosystem services such as nutrient removal and CO2 assimilation. The use of SABs in potential carbon dioxide (CO2) mitigation efforts has been proposed with commercial seaweed production. In 2012, the total annual production of Asia Pacific SABs surpassed 2.31 x 106 t dw. Total carbon accumulated annually was more than 0.69 x 106 t yr-1, equivalent to over 2.55 x 106 t CO2 yr-1. By increasing the area available for SABs, biomass production, carbon accumulation and CO2 drawdown can be enhanced. The conversion of biomass to biofuel can reduce the use of fossil fuels, and provide additional mitigation of CO2 emissions. Contributions of seaweeds as carbon donors to other ecosystems could be significant in global carbon sequestration. The ongoing development of SABs would not only ensures that Asian Pacific countries will remain leaders in the seaweed industry but may also provide an added dimension of helping to mitigate and adapt against global warming and ocean acidification

OR-35-06

Effects of fish farm effluents on epiphytic algal communities in Laminaria hyperborea forests

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et al.

During the last two decades Norwegian aquaculture has grown rapidly, with production exceeding 1.2 million tons in 2014. This rapid expansion has resulted in a significant restructuring of the industry, including increased farm sizes (from 3-5000 tons up to 14 000 tons) and relocation of farms from quiescent fjords to dynamic and exposed areas along the coast. It is well known that discharges (i.e. particulate and dissolved effluents) from intensive fish farming in net cages alters the structure and functioning of benthic communities, although this knowledge is restricted to soft bottom habitats. Impacts to other habitats (i.e. hard-bottom habitats) along the Norwegian coast have been poorly studied. L. hyperborea is the dominating kelp species at exposed hard-bottom sites along the Norwegian coast, providing structurally complex habitats supporting high floral and faunal diversity, including economically important species that use the forests as nurseries. Epiphytic algae found growing on kelp are often fast growing species, with a capacity to take up nutrients at a faster rate than L. hyperborea. It is hypothesized that increased loading of available nutrients could stimulate the growth of epiphytic algae which could negatively influence the kelp through decreasing total surface area available for nutrient uptake and light interception necessary to conduct photosynthesis. To assess the effects on epiphytic growth on L. hyperborea, 6 different fish farms were chosen: 3 at the beginning of the production cycle (had a low fish biomass and therefore low effluent load), and 3 at the end of the production cycle (high fish biomass and high effluent load), in addition to 6 reference locations. 10 individual plants were collected along transects from each location. Epiphytic growth on stipe and lamina were identified and weighed. Tissue samples of the lamina for C:N ratio and isotopic analysis were also collected.

OR-36-01
Seaweed biorefineries – Value chain analyses and cost assessments

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Cultivated seaweed is proposed as one of the solutions that can contribute to meet the demand for food for the increasing global population, as well as a sustainable biomass resource for conversion to chemicals and fuels. An increasing number of small companies are engaging in seaweed cultivation, and despite that seaweed farming is still in its infancy in Europe, it is predicted that this can be an industry of significant importance in the Atlantic and North Sea regions. The biomass costs are yet too high to allow use of seaweed as a feedstock for conversion to chemicals and fuels. Even with large-scale off-shore farms and co-production of added-value products, it will be a challenge for seaweed biomass to be competitive with sugars from other 2nd generation biomass resources, such as lignocellulose and agricultural wastes. Seaweed can be used directly as food, but an extended product range is required for development and establishment of a new industry based on seaweed. Seaweed contains a high number of potentially commercial products. Several reports have been published where the biomass composition has been multiplied with the price of the individual components. This illustrates a huge economic potential, but is of little value without an assessment of the processing costs. We have carried out a more thorough evaluation of products, processes and production costs. Operating and capital costs have been estimated based on own experimental data, literature and assumptions, and maximum allowable biomass costs for different product combinations and product prices have been calculated. Results from two cases will be presented, one for application of the biomass as a fermentation carbon source, and one where the biomass components are isolated for application as food/feed ingredients, cosmetics, or chemicals for technical applications.

OR-36-02
Brown seaweed as a bioresource for phloroglucinol based bio-polymers

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Brown seaweeds are rich in polyphenols with a basic building block of 1,3,5 triol benzene (phloroglucinol). We investigate the selective extraction of polyphenols from brown seaweeds as a bioresource for the production of phloroglucinol based bio-polymers. Species of brown seaweed with high contents of polyphenols were identified through meta-analysis and selected for the comparative assessment of the extraction efficiency of polyphenols of microwave assisted hydrothermal upgrading (HTU) to extract polyphenols vs. traditional solvent extraction methods. Ten species from Australia and New Zealand were screened with Carpophyllum flexuosum (8.6%) and C. plumosum (7.5%) having the highest contents of polyphenols, and these were selected for HTU extraction. HTU solvent (water, acetone, ethanol, ethyl acetate) and processing conditions (extraction time and temperature) were optimized and the optimized conditions (aqueous extraction at 175 °C for 3 minutes) then used to extract polyphenols from both species. C. flexuosum was the best species for the extraction of polyphenols, with a doubling in the yield of polyphenols using optimized mild HTU in water compared to traditional solvent extraction. The selective extraction of polyphenols is the first step in the development of a cascading biorefinery model with bio-polymer, pigment, and polysaccharide product streams.

OR-36-03
Aqueous solutions of ionic liquids to extract phycobiliproteins from red seaweeds

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Macroalgae, with more than 10000 species worldwide and more than 400 present in Portuguese waters are natural renewable sources of valuable bioactive compounds of industrial interest, e.g. proteins and pigments, with a wide range of applications. Gracilaria vermyculophylla, the focus of this work, is abundant worldwide, being a promising source of phycobiliproteins. Phycobiliproteins are photosynthetic

proteins recognized for their high solubility in water, very high photoluminescence efficiency, and stability under different pH values, temperature and time of storage. The major drawback associated with phycobiliproteins is the demand for an effective/more sustainable purification method to remove them from the biomass, while maintaining their properties/activities. This work focus the use of ionic liquids (ILs) aqueous solutions as alternative solvents to extract phycobiliproteins from the red macroalga Gracilaria vermiculophylla. Different structural features of ILs were tested considering their capacity to disrupt the macroalgae cells and to extract as much as possible the phycobiliproteins. The extraction performance was followed by the yields of extraction and purity indexes and then compared with those of conventional methods. Acknowledgements: The authors are grateful for the financial support from FEDER funds through the program COMPETE and for national fund through the Portuguese Foundation for Science and Technology (FCT) under the scope of the Project FCT UID/CTM/50011/2013 financed by national funds through the FCT/MEC and when applicable co-financed by FEDER under the PT2020 Partnership Agreement and European Research Area Network; ERANet LAC (ref. ELAC2014/BEE-0341). The authors also thank the financial support of FCT considering the post-doctoral grant SFRH/BPD/79263/2011 of S.P.M. Ventura. The authors also thank the financial support from CNPq (Ciência sem Fronteiras) for the supply of the post-doctoral fellowship (249485/2013-3) of F. A. Vieira.

OR-36-04

Antiviral compounds isolation from red seaweeds by EAE using response surface methodology.

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Macroalgal blooms frequently occur in France. In South Brittany, these algal blooms are mainly composed of red seaweeds like Solieria chordalis and constitute an unexploited significant natural biomass. In this study, active compounds from Solieria chordalis were extracted and evaluated as a potential source of natural antivirals, coupling biotechnological development with economic and ecologic benefits. In order to extract the highest quantity of antiviral compounds, a sustainable process was developed: Enzyme-Assisted Extraction (EAE) following a response surface methodology. The quantity of water-soluble compounds increased by 30 % after the action of a marine subtilase in comparison with an aqueous extraction under the same conditions. The maximum number of compounds was released at 50°C for 200 min, with a ratio of enzymes on the dried algal biomass of 7.5 %. The optimization of extraction conditions improved the yield and confirmed the robustness of the enzyme-assisted extraction. A more efficient antiherpetic activity was obtained with the extract after the action of the subtilase with an EC50 of 86.0 µg.mL-1 followed by the extracts after action of carbohydrases from microorganisms. Moreover, a positive correlation between sulfated saccharides and the antiviral activity of extracts was demonstrated. In conclusion, soft biotechnology with marine and terrestrial enzymes following a response surface methodology has been used in order to enhance in optimal conditions the quantity of soluble antiviral compounds extracted from proliferative seaweeds.

OR-36-05

Application of surfactants on the extraction of added-value compounds from brown seaweeds

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There is an accrued interest for bioactive compounds extracted from natural sources. The search for natural molecules have been pointed out as of industrial and commercial interest. Carotenoids, and in particular fucoxanthin, are one of these examples with a large range of applications in different fields. One of the major issues associated with biomolecules being extracted from natural biomass is the demand for a highly performant and low cost extraction process to extract them, while maintaining their most interesting properties. It is known that carotenoids are hydrophobic molecules and thus, this work aims at the development of a new cost-effective process to extract carotenoids from the brown macroalga Sargassum muticum, by applying aqueous solutions of various surfactants. This extractive platform will be optimized in what concerns the solid-liquid ratio, the surfactant concentration and the time of extraction.

OR-37-01

Biomass and carbon content of calcareous green algae at the north coast of the Yucatan, Mexico

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Calcareous green algae (CGA) are important producers of carbonaceous sediments in coastal environments, they play critical roles facilitating seagrass establishment, and contribute to the accumulation of organic matter in their meadows. Yucatan has 378 km of coastline with large seagrass and CGA meadows which provide important services to the region, however little is known of their actual production and seasonal dynamics. In this study the CGA production was quantified and its CaCO3 and organic carbon were estimated at two sampling sites (Cerritos 1 and Cerritos 2) at the north coast of Yucatan, each site was visited four times between June 2014 and March 2015. Three CGA species: Halimeda incrassata, Halimeda opuntia and Penicillus dumetosus were the dominant algal species producing an annual mass average of 1087.2 g/m2, with a maximum production reported for Cerritos 2 (1338.2 g/m2/year). From the total mass produced 88% correspond to CaCO3 and 12% to organic carbon (Corg). Seasonal significant differences are reported for the three estimated parameters with a maximum production in the summer for Cerritos 1 and fall for Cerritos 2. Halimeda opuntia had the highest production. The CGA production in the Yucatan is in the range of the global production and might be as important as seagrass production. Production differences between the two sites might respond to depth and subaquatic vegetation present, while temporal differences might respond to temperature. The high production of H. opuntia is consistent with the "weedy" behavior of this species reported in reef sites. This study provide the base line production of CGA for the Yucatan.

OR-37-02

Can reduced ice scouring cause changes in the littoral zone in Spitsbergen, Svalbard?

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The island group Svalbard is situated between 76°30 and 80° 30N in the north Atlantic. Svalbard comprises different biogeographic regions, from cold temperate to arctic depending on definition. To date only three macroalgal investigations revisited previously sampled sites at the west coast of Spitsbergen namely Hornsund and South Cape area, Kapp Linné in the outermost part of Isfjorden, and Hansneset in Kongsfjorden. Based on these revisits a change in the littoral and shallow macroalgal communities has been documented. A considerable increase in species richness of macroalgae has been recorded at these sites compared to the earlier investigations. In contrast, on the eastern coast of the same island, which has drift or fast ice for more than 6 months per year, very few algal records exist. On a cruise to the eastern side of Spitsbergen summer 2013 the littoral macroalgal vegetation was studied and the littoral was found to be species poor and algae were often limited to crevices in the rocks in contrast to the well-developed littoral on the western side. In some fjords on the eastern side, the water was very turbid and sediments covered shallow algal vegetation. The western side of Spitsbergen receives warm Atlantic water from the West Spitsbergen current while the eastern side receives cold water from the high Arctic. The gradually increasing temperature in the West Spitsbergen current has decreased the ice formation in fjords within the last decade and even during winters open waters are found. This has reduced the ice scouring on the western side of Spitsbergen, which in turn probably has fostered the development of the more diverse benthic algal flora. No similar trend can be stated from the east coast.

OR-37-03

Impact of ocean acidification on lipid composition in seaweeds and associated grazers

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Ocean acidification (OA) is predicted to affect the structure and functioning of global marine ecosystems. Seaweeds are key primary producers that provide 50% of food to marine animals in coastal regions, so their response to OA will affect the functioning of near-shore ecosystems. Seaweeds without carbon concentrating mechanisms (CCM) rely solely on dissolved CO2 for photosynthesis. The predicted 225% increase in CO2 by the year 2100 is expected to enhance growth and photosynthetic rates and change

the biochemical composition in non-CCM species. The number of non-CCMs has been assumed to be rather small (ca. 5% of coastal communities). However, a recent study has identified a surprisingly large percentage (up to 90%) of non-CCM seaweed species along the Tasmanian coastline. This suggests that the impact of OA for seaweed assemblages and higher trophic levels could be much larger than previously assumed. Seaweeds, as a food source for marine invertebrates, are important primary producers of polyunsaturated fatty acids (PUFAs). PUFAs play a number of vitally important functions in seaweeds and other organisms. Increased carbon availability, as occurs under OA, has been shown to induce a decrease of the percentage of important PUFAs of micro-algae. The increased carbon availability under OA could trigger a similar response in non-CCM seaweeds. This would not only affect the seaweeds but also alter the their food value for their consumers. The presented project, investigates the response in fatty acids of non-CCM seaweeds to increased levels of CO2 and how a changed lipid composition in seaweeds affects seaweed-consuming organisms. Results of this study provide a better understanding of how the predicted abiotic changes in the marine ecosystem impact the energy flow in the coastal ecosystem.

OR-37-04

Growth and competition in a warmer ocean: A field experiment with non-native and native seaweeds

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Under climate change, warming is predicted to lead to changes in the ranges of seaweeds. Non-native seaweeds may experience more favourable conditions because of this; for example, competition from heat-intolerant native species may be reduced, and southern species may benefit directly from increased temperatures. We examined competition between three brown seaweeds which grow together in the infralittoral fringe on the south-west coast of Norway – the native fucoid Fucus serratus and kelp Saccharina latissima, and the non-native Sargassum muticum. This was done by recording thallus growth and mortality in a field experiment consisting of artificial assemblages of all species combinations, during summers with normal (2015) and high (2014) temperatures. Seawater temperature, nutrient levels, and C:N ratio of the seaweeds were recorded. The results showed that Sargassum muticum had higher mortality when grown together with both native species, and there was little influence of temperature on growth. On the other hand, there was a large difference in the performance of Saccharina latissima between years, with lower growth and higher erosion during the hot summer. Some interactive effects between species combinations and year were found, indicating that warming may influence competitive relationships between these species.

OR-37-05

Response of kelps from different latitudes to consecutive heat shock

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Little is known about kelp response to the consecutive temperature shocks they are often exposed to in the shallow subtidal and intertidal pools. We characterized the responses of the two southernmost forest-forming kelp species in the Northeast Atlantic, Laminaria ochroleuca and Saccorhiza polyschides to multiple cycles of thermal stress. Individuals from the upper vertical limit of the geographical distribution edges where the two species co-occur, France and Portugal, were exposed to 4 consecutive cycles of thermal shock simulating a spring tide at five levels (20, 22.5, 25, 27.5 or 30°C). Maximum quantum yield (Fv/Fm) of chlorophyll fluorescence of photosystem 2 (PS2) was used to detect impaired reaction centre function, as a proxy for individual fitness. Both species showed resilience to temperatures from 20 to 25°C. While exposure to 27.5°C caused no inhibition to Fv/Fm of S. polyschides, a threshold was met above this and exposure to 30°C caused the death of all individuals. In contrast, L. ochroleuca from France was damaged but able to survive 30°C shocks and individuals from Portugal showed complete resilience to this treatment. In both species, blade elongation decreased with increasing temperature, with necrosis surpassing growth at higher temperatures. While both species recruit in tide pools, resilience to high temperature exposure may confer an advantage to L. ochroleuca. Our results indicate that with climate change, the disappearance of S. polyschides from intertidal pools and a decrease in the density of L. ochroleuca can be expected.

OR-38-01

RNA-Seq revealed complex response to heat stress on transcriptomic level in Saccharina japonica

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As a temperate-cold species, Saccharina japonica often suffers heat stress when it is transplanted to temperate and subtropical zones. Study the heat stress response and resistance mechanism of Saccharina is of great significance for understanding the acclimation to heat stress under domestication as well as for breeding new cultivars with heat stress resistance. In this study we investigated the response of this alga to heat stress on transcriptomic level. A total of 947 genes were identified as different expression genes (DEGs), out of which 548 and 399 genes were respectively up- and down-regulated by the heat stress. Function annotation of the DEGs showed that over half of these DEGs were involved in "Protein processing in endoplasmic reticulum", "Metabolic pathway" and "biosynthesis of secondary metabolites". These DEGs also involved in other metabolic process or pathways, such as resistance-related factors (including heat shock protein, antioxidant system and others); channel protein and transporter; carbohydrate metabolism; lipid metabolism; energy generation-related genes; photosynthesis-related components, etc. Moreover, we identified a set of heat stress responsive miRNAs and analyzed their regulation during the heat stress response. Forty-nine known miRNAs and 75 novel miRNAs were identified, of which seven known and 25 novel miRNAs were expressed differentially under heat stress. Quantitative PCR of six selected miRNAs confirmed that these loci were responsive to heat stress. Thirty nine and 712 genes were predicted to be targeted by the seven known miRNAs and 25 novel miRNAs, respectively. Gene function and pathway analyses showed that these genes probably play important roles in S. japonica heat stress tolerance. These results indicated that the heat stress triggered complex response of S. japonica. The identified DEGs and miRNAs will help to elucidate the heat stress response and the resistance mechanisms in S. japonica.

OR-38-02

Investigation on the higher tolerance in Kappaphycus striatum compared with K. alvarezii

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The kappa-carrageenan-producing seaweed Kappaphycus striatum is different from K. alvarezii in that it grows well in the intertidal zone, where the thalli are exposed periodically to dehydration and rehydration. To investigate the specific tolerance mechanism of K. striatum, the photosynthetic behaviour of K. alvarezii and K. striatum exposed to osmotic variation was compared. Increase in the phenomenological energy fluxes (per excited crosssection (CS)) for absorption (ABS/CS) was detected in both K. alvarezii and K. striatum during rehydration. However, a sharp increase in the ABS/CS0 was detected in the K. alvarezii but not in the K. striatum. The normalized non photochemical quenching (NPQ) of K. striatum is significantly higher and increased faster than that of K. alvarezii. The normalized ΦPSII of K. alvarezii was significantly lower than that of K. striatum during the process of dehydration and rehydration in both the light and dark treatments. Moreover, a sharp increase in the antenna pigments (PBP) was also detected in the K. alvarezii but not in K. striatum during rehydration. So we estimated that the sharply increase of absorption energy in K. alvarezii may increase the surplus energy which may arouse the damage of the photosystem. Moreover, the faster increase of NPQ in K. striatum but not K. alvarezii also can help eliminate the surplus energy. This may be one reason of the relatively higher tolerance of PSII reaction centers in K. striatum compared with K. alvarezii. Such an increased tolerance of PSII may help to improve the tolerance of the whole plant to dehydration.

OR-38-03

Dissecting the strategy of Pyropia yezoensis to survive in salty water through Na+/K+ homeostasis

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Seaweeds are distinct in a way that they can withstand or possibly utilise extremely high concentrations of sodium (Na+) in seawater whereas most of the terrestrial plants are susceptible to salt stress. Na+ is known to disturb potassium (K+) homeostasis to exert deleterious effects on plant growth. Therefore, seaweeds must have evolved an adaptative trait to cope with a salty environment, although molecular knowledge on seaweeds is scarcely known. The red alga Pyropia yezoensis is one of the most commercially important seaweeds whose whole genome sequences are revealed. In an effort to obtain information on expressed genes in Pyropia, a full-length cDNA library covering multiple stages of the life cycle of Pyropia are being created. Several candidate Na+/K+ channels were isolated and gene expression of these channels were analysed in each stage of its life cycle. Functional analysis of these channels was performed in a heterologous system. Concentrations of Na+/K+ in each tissue of different stages of life were also

investigated to characterise Na+/K+ homeostasis in Pyropia. Taken together, the strategy of Pyropia to survive in the marine environment will be discussed and compared to that of land plants in order to provide clues to improve their salt tolerance.

OR-38-04

Innate immunity and constitutional defense mechanism of Pyropia tenera against viral infection

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Emerging viral diseases became one of the most serious threats for the aquaculture industry and the recent development of intensive and dense algal cultivation practices has enabled some viral diseases to spread much faster than ever. PyroV1 is a chloroplast virus that causes Green-spot disease (GSD), one of the most devastating plagues of Pyropia sea-farms in Korea. To develop a GSD-resistant strain of Pyropia, the viral infection-related genes were analyzed using proteomics and genomics tools. Proteomic analysis showed upregulation of ATP synthase CF1 beta subunit and RuBisCO small subunit proteins in PyroV1 infected P. tenera, suggesting a metabolic modulation is involved in resistance to the viral infection. Microarray analysis using 15,118 primers designed from the pyrosequencing data revealed the basic structure of innate immunity of P. tenera. RPS-2 (40S ribosomal protein S2) involved in the viral-defense was highly up-regulated in the infected cells. Structural analysis of RPS-2 showed the presence of nucleotide-binding domain and leucine-rich repeat. Alternative oxidase and ubiquitin-related 28s proteasome as well as cell wall serine protease which are involved in the constitutional defense mechanism to viral infection were also highly upregulated in the infected cells. These results suggest that P. tenera has most of the defense mechanism for viral infection which have been reported in higher plants.

OR-38-05

Transcript analysis of hsp genes in different phase of Gracilaria vermiculophylla

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Gracilaria is the important agarophytic red alga genera whose life history is composed of one gametophytic phase and two sporophytic phases, including tetrasporaphyte as well as carposporaphyte which is grown on the branches of female gametophyte. Until now, the gene munipulation during this complicated life cycle procedureare still obscur, with little and preliminary studies. In our previous results of the ssh libraries constructed between the tetrasporaphyte and male/female gametophytes, a specific clone from male gametophyte library subtracted with female gametophyte was blasted as hsp70 analog indicating the involving of heat shock protein in the male gametogenesis. Actually, other reports also found the relationship between heat shock protein and gematogenesis as well as sex determination of plants. For example, the expression of gene hsp81 (belongs to hsp 90 family) was only detected in pollen but not in ovule of arabidopsis thaliana. Also in red algae griffithsia japonica, hsp 90 was proved to be active in the differentiation of female gametophyte. So here an hsp90 gene and 3 types of hsp70 genes were cloned and compared with their expression level in male and female gametophyte of gracilaria vermiculophylla and the results again showed the heat shock protein involving in the gametogenesis.

OR-39-01

Temperature induced changes in the biochemical composition of Ulva lactuca (Chlorophyta, Ulvales)

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Ulva lactuca Linnaeus (Chlorophyta, Ulvales) is a potential edible seaweed that grows in intertidal zone along the Gulf of Mannar, South East coast of India. This seaweed is a rich source of proteins, essential amino acids, fatty acids, vitamins, dietary fibers and minerals vital for human nutrition. In the present study, biochemical responses of Ulva lactuca to temperature stress were studied following the exposure to different temperatures (25, 30, 35 and 40°C). Chemical composition was analyzed from dried alga (%, dw): Ash (8.98 – 16.45), protein (17.58 – 23.42), carbohydrate (14.34 – 36.67), crude fibre (16.91 – 30.21) and lipid (0.08 – 4.11). The level of protein, carbohydrate, lipid and crude fibre showed significant variations ($P< 0.05$) between temperatures. The concentrations of six vitamin levels were also determined: A, C, E, D, B6 and B12. Twenty amino acids were analyzed and aspartic acid, glutamine, glutamic acid, leucine, phenylanine, isoleucine and lysine are major components present in 35°C and 40°C-cultivated algae. The most abundant fatty acid was alpha linolenic acid C18:3 (22 to 46%). Stearidonic acid was 48 % and 18% in 35°C and 40°C –cultivated alga respectively. Seven minerals were analyzed and concentration ranges were as follows: Na, 10.3-50.3; K, 40.60–120.3, Ca, 13.6–65.5; Mg, 9.4–16.4; Fe, 1.35-20.34; Zn, 2.9-10.3 and

Cu, 0.32-1.94 expressed in mg/100 g dry weight. The present study suggest that this alga is tolerant to fluctuating temperatures, it corresponds well to the natural growth environment of this local species and is therefore an appropriate species for cultivation.

OR-39-02

Use of AMPEP K+ and inhibitors in shoot formation of Kappaphycus alvarezii (Doty) Doty

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The bio-stimulant, Acadian Marine Plant Extract Powder (AMPEP) K+ (a Canadian commercial extract of the brown seaweed Ascophyllum nodosum), with and without plant growth regulator (PGR) and inhibitors (i.e. colchicine and oryzalin) were use used to induce the formation of direct, erect shoots of K. alvarezii under micro-propagation conditions. Colchicine and oryzalin (0.1, 0.5 and 1.0 mg L-1) were added separately to different concentrations of AMPEP K+ (0.1, 0.5, 1.0, 5.0 and 10 mg L-1) in the study. AMPEP K+ was used as Control. Twenty (20) 3mm thick sections were cut from the apical sections of a clean and epiphyte-free K. alvarezii as explants. Three replicates were used for each concentration with 20 sections containing UV treated seawater in a 200 mL Erlenmeyer flask, incubated at 23-24°C, 13h D:11h L photoperiod, light intensity at 30-40 µm m2 sec-1 and provided with mild aeration. Length (mm), number of direct erect shoots and % number of sections with direct erect shoots were measured after 45 days of incubation. Results showed that there was no significant interaction ($P>0.05$) between AMPEP K+ levels and inhibitors, however, there were significant differences ($P<0.05$) between inhibitors, averaged across the AMPEP K+ levels as applied in this study. Between the two inhibitors, the longest (8.7 mm ± 0.67) and shortest (5.3 mm ± 0.89) shoots measured were those treated with 0.1 mg AMPEP K+ + 1.0 mg L-1 oryzalin and 0.5 AMPEP K+ + 0.1 mg L-1 colchicine, respectively. Those treated with AMPEP K+ (except for 0.5 mg L-1) produced significantly shorter branches than any level treated with AMPEP K+ with PGR + inhibitors. Percentage direct shoot formation ranged from 92-100% and 87-100% in AMPEP K+ with PGR + colchicine and AMPEP K+ with PGR + oryzalin, respectively. It can be concluded that combinations of AMPEP K+ with PGR + colchicine or oryzalin provided better formulations for robust seedling, shoot production in K. alvarezii.

OR-39-03

Use of fertilized molten slags for creating Sargassum forests in subtropical shallow waters

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As the algal beds have decreased in many parts of Japan, a variety of restoration techniques have been developed. In the case of oligotrophic conditions, fertilization (manuring) should be a major concern. However, quick dilution of nutrients from the fertilizers and longevity of fertilizers are weak points of the techniques and the establishment of methods to evaluate their effects is also needed. Recently, a solid fertilizer with condensed nutrients have been made of molten slag from municipal solid waste and livestock excreta (e.g. cow dung) and have been used for the afforestation of Sargassum forests in a bay of the subtropical island Amami-Ohshima. The target species is S. alternato-pinnatum Yamada; seedling was made on the spread discoid fertilized molten slag blocks (28 cm in diameter, 5 cm thick) by suspending the fertile thalli within a 1 m3 cage deployed at 2 to 5 m in depth in March to April. The summered germlings rapidly grow up to > 1 m in height in winter to fulfill the cage in the next reproductive period (March to April). The water temperature varied between 17.6 and 31.9 °C. Nutrients in the ambient water were as low as 0-3.54 µmol/l in NO3-N, 0-0.04 µmol/l in NO2-N, 0-2.67 µmol/l in NH4-N, 0-2.17 µmol/l in PO4-P and 0-35.49 µmol/l in SiO2-Si. To measure nutrient eluted from the above discoid blocks, a batch immersion tank experiment was practiced in the laboratory by exchanging and monitoring the water weekly; high concentration of NH4-N (20-80 µmol/l) were eluted for more than 3 months accompanied by the decrease of PO4-P and SiO2-Si. To visualize the effect of nutrient eluted from the fertilized molten slag blocks on algal physiology, introduction of yellowed thalli of common red alga Chondracanthus intermedius was useful because its thallus color turned red in the enriched conditions.

OR-39-04

Utilization of ephiphytic bacteria on a red alga Gracilariopsis chorda for algal growth

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An increased growth rate of an algal strain leads to an increase in its production. 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 produce bioactive substances such as enzymes and hemagglutinins (e.g. Kakita et al., Bot. Mar. 1997, J. Appl. Phycol. 1999. Bot. Mar. 2006). The effects of environmental factors and metal ions on the Japanese Gracilariaceae growth have already been reported (e.g. Kakita and Kamishima, J. Appl. Phycol. 2006). On the other hand, some kinds of seaweeds assimilate the vitamins and the phytohormones produced by an environmental microorganism, assisting algal growth. However, details of the environmental microorganisms on Japanese Gracilariaceae have never been reported on. Thus, in this study, to describe an interaction between Japanese G. chorda and its environmental microorganisms, the microorganism population and the flora on G. chorda were investigated. The effects of the environmental microorganisms on algal growth were also investigated. Seaweed 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) revealed that the predominant bacterial isolate UGC1-1 obtained from G. chorda closely to Ascidianbacter aurantiacus (Similarity 93.2%) (Flavobacteriaceae). The isolate UGC1-1 and a bacterial auxin, indole-3-acetic acid accelerated the growth of the red alga G. Chorda, and changed the amino acid and saccharide compositions of G. chroda. From these findings, the ephiphytic bacteria and bacterial products seem to be useful for the acceleration of algal growth.

OR-39-05

The Use of L. camara extract to Prevent Ice-ice Disease & Trigger Growth Rate of K. alvarezii

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Research on the use of plant extract Lantana camara has been carried out on the culture of seaweed Kappaphicus alvarezii both by experimental scale and mass culture at several locations in the coastal waters of South Konawe Southeast Sulawesi Province. The treatments were soaking seaweed seeds in solution of plant extract Lantana camara at various doses and different soaking time before rearing in coastal waters. Observed parameters are incidence of ice-ice disease and growth rate of seaweed. Results showed that during maintenance period, there was no incidence of ice-ice disease on which seaweed seedlings initially were soaked in Lantana camara extract. Healthy thalli had dark-colored and no ice-ice disease symptom, while seaweed seed without extract soaked treatment showed brightly colored and infected thalli parts were white. The result also showed that of Lantana camara extract was able to increase the growth rate, which the highest of absolute growth at a dose treatment of 500 ppm with 30 minutes soaking time. The average value of absolut growth was 387.15 g/clump or increase 12.9 times folding of the initial weight of 30 g/clump. The average highest of specific growth rate was 6.43 %/day, while seaweed seedlings without immersion in Lantana camara extract solution was only 5.86%/day. The highest average of production was 417.15 g/clump, while seaweed seeds without extract obtained an average yield of 295.70 g/clump. The highest average of carrageenan content was 53.5%, whereas treatment without extract immersion was 38.6%. Keywords: Lantana camara extract, Kappaphicus alvarezii

OR-40-01

Should South Australia increase its participation in the macroalgae value chain?

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South Australia is going through a major restructuring of its industrial landscape involving exit of the local automotive production, the resource industry moving from exploration to exploitation with focus on productivity improvements and cost reductions, uncertainties around the future defence industry and the impact of a period of low productivity growth. It is presently also in the aftermath of a Dutch disease period with release of labour from the resource industry and a lowering of the Australian Dollar exchange rate. In this situation it is important to try to identify new industries in which South Australia have the potential to participate successfully, industries that can form the basis for future growth. The paper reviews all the different stages in the value chain: Cultivation; Harvesting; Post Harvesting Processing; Storage; Transportation; Extraction; and Waste Handling. It looks at these stages from technological and

economic perspectives. The study concludes that South Australia have comparative advantages in the early stages of the macroalgae value chain. This provides a foundation for building a macroalgae aquaculture industry. Work needs to be done identifying suitable locations as well as developing the aquaculture tools (either locally or through establishing relationships with existing equipment providers) and techniques (it is likely that these techniques will be modifications of existing techniques in other parts of the world) for maximising both the economic and the biomass yield of whatever spices are selected.

OR-40-02

Opportunities, challenges and outlook of seaweed cultivation in Europe: an industry vision

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Seaweed cultivation is a significant economic sector in Asia, but in Europe the production is largely still at R&D scale. Several emerging societal issues such as population growth, climate change and limitation of land-based resources are expected to be strong drivers for greater utilization of marine habitats for the production of biomass, including cultivation of seaweeds. On the other hand, there are several constraints to such a development, among which some uncertainty in market demand, lack of processing technologies for valuable end products, and limited suitable sea space leading to potential concession issues. Hence it is unclear when seaweed cultivation turns commercially viable in Europe. Seaweed Energy Solutions AS (SES), based in Norway, is developing new technologies for industrial scale cultivation of seaweed in offshore waters. The company was established with a long term vision of producing seaweed biofuels, but production for higher value markets which can be commercialized at smaller scale is needed on a shorter tem. The company is currently operating a pilot farm in Norway at a scale of 100 ton wet weight, and has recently widened its focus on securing processing of the product and developing marketable products. This is a complex challenge that in addition to substantial public funding in the initial phase, requires solid partnerships. The technical and economical challenges of scaling up novel seaweed cultivation systems and the opportunities for commercialization in different markets, including projections for future cultivation costs and profitabilities at different volumes and time scales will be presented. Further, an industry vision of the needs for exploiting this market will be given, highlighting potential of and benefits for collaboration on technical and strategic level.

OR-40-03

Perceptions of kelp aquaculture and its social acceptability in Sweden

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The cultivation of kelps for food, fuel and other biobased commodities offers advantages compared to terrestrial equivalents, while also providing environmental goods and services. Despite having one of the longest coastlines of any European country, opportunities for kelp cultivation in Sweden are limited, primarily due to salinity, to the West Coast. Commonly regarded by Swedes as an area of outstanding natural beauty, a potential conflict of interests in terms of perceptions of seaweed farm aesthetics and impacts, has been identified as a specific hurdle to the long term sustainability of a seaweed industry in Sweden. This study marks an effort to benchmark both public attitudes toward and knowledge of aquaculture in this region and to shed some light on the social acceptability of kelp industry development scenarios for the West Coast. Analysis of 697 responses from residents of 16 municipalities bordering the Skagerrak and Kattegat Seas indicate a neutrality of opinion toward aquaculture as a whole. Further analysis revealed favourable perceptions of seaweed and mollusk aquaculture as opposed to slightly negative perceptions of fish aquaculture, partly for aesthetic reasons, but also due to concerns regarding impacts on other species, chemical leakage and water quality degradation. Finally, when presented with development scenarios for a kelp industry along the West Coast, a clear and consistent majority of respondents were favourable to the developments portrayed.

OR-40-04
Cost of commercial-scale offshore cultivation in the Faroe Islands using multiple partial cutting

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Ocean Rainforest Sp/F is a limited company located in the Faroe Islands, the North Atlantic Ocean, engaged in the production of marine biomass from macroalgae in open ocean cultivation installations. Ocean Rainforest has 13,500 m of macroalgae seed lines deployed in the Faroe Islands, where continuous nutrient-rich water, high current and stable sea temperature provide the perfect condition for seaweed farming. The company is developing methods for cultivating macroalgae with the purpose of moving this maritime resource away from a hunter-gathering style of procurement and into the realm of true aquaculture. The European macroalgae industry relies on wild harvest and growth is limited by ecological sustainability considerations. But sustainable large scale macroalgae cultivation can satisfy this demand. However, macroalgae cultivation needs increased knowledge and understanding of seasonal variation of growth rates and biological content development. This lack of knowledge is one of the main obstacle in making large scale production of macroalgae economically feasible. The macroalgae Saccharina latissima and Alaria esculenta is cultivated by Ocean Rainforest on a special designed long line installation (MacroAlgae Cultivation Rig - MACR), anchored in a water depth of 50-70 m and suited for harsh off shore conditions. The advantageous growth condition of the sea in the Faroe Islands enables multiple partial-cutting with harvest 4-7 times of the same macroalgae crop without re-seeding. This approach gives favourable opportunities for large scale commercial production - as seeding, hatchery phase and handling at sea is minimized. Current results found in the project MacroValue (2015-2018) funded by Nordic Innovation provides growth measurements on the perennial macroalgae biomass and cost data in relation to seeding, harvest, handling and sale. Within the project an economic analysis of key economic indicators is conducted.

OR-40-05
Introducing nephelometry for non-invasive biomass and growth monitoring macroalgae

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et al.

With the exponential development of algal aquaculture and blue biotechnology, there is a strong demand for simple, inexpensive, medium-throughput, quantitative phenotyping assays to measure the biomass, growth and fertility of algae and other marine protists. Here, we validate nephelometry, a method that relies on measuring the scattering of light by particles in suspension, as a non-invasive tool to measure in real-time the biomass of aquatic micro-organisms, such as microalgae, filamentous algae, as well as non-photosynthetic protists. Nephelometry is equally applicable than optic density and chlorophyll fluorescence measurements for the quantification of microalgae, but outperforms other spectroscopy methods to quantify the biomass of biofilm-forming and filamentous algae, highly pigmented samples and non-photosynthetic eukaryotes. Thanks to its insensitivity to the sample's pigmentation, nephelometry is also the method of choice when chlorophyll content is bound to vary between measurements, for example due to abiotic stress or pathogen infection. We illustrate how nephelometry can be combined with fluorometry or image analysis to monitor for example the quantity and time-course of spore release in fertile kelps or the progression of symptoms in diseased algal cultures.

PO-01-01

Pretreatment, saccharification and fermentation of algae for the production of bioethanol

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Algal biomass is a promising source of sugars for third-generation biofuel. Additionally, unlike other biomass feedstocks, such as corn or bagasse, has the potential to produce platform chemicals. The brown algae studied in this work are Macrocystis pyrifera collected off the coasts of the South of Chile. The main carbohydrate components of algae are alginate (a polymer consisting of 1,4-linked β-D-mannuronic acid and α-L-guluronic acid) and cellulose (a polysaccharide consisting of a linear chain of β-1,4-linked D-glucose units). The carbohydrate content of M. pyrifera was determined via gas chromatography. This algae was pretreated with water or dilute sulfuric acid, enzymatically saccharified with cellulases or alginases, and fermented into ethanol, using Saccharomyces cerevisiae or BAL1611 Escherichia coli. Simultaneous saccharification and fermentation of glucose with S. cerevisiae strain Ethanol Red® of M. pyrifera pretreated with dilute sulfuric acid/autoclaved, or with water/autoclaved pretreated M. pyrifera achieved 58.20 and 76.48 wt-% respectively of the theoretical yield for ethanol production. In terms of glucose and uronic acid fermentation with BAL1611 E. coli (which was kindly provided by BAL Company), sequential saccharification and fermentation of M. pyrifera pretreated with dilute sulfuric acid produced 0.206 g ethanol/g uronic acid + glucose, and residues pretreated with water produced 0.155 g ethanol/g uronic acid + glucose. These values reflect 39.5 wt-% and 29.8 wt-% respectively of the theoretical yield. The low production of ethanol could be due to the ratio between alginate, mannitol, and glucose in this algae, considering that E. coli BAL1611 requires greater concentration of mannitol. Future optimization of the operational conditions, such as a recombinant alginases, could further improve this process. Grant support: CONICYT (Project AKA-ERNC 0009), CeBiB (Project FB-0001) and The Academy of Finland (Grant N°: 125113 and 138448).

PO-01-03

Approach application of aldehyde bioflavor and gel for Kelp forest conservation

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Since sea urchin is the prominent pest of the Kelp forest and the enzymatic aldehyde formation [aldehyde bioflavor (B/F)] in Kelp, Saccharina angustata through lipoxygenase and hydroperoxide lyase pathway was reported. To overcome those B/F for Kelp culture under hypothesis that B/F which was immobilized by hydrogel using developed inclusion entrapment technique (bioflavor-hydrogel, B/F-HG) might be the attractant agent to remove the sea urchin from the Kelp forest. The evidence that corresponded to hypothesis was initiated. The first was identification and quantification aldehyde B/F in Kelp, S. angustata (Hokkaido, Japan) by GC/GCMS. Seven aldehyde were formed and the highest yield by maximized production was 2E-nonenal (4.3 g /g wet weight algae). The second was the effect of the attractant agent of B/F-HG on sea urchin behavior. Ball form of B/F-HG had been placed in the present of six sea urchins in a glass tank that contained the sea water to observe the preliminary effect by theirs expecting movement direction. Two of sea urchin moved to touch the B/F-HG and still remained around the B/F-HG. When the pieces of the Kelp and HG without B/F were placed near them, two of those sea urchins still stayed around B/F-HG. This evidence was confirmed by using two form of the B/F-HG (flat type and ball type). Each form of B/F-HG was compared with a piece of Kelp. The attraction of six sea urchins had been observed through the moving of them. At least five sea urchins moved to stay around the B/F-HG but not the Kelp. The last was the effect of the attractive agent of B/F-HG with aldehyde standard (the same type in S. angustata) to the sea urchin behavior. B/F-HG was compared among three treatments; they were B/F-HG with and

without standard aldehyde as same as in the Kelp and the Kelp. The movement of sea urchin to B/F-HG with standard was found. Aldehyde from kelp was confirmed as the attractive agent. This was promising useful idea for Kelp forest conservation.

PO-01-05

Sustainable fertilisers & biofuels from overabundant seaweeds for Pacific SIDS

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The recent upsurge in coastal macro-algal blooms in Pacific Islands such as Fiji, Tuvalu and the Marshall Islands has led to local research on sustainable ways to use this biomass for symptomatic control. Here we report on two best-practice initiatives using the over- abundant algal species Sargassum polycystum (Phaeophyceae) and Gracilaria edulis (Rhodophyceae) to convert them into low-cost organic liquid and solid fertilisers and biomethane using easily assembled anaerobic digesters. The emphasis of the research is to enable local island communities to develop their own low-cost biofertilisers and biofuel from seaweeds for their food and energy security needs, thereby reducing their dependence on chemical fertilisers and fossil fuels and improving their economic status. Preliminary controlled field experiments using G.edulis and S. polycystum fertliser on common Pacific food crops such as tomatoes, cabbage and capsicum obtained significantly positive results on growth, general plant health and yield. Similarly, anaerobic digestion of G. edulis and S. polycystum biomass using simple digesters demonstrated practical yields of bio-methane that could replace fossil and non-renewable energy sources currently in use by local communities. This research will have immediate and practical implications to improve food and energy security in SIDS faced with the negative impacts of climate change.

PO-01-06

Native agar quality of Gracilaria parvispora from coastal lagoons in the Southern Mexican Pacific

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Gracilaria species produced agar with low gel strength, but this genus is considered the second resource of this phycocolloid around the world. Since two decades ago, it was registered the presence of Gracilaria parvispora in different regions of the Mexican Pacific, especially in Oaxaca and Chiapas coasts. However, there are no studies about agar yield or quality from specimens sampled in these areas. The objective of this research was to assess the physical and chemical characteristics of agar extracted from G. parvispora collected in coastal lagoons of Oaxaca and Chiapas, in order to find some possible use. Samples were collected in the coastal lagoons of Oaxaca (San Vicente Beach) and Chiapas (Ballenato and Paredón beaches). The agar yield, gel strength, melting and gelling temperatures were determined for each native agar sample. Also 3,6-anhydrogalactose (3,6-AG) and sulfate contents were determined by resorcinol-acetal method (Yaphe & Arsenault 1965) and rhodizonate sodium method (Terho & Hartiala 1971), respectively. The agar yield was 14.8-18.4%, gel strength was 203-337 g cm-2, and gelling and melting temperature was 34.7-43.2 °C and 65.7-78.5 °C, respectively. 3,6-AG content was 28.6-32.0%, and sulfate content was 6.5-8.9%. The results show the following trend: agar from Ballenato Beach (Chiapas) showed better characteristics, followed by the ones obtained from Paredón Beach (Chiapas) and finally San Vicente Beach (Oaxaca). According to these results, the native agar extracted from G. parvispora shows good features when compared with those registered from other species of the same genus. Finally, the native agar extracted fails to reach the standards for food and industrial use, but there is a possibility for improved the quality by using an alkali treatment during the extraction process.

PO-01-07

A review : Therapeutic and medicinal utilities of marine macro algae

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Marine macro algae are commonly known as seaweeds, the amazing plants composed of pigments, high amount of nutrients, minerals, vitamins, organic and inorganic compounds which are useful for food industries, animal fodder, nutraceuticals, pharmaceuticals, medicinal and cosmoceuticals. Pharmaceutically marine macro algae have various implications such as treatment of cancer, gastrointestinal disorder, hepatic diseases, cardiovascular disease, diabetes, obesity, HIV, neurogenital disease. It contains a high amount of antioxidant, poly phenolic compounds and vitamins. Due its antioxidant activity, it inhibits the oxidation of the low density lipoproteins. It has antimicrobial activities against human pathogenic microrganism. Seaweeds extracts with saturated and unsaturated fatty acids predominantly myristic, palmitic, oleic and eicosapentaenoic acids attribute overall defense against pathogenic bacteria. Seaweeds derived product such as sulphated polysaccharides act as antiviral substances, halogenated furanones from Delisea pulchra active as antimicrobial compounds and Bryopsis sp. produce kahalalide F use for treatment of lung cancer, tumours and AIDS. The red algae comparatively show high anticholesterol activity than brown and green algae. The coralline calcareous red algae are used for preparing artificial bone which is applying for gap filling of broken bones. Seaweeds also have anticoagulant and anti-haemorrhagic activities. Due to its high content of micronutrients and minerals, diet supplement of seaweeds increase the haemoglobin and reduce anaemia. The various healing properties of seaweeds increase the interest and attention of researchers to focus the elaborative search of its importance. This review is mainly focused on the details of pharmaceutical and medicinal importance of seaweeds.

PO-01-08

Increased value of seaweed processing

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The aim of the present study was to explore different possibilities to utilize seaweed byproducts, thereby increasing the value of the seaweed processing. One class of secondary compounds in brown seaweeds are phlorotannins who have attracted special interest due to their bioactive properties. Isolating phlorotannins in a gentle yet efficient way is challenging. Marinox in collaboration with Matís has developed an extraction method of phlorotannin compounds in Fucus vesiculosus using a mild and solvent free method and filtration steps. During this process of phlorotannin extraction a certain amount of byproducts are generated which could be utilized. In this study the seaweed byproducts were chemically characterized and their bioactive properties studied in vitro using both chemical and cell based assays. We also extracted polysaccharides using weak acid hydrolysis for potential use in food, nutraceuticals or cosmetics. To explore further uses of seaweed byproducts we performed a feasibility study focusing on fertilizers and creation of high quality protein using Black soldier fly larvae aiming at the production of raw material for aquaculture feed. Finally, the possibility of using the seaweed byproducts as a carbon source for aerobic and anaerobic bacteria was investigated in preliminary studies.

PO-01-09

Extraction and quantification of phycobiliproteins from the red alga Furcellaria lumbricalis

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Phycobiliproteins are the main photosynthetic accessory pigments found in red algae (rhodophyta). The vivid color and strong fluorescent properties of these biomolecules make them valuable substances for various food and non-food applications, including cosmetics, medicinal diagnostics and biochemical studies. Among phycobiliproteins, the red coloured phycoerythrin and the blue phycocyanin are the most widely exploited natural colorants. There are not many raw-materials suitable for the effective phycobiliprotein extraction as red algae often contain cold-water soluble viscous polysaccharides (e.g. lambda and iota carrageenans) making the extraction process rather complicated. The red alga Furcellaria lumbricalis (Hudson) J. V. Lamouroux is the only seaweed species of industrial use in the Baltic region. Historically,

the galactan mixture from F. lumbricalis (named furcellaran or so-called 'Danish agar') was one of the first hydrocolloids to have been industrially produced from red algae. The poor solubility of furcellaran in cold water makes F. lumbricalis a prospective raw material for phycobiliprotein extraction. In this study the phycobiliproteins were isolated from the fresh and dried biomass or F. lumbricalis originating from the Baltic Sea, Estonia. The effect of collection season, storage, drying, homogenization and extraction conditions (pH, solvent, temperature, processing duration) on the yield of phycobiliprotein extraction was investigated. F. lumbricalis was found to be a promising raw-material for phycobiliprotein extraction, containing 0.1% of R-phycoerythrin on the basis of the dried algae and very small amounts of phycocyanin.

PO-01-10

Characterization of PMM genes and analysis of its transcriptions to Saccharina japonica

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Saccharina japonica one of the most important commercial brown seaweed, the fucoidan and alginate are the unique bioactive substances in the kelp, and their metabolism for the fucoidan and alginate synthesis is important. Phosphomannomutase (PMM) is one crucial enzyme during the synthesis of fucoidan and alginate. To characterize the structure and activities of PMM, we obtained the two Sjpmm1 and Sjpmm2 sequences through the RACE amplification, and concluded that Sjpmm1 belongs to the HAD superfamily, with the length of open reading frame (ORF) of Sjpmm1 is 759 bp, which encoding a protein of 252 amino acids, presumed molecular weight (MV) at 28.51 kDa and the PI was 4.89; while to the Sjpmm2, it belonged to the member of phosphohexomutase super-family, with the ORF region of 759 bp, which encoding 621 amino acids, and the presumed MV was 66.49 kDa and PI was 5.32. Stereo structure simulation indicated that α-helix is the major structure to Sjpmm1 and Sjpmm2. Phylogenetic analysis showed that SJPMN1was evolved from the ancient eukaryotes, while SJPMM2 was originated from the primary endosymbiosis. The transcriptional analysis indicated that both lower and higher temperature could increse transcriptions to Sjpmm1 and Sjpmm2, which implied that the synthesize abilities for fucoidan was increased, similar analysis were conducted to the different growth stages of the kelp. Finally, the high-concentration fusion protein SjPMM1 was successfully expressed with pMAL-c5X systems, and ideal for the enzymes properties study and followed high yielding of fucoidan and alginate.

PO-01-12

Antioxidant and hepatoprotective effect of fucoidans from brown algae of Yucatan Peninsula

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Reactive oxygen species (ROS) are involved in the initiating and promoting hepatic diseases. Efficient antioxidant molecules that scavenge radicals or neutralize ROS may prevent liver diseases. Fucoidans from several tropical algal species have shown pharmacological activities including antioxidant and antiinflammatory effects. This study determined the antioxidant and hepatoprotective activity of water extracted fucoidans from three species collected at Caribbean coast of the Yucatan Peninsula: Dictyota ciliolata, Sargassum fluitans and Padina sanctae-crucis. The chemical composition and structure of the fucoidans extracts were determined by Fourier transform infrared spectroscopy (FTIR) and nuclear magnetic resonance (NMR). The antioxidant potential was determined by the 2,2-diphenyl-1- picrylhydrazyl (DPPH) radical scavenging assay. The cytotoxicity was determined in human hepatoma cell (HepG2) and human embryonic kidney cells (Hek-293). The hepatoprotective effect was evaluated by using the hydrogen peroxide (H2O2)-induced toxicity on HepG2 cells. In order to assess the possible mechanisms of hepatoprotection of the fucoidan extracts, ROS intracellular inhibition, glutathione (GSH) level, and catalase (CAT) activity were determined. The fucoidan extracts showed good hability to scavenging DPPH radicals. None of the fucoidans were cytotoxic and showed a good hepatoprotective effect dose dependent. All fucoidans reduced the ROS generation ($p<0.01$), increased the level of GSH ($p<0.01$) and modulated the CAT activity ($p<0.01$) at a concentration of 0.5 mg/mL. The potential use of these extracts as a supplement in the prevention of hepatic damage is discussed. Financial support CONACYT PDCPN 2014 248004.

PO-01-13

Extraction of polysaccharides from four Irish seaweeds

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Background: Many methods have been developed for extraction of seaweed polysaccharides. However, most, as well as being difficult to scale-up industrially, are not cost-effective, food grade, or environmentally-friendly. Polysaccharides vary between species, harvest location, season, and, developmental conditions making it difficult to identify a well-defined, single-step, extraction process that optimally extracts phycocolloids regardless of type and source. Known bioactivities of seaweed polysaccharides are related to composition, molecular weight and structure which are all impacted by extraction method. This study aimed to establish an industrially relevant process for extracting polysaccharides. Methods: Four edible seaweeds were harvested, cleaned of epiphytes and grazers, and processed into a lyophilized powder. The dried powders were extracted using a range of different extractants including; hot and cold water, acids (citric acid, acetic acid, and HCl), and alkalis (CaCl2, ammonium oxalate and NaOH) of different strengths, and chelators (e.g. EDTA and cadoxen); variables including temperature and molarity of extractant were investigated. A wide range of enzyme preparations were used to degrade the cell wall and extract various seaweed polysaccharides including; Driselase, cellulase, xylanase and Viscozyme. The dried algal powder was also subjected to a range of pretreatment washes using polar and non-polar solvents. Crude extract composition was analyzed using a range of colorimetric assays, acid/enzyme hydrolysis and thin-layer chromatography. Polysaccharide yield was assessed using the Dubois assay and uronic acid and sulfate content determined using the colorimeter assays. Findings: The highest polysaccharide yields resulted from extractions with water, HCl, and citric acid. Enzyme cell wall degradation yielded large amount of polysaccharide. Viscozyme also proved to be highly efficient in hydrolyzing polysaccharide extracts.

PO-01-14

Seasonal variation in anti-proliferative activity of tropical brown alga against GLC4/Adr cell line

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The present study aimed to investigate the anti-proliferative activity of the extracts of Sargassum binderi and S. oligocystum, against adriamycin-resistant human small cell lung carcinoma cell line (GLC4/Adr). The sample was collected from Nang Rong Beach, Chonburi province, Thailand during February (summer), May (per-monsoon) and August (monsoon). Four different extracts were obtained; ethoanolic extracts (E1), lipophilic extract (E2), polysaccharide extracted by acid (E3) and polysaccharide extracted by alkali (E4). The anti-proliferative activity of the extracts was found to be subject to seasonal variation, with the highest level of activity recorded from samples collected in August. The E2 extracts showed highest anti-proliferative activity with IC50 (The half maximal inhibitory concentration) of 3.20 ± 0.15 µg/mL for S. binderi and 2.52 ± 0.54 µg/mL for S. oligocystum. Moreover, the anti-proliferative activity showed positive correlation with vitamin E (□-tocopherol) in extracts. However, there are not clearly correlation between polyphenol or fucoxanthin contents and anti-proliferative activity. These results indicated that the extracts of Sargassum spp. found in Thailand had a potential as an alternative source for cancer treatment in the future.

PO-01-15

Extracts from Ulva lactuca on seddling growth of Vigna radiata and toxicity in Raphanus sativus

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The seaweed extracts contain a variety of compounds as macro and micronutrients and plant growth regulations that could be utilized by the plants. It is known that these extracts can have both negative and positive effects (depending on concentration) when are applied directly on seeds and plants. In the present study five extracts of Ulva lactuca (UL2, UL4, UL6, UL8 and UL10) were obtained by hydrolysis with different concentrations of H2SO4. Chemical composition of seaweed and Fourier transform infrared analysis was used as method for the quantification of the main chemical constituents from acid seaweed extracts, revealed interactions of amino, carboxyl, and sulphonate groups. The extracts were tested at different concentrations under the germination and seedling growth of mung bean (Vigna radiata) and toxicity red radish (Raphanus sativus). All extracts at low concentrations (0.2 to 0.4 %) caused high germination percentage of mung bean. The treatments of UL6, UL8 and UL10 induced 100 % of germination in bean seeds. The growth of mung bean seedling with UL6 at 0.2 % caused superior root growth (8 cm) and

the major number of adventitious roots (37) compared to the control (6.5 cm and 16 respectively), the treatment of UL2 at 0.2 % had the highest stem length (10.45 cm) and greater dry weight (0.256 g). Most total length of the seedlings was observed with extracts UL6 and UL2 at 0.2% with a maximum of 18 cm. Furthermore, the results of the toxicity test conducted in red radish suggest that extracts at high concentrations (> 1.0 %) have toxicity, which is reflected in the damage observed in plants such as browning and decay of roots.

PO-01-16

Activity of polysaccharide enriched extracts from seaweeds as growth promoters of plants

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Although marine seaweeds have been used as biostimulants since the beginning of modern agriculture, studies have only recently focused on the ability of seaweed extracts and their polysaccharides to enhance growth of plants. In this work, two bioassays were carried out to study the growth-promoting activity of polysaccharide enriched extracts from Ulva lactuca and Padina gymnospora, obtained in neutral (N-PEEs) and alkaline (A-PEEs) conditions. Initially, the effect of polysaccharide enriched extracts on seed germination and growth-promoting activity on tomato (Solanum lycopersicum cv. Río Grande) plants under in vitro conditions was studied. Half-strength Murashige-Skoog (MS) medium with or without sucrose was supplemented with different concentrations of polysaccharide enriched extracts (0.2, 0.4 and 1.0 mg mL-1). The parameters evaluated were germination percentage, radicle and shoot length and dry weight. In a second experiment, polysaccharide enriched extracts at 1.0 mg mL-1 and indole-3-butyric acid as the control were studied for root inducer activity in mung bean (Vigna radiata). The majority of polysaccharide enriched extracts obtained from U. lactuca and P. gymnospora promoted germination and stimulated growth of tomato plants compared to the controls. Additionally, treatment of mung bean hypocotyl cuttings with polysaccharide enriched extracts of U. lactuca and P. gymnospora induced rooting more rapidly and in greater number compared to the controls when tested at a concentration of 1.0 mg mL-1. The greatest number of roots was achieved with polysaccharide enriched extracts obtained with neutral rather than alkaline conditions. The N-PEE of U. lactuca exhibited higher number or root than equivalents IBA to 10-3. In contrast, A-PEE conditions presented low number of roots. These results provide evidence that polysaccharide enriched extracts act as an effective growth-promoting treatment.

PO-01-17

Fusion of two process for obtain seaweeds extracts with stimulant effects in land crops

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Liquid extracts made from algae (ELA's) have a bio-stimulating effect that promotes the development and growth of terrestrial plants. This effect is attributed to their growth regulators such as phytohormones, polysaccharides and nutrients released during hydrolysis. The effect may vary with each group of algae and extraction process used in its preparation. Based on these considerations, the objective of this work was to determine the best process for the production of an extract from three species of algae (Ulva lactuca, Acanthophora spicifera, Eisenia arborea), and mixtures thereof, comparing two extraction processes: water bath (BM) and autoclave alkaline phase (AFA) and the addition of the cyanobacterium Arthrospira maxima supplement and assess the effect of these extracts on the growth of terrestrial plants. The effectiveness of ELA's in vitro and in vivo (hydroponics) of mung bean (Vigna radiata), red radish (Raphanus sativus) and romaine lettuce (Lactuca sativa) was evaluated. There were significant differences between extraction methods and a synergistic effect in combining the ELA'S of two algal species. Effect of promoter activity on growth was dependent on the crop assessed. In the in vitro cultivation of mung bean, extracts with the best effects were those produced in tests using AFA and the alga E. arborea. In the cultivation of radish, the most effective extract was made with AFA and U. lactuca + A. spicifera. Lettuce growth was enhanced by more than one extract, the most prominent being ELA's made with U. lactuca and A. spicifera + U. lactuca. In vivo tests showed that plants treated with ELA's mixtures of: U. lactuca

+ A. spicifera produced in AFA, U. lactuca + E. arborea produced in BM and the positive control, had a greater resistance to high temperatures (12 weeks 35- 41 °C), and those plants treated with a mixture of U. lactuca + A. spicifera were resistant to pests.

PO-01-18

Bioactive compounds in the alien species Undaria pinnatifida (Laminariales, Phaeophyceae)

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The interest in marine seaweeds as a potential and promising source of pharmaceutical agents has increased during the last years. In particular, some macroalgae were reported to produce chemicals that have potent antibacterial, antialgal, antifungal, and antitumoral properties. Importantly, it is known that seaweeds often produce salt-stable antimicrobial compounds useful in the control of fish or shellfish pathogens in aquaculture where the high-salt conditions might reduce antibiotic efficacy. The seaweed Undaria pinnatifida (Harvey) Suringar is a cold-temperate species coming from China, Japan and Korea that during the early 1990s was recorded, as a new introduced species, near the fishing markets of Chioggia and Venice (Italy) and rapidly colonized the hard substrata. In the Mediterranean Sea, it is also reported in the Thau Lagoon (France) and was present in the Mar Piccolo of Taranto (Ionian Sea, southern Italy) until 2009. The species strongly attaches to the substratum by means of thick rhizoids and the eradication is very difficult and expensive. In this investigation U. pinnatifida was collected in the Venice Lagoon (northern Adriatic Sea, Italy), washed and then blades were dried and powdered. The powdered material was subjected to Soxhlet extraction using choloroform/methanol (2:1 at 55-60 °C for 24 h). Five milligrams of extract were dissolved in ethanol and assayed for antimicrobial activity using the Kirby Bauer method (1966). The lipidic extract of U. pinnatifida blade showed an antibacterial activity against six tested Vibrio species V. litoralis, V. mediterranei, V. inusitatus. V. diazotrophicus, V. chagasii and V. splendidus. The results of these tests are noteworthy, considering that public health hazards related to antimicrobial use and the development of antimicrobial-resistant bacteria represent a serious treat for the aquaculture sector and that vibrios produce fish and shellfish diseases.

PO-01-19

Effects of seaweed extracts on the growth of Arabidopsis thaliana under salinity stress

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Methanolic and aqueous extracts of three seaweeds (Kapphycus alvarezii - KP, Sargassum filipendula – SG and Ascophyllum nodosum - AS) were tested on Arabidopsis thaliana to evaluate their effect on plant growth under salinity stress. Firstly, seaweed extracts (SE) concentrations (ranging from 0.01 to 1.0 mg mL-1) were established, and after tested in plants under salinity stress. SE were obtained by incubating seaweed samples in methanol for two hours (methanolic) and after in 50°C water for one hour (aqueous), in constant agitation, and concentrated to 100 mg mL-1 in nitrogen flux. SE were added to A. thaliana M/S culture medium enriched with B complex vitamins, 1% sucrose, solidified in 0.8% agar, in the presence or absence of 50 mM NaCl. After seven days, the length of the main root, number of lateral roots, linear length of all roots and the dry weight of shoots were measured. Higher concentrations (0.5 and 1.0 mg mL-1) of SE inhibited plant growth; therefore 0.01, 0.03 and 0.05 mg mL-1 concentrations were tested on plants cultivated under salinity stress. All SE significantly stimulated ($p<0.05$) the linear length of roots under salinity stress, which reached 15.03 ±1.62 cm (0.01 mg mL-1 KP), 16.27 ±1.62 cm (0.05 mg mL-1 SG) and 14.63 ±1.61cm (0.05 mg mL-1 AS) in methanolic extracts, compared to 10.41 ±1.62 cm in control (mean ± confidence interval). No significant differences were observed in the number of lateral roots or dry weight in all methanolic SE. In addition, aqueous SE presented significant differences only in linear length of roots in NaCl stressed plants treated with 0.03 mg mL-1 SG (15.67± 3.67 cm) in relation to control (10.41 ± 1.62 cm). Based on these results, we conclude that methanolic extracts of K. alvarezii (at 0.01 mg mL-1) and both S. filipendula and A. nodosum (at 0.05 mg mL 1), as well as aqueous extract of S. filipendula (at 0.03 mg mL-1) showed bioactivity and may improve the growth of A. thaliana under salinity stress.

PO-01-20

Purification and bioactivity of polysaccharide fractions from Palmaria palmata

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Many seaweed species are part of traditional food and in the north Palmaria palmata served as a snack. In recent years, studies have shown that seaweed can have beneficial effects as well as being nutritious. P. palmata contains unique polysaccharides with interesting properties. These polysaccharides were purified, using enzymatic methods, and their bioactivity studied. In this study, seaweed collected in Norway was used. These polysaccharide fractions were studied using TLC, enzyme hydrolysis and HPLC. We put these fractions through several bioactivity assays (including DPPH, ORAC and anti-diabetic enzymatic assays). These polysaccharides are good for both human consumption and as animal feed, with high amount of dietary fibers, but we will discuss their bioactivity which need to be considered before these applications. This work is part of PROMAC, funded by the Research Council of Norway, through the BIONÆR (Sustainable Innovation in Food and Bio-based Industries) programme.

PO-01-21

Determination of SPF number of seaweeds from Drini Beach Gunung Kidul, Yogyakarta, Indonesia

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The objective of this research was to determine the ultraviolet (UV) protection absorption properties of three species of seaweed from Drini Beach Gunung Kidul, Indonesia. This research was conducted with determination of SPF number. The in vitro SPF number is determined according to the spectrophotometric method and calculated by applying Mansur mathematical equation. The results showed that seaweeds have potency as UV protector. Keyword: seaweed, UV absorption, sun protection factor

PO-01-22

Sargassum cymosum and Ascophyllum nodosum extracts as biostimulants of red rice growth

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In the last years, the interest of seaweed extracts as growth promoters and biostimulants in crops has been increased. This work investigated the biostimulant effect of alkaline extracts of Sargassum cymosum and Ascophyllum nodosum in the germination and growth of red rice seedlings (Rubi variety). Dried and crushed samples (1000 g fresh weight) of S. cymosum and A. nodosum were added in 1000 mL of 1.5 M KOH solution. Fifty rice seeds were placed on Germitest paper towel and sprayed with 2.5 times the mass of paper towel of distilled water (control) or seaweed extracts (in concentrations of 0.1, 0.5, 0.75, and 1.0 g L-1). Four replicates were made for each treatment and control. The seeds were kept in germination chamber for 7 days at 25°C in 12h photoperiod. Rice seedlings treated with extracts had significantly higher growth rates ($p<0.05$) in relation to control. Seedlings treated with 0.75g L-1 S. cymosum extract and 0.5 g L-1 and 0.75 g L-1 A. nodosum extracts increased 18% and 15% the aerial part and 19% and 15% the roots, respectively, in comparison to control. Highest concentration of A. nodosum extract (1.0 g L-1) was inhibitory to the seedlings growing. The results showed the stimulant effect of the brown seaweed extracts on the growth of red strain rice seedlings, with superior performance of S. cymosum.

PO-01-24

Towards a novel ultra-high viscosity alginate scaffold for cardiac tissue engineering

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Approximately 50% off all deaths in Europe are caused by cardiovascular diseases. To relief the burden of cardiac pathologies, researchers lack cardiac models that fully reflect the heart. Thus a new cardiac muscle model is developed to satisfy worldwide demand. One of the main problems with conventional heart muscle models is that the stiffness of conventional cell culture plastic cannot recapitulate the soft and elastic environment of the physiological heart. Therefore, ultra-high viscosity (UHV) alginate, a biopolymer obtained from a special blend of algae (L. nigrescens and L. trabeculata) is used to engineer a cardiac scaffold. UHV Alginate is highly biocompatible and its stiffness can be adjusted accordingly to the needs; gelling is induced under mild conditions and a broad range of surface modifications can mimic the natural cell microenvironment, including that of the heart. Hydrogel scaffolds are engineered with the Bioscaffolder (GeSim), a 3D printer executing additive layer manufacturing. The scaffolds generated are then seeded with induced pluripotent stem cell (hiPSC) - derived cardiomyocytes (CMs) to create a model system closely resembling the physiology of the cardiac muscle. Cardiomyocyte-populated scaffolds are characterized by means of gene expression profiling by qPCR and immunocytochemistry, to combine the molecular signature with the morphology and cytoskeletal arrangements of the cells. Furthermore, contraction profiles are investigated to evaluate the functionality of the CM-populated scaffold as a whole. The Cardiopatch can be maintained in culture for long term, showing spontaneous synchronized depolarization over the whole time period, supporting the resemblance of our constructs to the physiological conditions of a living organism. In conclusion, UHV alginate's superior physical chemical features make it an exceptional substrate for tissue engineering applications.

PO-01-25

RIV-ALG, an applied project on the isolation of active ingredients for cosmetic applications

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Marine plants, i.e. macroalgae and halophytes, living in coastal areas, are subjected to numerous environmental factors, which can be negative for their physiology. Face to these stresses, some species are able to develop chemical strategies, in producing some protective and original molecules known to be extremely active and acting at low concentration. The research project RIV-ALG was built in joining academic and industrial partners with the aims at (1) selecting abundant marine plants from the region Brittany, (2) isolating active molecules at laboratory scale (academic partner LEMAR) and (3) including active ingredients in cosmetic products (SME Science & Mer). The project gathers 2 partners, UBO and Science & Mer, around fundamental and applied research topics. We present our approach to isolate active molecules using eco-friendly processes for extraction and purification, but also our interest to find applications using invasive species (a pest for the environment). Natural compounds of concern present antioxidant, antimicrobial and photoprotective properties. A discussion is addressed about the actual synthetic ingredients which could be replaced by these natural ingredients, more and more popular in the cosmetic industry. The project RIV-ALG was financed with the support of a regional program (AAP CRITT SANTE 2013 n. 13006760) from Brittany

PO-01-26

Potential habitat and bioactive compounds from brown algae in Lombok Island (Indonesia)

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Brown algae have not been massively cultivated in Indonesia. Their existence relies heavily on their natural population growing naturally in their habitat. Nevertheless, it is predicted a decrease of these natural populations, due to dramatic environmental and anthropogenic stresses along Indonesian coastal areas. This study was carried on Lombok Island-Indonesia, a pilot area of the seaweed aquaculture development in blue economy concept. The purpose of this research is to identify the potential habitat and the bioactive compounds of three brown macroalgal species: Sargassum polycystum, Padina australis and Turbinaria conoïdes, forming abundant populations in Lombok Island. The environmental data collected from the field such as turbidity, types of substrate and biomass of macroalgae were collected in different seasons. Bathymetry, tide and current velocities have been estimated from local data and numerical modeling. Based on all environmental data, the WorldView-2 imagery showed the mapping of three brown algae habitat in regions shallower than 3 m. Concerning the production of natural products, the highest total phenolic content on purified fractions was found in Padina australis and Sargassum polycystum, with respectively 43,9 ± 4,2 mg/g DW in dry season and 37,8 ± 2,6 mg/g DW in rainy season, after an EtOH:water 25:75 extraction. The results of this research were discussed for promising and present encouraging perspectives about the potential development, conservation and aquaculture management of brown seaweeds in Indonesia.

PO-01-27

Antiviral and cytotoxic activities of four seaweeds from Yucatan Peninsula

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Viral infections are a public health problem around the world. Tropical algae could be a potential source of compounds with antiviral activity. The cytotoxic and antiviral activities of four species of tropical macroalgae (Rhodymenia pseudopalmata, Solieria filiformis, Hydropuntia cornea and Sargassum fluitans) from the Yucatan Peninsula were evaluated using cytopathic assay on Vero cells lines infected with Herpes simplex virus (type I). Initially the lyophilized biomass was degreased and depigmented using acetone and methanol. Subsequently, hot water extraction was performed and the polysaccharides precipitated by adding absolute ethanol. Chemical characterization of extracts was done using infrared spectroscopy. The preliminary chemical characterization showed the presence of agar in H. cornea; an agaroid type in R. pseudopalmata; carrageenan in S. filiformis and a mixture of fucoidan and alginate in S. fluitans. Cytotoxic and antiviral activities were performed with each of the polysaccharide extract using standardized red neutral assay. None of the four polysaccharide extracts was toxic towards cells lines (CC50 > 200 µg/ml). S. fluitans (IC50 = 42.8 µg/ml) and S. filiformis (IC50 = 136.0 µg/ml) showed a significant antiviral activity. Both S. filiformis and S. fluitans extracts could be evaluated further against Herpes simplex virus to understand their pharmacological action mechanism.

PO-01-28

Ulva rigida from San Jorge Gulf, Argentina: Pharmacological aspects and traditional uses.

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The genus Ulva is used in traditional medicine; original people from Patagonia Argentina (Tehuelches and Mapuches) had used Ulva ("lúa", "luga-luga") for the treatment of diseases (scrofula, internal inflammations and gout). In previous studies we showed bioactivity in Ulva rigida (Ulvaceae), for this reason we selected this alga for analysis of anti-inflammatory, antinociceptive and antiproliferative activity. Ulva rigida was collected in San Jorge Gulf in spring (Patagonia Argentina). Metabolites were extracted from the dried powder of the fronds with water at 100 °C by 20 minutes. We analyze the chemical composition in carbohydrate (Phenol-Sulphuric's method), proteins (Lowry's method), sulfate (Dodgson and Price's method), uronic acid (Blumenkrantz and Asboe-Hansen's method), total phenols (Folin-Ciocalteu's method). Antinociceptive activity was analyzed with acetic acid test. Anti-inflammatory activity was analyzed with auricular edema by tetradecanoylphorbol acetate (TPA) in mice and carragenan-induced leg edema in rats. Antiproliferative activity was analyzed with Caco-2 and MCF-7 cells cultured

in DMEM, 10% FBS, 2 mM glutamine, 10 U/L peniciline and 100 µg/mL estreptomicine, in 5 % de CO2. Antinociceptive inhibition was shown of 97.61 % (dose of 500 mg/Kg), anti-inflammatory activity was shown 57.9 % after 3 hours of carragenan-induced, auricular edema by TPA didn't show activity. Antiproliferative activity was shown 40 % of inhibition from CaCo-2 cells (1 mg/ml to 0.25 mg/ml), and 40 % of inhibition from MCF-7 cells (0.125 mg/ml). Seaweeds are an important source of metabolites that have shown promising bioactivities. Among the compounds responsible for this activity, they are highlighted sulfated polysaccharides. In decoction we determine the presence of oligosaccharides enriched in rhamnose, xylose and/or arabinose, galactose residues with heavily sulfated. This bioactivity explains the use of these algae that gave the original peoples from Patagonia.

PO-01-29

Seasonal Variations in the Proximate Composition of the Southern Caspian Sea Macroalgae

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As the first organisms in marine food chain, macroalgae provide nutrients for other living organisms. They also provide shelter and habitat for many coastal animals. Two representative of green algae (Cladophora glomerata, Enteromorpha intestinalis) and one red alga species (Laurencia caspica) were collected from eight sampling stations along the southern coasts of the Caspian Sea (Astara, Anzali Port, Chamkhaleh, Ramsar, Sisangan, Babolsar, Amirabad Port and Khajeh nafas) from spring to winter 2014. The investigated species demonstrated high protein contents (6.83±0.36 - 35.09±1.88 %DW), carbohydrate (13.85±0.93 - 28.20±1.88 %DW) and ash content (9.7±0.31 to 40.00±1.30 %DW) and low lipid compositions (0.1±0.01 - 2.7±0.25 %DW). The highest values of carbohydrate, protein and lipid were detected in summer and winter, respectively. Palmitic (C16:0) and miristic acid (C14:0) were recorded as the most abundant saturated fatty acids. Oleic (C18:1n-9) and palmitoleic acids (C16:1n-7) were presented as the major monounsaturated fatty acids. Linoleic acid (C18:2n-6) in C. glomerata, α-linoleic acid (C18:3n-3) in E. intestinalis and arachidonic acid (C20:4n-6) in L. caspica were detected as the predominant polyunsaturated fatty acids.

PO-01-31

Antioxidant capacity and anti-UV compounds increase in Rhodymenia pseudopalmata under IMTA

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Rhodymenia pseudopalmata inhabits the intertidal zone of the Mexican Caribbean coast where it´s subjected to highly variable environment. It has been shown that oxidative stress can be reduced in presence of dissolved inorganic N-compounds. In this regard, marine aquaculture effluents can supply high quantities of N-compounds to macroalgae which can effectively remove them by biofiltration and produce biomass (Integrated Multitrophic Aquaculture). The aim of this research was to evaluate the physiological and biochemical responses of R. pseudopalmata to solar exposition using the Maximum Quantum Yield of PSII (Fv/Fm), the Antioxidant capacity and the composition of Anti-UV compounds as proxies. R. pseudopalmata were transferred from indoor conditions under low artificial light to outdoor conditions in order to expose to high solar radiation. Transparent acrylic exposition chambers integrated to marine fish effluents were used to culture R. pseudopalmata. Plants were taken each two days during seven days. R. pseudopalmata showed an average SGR of 3.79 ± 0.79 % d-1, even when exposed to high solar radiation. Photoinhibition of PSII was noted as solar irradiance increased from sunrise 0.64 ± 0.02 to midday 0.03 ± 0.05, nevertheless Fv/Fm recover as irradiance decreased. The extent exposure to solar radiation show a significant increase in DPPH antioxidant activity, EC50 decreasing from day one to day seven (6.17 ± 0.06 to 3.55 ± 0.11 mg mL-1), while total phenolic content showed a slightly increase at day five (40.3 ± 0.5 to 45.7 ± 5.4 µg GAE mg DW-1). Anti-UV compounds were detected by HPLC-DAD, six unknown compounds absorbing in the UV-range characteristic for MAAs were found. These compounds showed a λmax of 332, 327, 328, 367, 325, 333 nm and retention times at 42.05, 46.5, 54.5, 56.3, 72.7, 87.7 min. The number of anti-UV compounds detected in R. pseudopalmata subjected to solar exposure increase when compared to those detected in non-exposed or wild population.

PO-01-32

Different extraction procedures and analysis of protein from Ulva sp. in Brittany, France

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Seaweeds are well recognized as an alternative protein source. The edible green seaweed, Ulva sp. is well abundant in the Brittany Coast, France and five different extraction procedures (Procedure 1: distilled water DW, Procedure 2: lysis solution 1 contains, 8 M urea, 2% tween 20, 2% triton X-100, 30 mM dithiothreitol, and 1% polyvinylpyrolidine; Procedure 3: lysis solution 2 contains, 50 mM Tris-HCl buffer pH 8, 10 mM EDTA, 2 mM Na2S2O5, and 1% triton X-100; Procedure 4: 50 mM Tris-HCl buffer, pH 8) were performed to extract Ulva proteins. The BSA colorimetric assay with bovine serum albumin as the standard was used to determine the extracted protein content in all extracts. The protein contents (%) in the above extracts from Procedures 1-4 were 4.36 ± 0.21, 11.88 ± 0.23, 10.34 ± 0.35, and 3.58 ± 0.48, respectively. Moreover, Ulva sp. was subjected to enzymatic hydrolysis (1% enzyme v/w) with Neutrase, Alcalase, Viscozyme, and Termamyl at 50̊ C for 5 h and the yielded protein contents were assessed for comparison. Furthermore, electrophoresis (PAGE) and MALDI-TOF/MS techniques were applied to further proteomic analysis of each extracts. Collectively, the results revealed that the protein extracted from Ulva sp. varies according to the extraction procedures. The analysis of amino acid compositions and studying the sugar-protein relationship of the extracted protein fractions from Ulva sp. are in progress. Keywords: Ulva sp.; Seaweeds; Seaweed proteins; Biochemical analysis; Nutraceuticals

PO-01-33

Seasonal variation of nitrogenous components of red seaweeds, Palmaria palmata and Chondrus crispus

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With an increasing global population and a corresponding increased demand for high quality and sustainable food, the oceans present a largely underexploited resource for responsible and renewable food production. Macroalgae (seaweeds) are a protein-rich and abundant food ,e.g., Porphyra tenera has been reported to contain 47% protein dry weight (dw). However, reported protein content may be misleading as a generic nitrogen-to-protein conversion factor of 6.25 is used to convert total nitrogen to protein. The quantification of total nitrogen (TN), protein nitrogen (PN) and non-protein nitrogen (NPN) as a function of season and geographical location is currently underway for the native Irish macroalgal species, Palmaria palmata and Chondrus crispus gathered bimestrially from three sites on the West coast of Ireland. This analysis has been carried out using the Kjeldahl Nitrogen determination method, with the PN and NPN fractions separated using trichloroacetic acid precipitation. Seasonal variation of the nitrogenous components has been observed, for example, Palmaria palmata and Chondrus crispus samples have shown variation in PN, ranging from 19.60±0.6 to 30.23±0.5 mg/g dw and 18.6±0.5 to 26.40±0.5mg/g dw, respectively, corresponding with a relative increase in TN content. The NPN fraction, which has often previously been included in analyses as protein nitrogen accounts for on avarage ~25% of the TN. Characterisation of the protein profiles of the macroalgae was performed by sodium dodecyl sulphate polyacrylamide gel electrophoresis. Differences have been observed in the protein profiles of the two species, with bands varying in intensity with season and geographical location. The data gathered will be cross-referenced with parallel bioactivity assessments, with the aim of providing an insight into the effects of growth conditions on the nitrogenous components in these macroalgal species.

PO-01-34

A red alga Gracilariopsis chorda is a source of a mitogenic hemagglutinin

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Seaweeds are expected to possess bioactive substances different from terrestrial ones, because sea and land environment are quite different each other. But raw materials for industry obtained from seaweeds are relatively few when compared with those originating from terrestrial plants. The discovery of new algal products and biological activities will help to expend the seaweed industry. The seaweeds possess many kinds of bioactive substances such as anti-tumor polysaccharides, anti-microbial components and hemagglutinins. We have never found any mitogenic activity in a polysaccharide hemagglutinin derived from Japanese seaweeds. Therefore, we surveyed seventeen species of seaweeds, which naturally occurred in the Inland Sea, for hemagglutinins and mitogens. After collection, algal specimens were

washed in sterile seawater and water, then freeze-dried, and stored at -20ºC until use. Hemagglutinating and mitogenic activities in an algal extract were measured. A rabbit erythrocyte and a sheep erythrocyte suspension treated with pronase (SETP) were used as standard erythrocytes for hemagglutinating activity assay. Chemical analysis for protein, saccharide, and sulphate contents were carried out. Among the seaweeds tested, one species of green alga, Ulva lactuca, four species of red algae, Gelidium elegans, Gloiopeltis furcara, Gracilaria vermiculophylla and Gracilariopsis chorda contained hemagglutinins with strong activity against rabbit erythrocytes. The hemagglutinating activity in the buffer extract of the red alga Gracilariopsis chorda (Holmes) Ohmi was strongest among the macroalgal extracts tested. The hemagglutinin obtained from G. chorda also had mitogenic activity and restored the immune-competence of a lymphocyte that had been damaged by a ultra-violet ray. From these findings, the red alga G. chorda seems to be a useful source for mitogenic hemagglutiniins and mitogens.

PO-01-35

Antioxidant activity and phytochemical of red algae from central basin of southern Thailand

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Red algae has become a recognized potential natural product in supplementary for human and animal, dye in food, cosmetic industry and medical. In this present study, 10 species in 7 genera of red algae viz Bostrychia,Caloglossa, Compsopogon, Compsopogonopsis, Kumanoa, Sirodotia and Thorea were collected both watershed and mangrove area, from upper east coast region, southern of Thailand, were analyzed for bioactive potentials such as chlorophylls-a, carotenoid, phycobiliprotein, total phenolic compound and antioxidant activity. The result found that Thorea siamensis showed the highest chlorophylls-a, r-phycoerythrin, r-phycocyanin and carotenoids contents, while Kumanoa nonocensis showed the highest allophycocyanin contents. The dried algae, Caloglossa and Compsopogon, which dominant species in amount were extracted with water, ethyl acetate and ethanol and examined for phenolic compounds and antioxidant activities by measuring the scavenging activity of both ABTS and DPPH radicals. The results indicated the aqueous extracts provided the highest reaction and total phenolic contents. The greater amount of phenolic compounds leads to more potent radical scavenging effect as shown by Caloglossa and Compsopogon aqueous extract. Therefore, these algae rather suggest its potential to anti oxidative agent in nutraceutical products

PO-01-36

Indexing bioactivity of a commercial extract of Ascophyllum nodosum against freezing in BY-2 cells

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The use of active biostimulatory components of the brown alga Ascophyllum nodosum has triggered much enthusiasm in the research community as the specific product tested promotes the growth and mediates stress tolerance in plants. However, for progressive research in the field, establishment of a standardized model system is imperative. The present study uses a robust cell culture bioassay using Nicotiana tobacum. L.cv Bright Yellow 2 (BY-2) cells and was specifically developed to identify the protection level that a commercial Ascophyllum nodosum extract (ANE; a product of Acadian Seaplants Limited) offers against freezing stress. To standardize the experiment, the growth parameters of BY-2 suspension cultures, treated with ANE, under freezing stress at 0 °C, -3 °C and -5 °C, were measured and the changes of the cells were tracked microscopically. The results revealed that ANE treatment was effective in improvement of the cell dry weight and viability under freezing stress at -5 °C and specifically during the thawing process. It was also shown that the ANE increased the membrane stability in BY-2 cultures during this stress, indicating antioxidant activity of the extract due to the presence of phenolic compounds of brown seaweed.

PO-01-37

Mycosporine-like amino acids in benthic red seaweeds along Brazilian coast

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Mycosporine-like amino acids (MAAs) are compounds present in various groups of organisms, and marine red macroalgae are those where consistently high amounts has been detected worldwide. These substances may be synthesized for protection against ultraviolet radiation, as nitrogen resource, and antioxidant defense. Their abundance has been referred with UV radiation and inorganic nitrogen availability. Brazil has a very long shoreline coast, with circa of 8000 km, and abundance of algal species, where Rhodophyta is the most diverse group. Samples were collected in twelve latitudes in Brazilian coast (from 3° to 28° S) in summer. Two sites at each latitude were considered (with one site exception), totalizing 23 sites of sampling. The most abundant and frequent species (at naked-eye) at each place were collected and inserted into silica-gel. MAAs were analyzed by HPLC, and five different secondary standards were used: porphyra-334, asterina-330, shinorine, palythine and mycosporine-glycine. Different MAAs were identified and quantified, as well as the total MAA concentration for each species. Thirty-six species were sampled, representing 8 orders. Only Hypnea musciformis occurred in all sampling sites. Preliminary analyses indicate higher MAAs concentrations in the south and southeast regions of Brazilian coast except for the specimens originated from Atol das Rocas, RN (3'8"). Pyropia acanthophora exhibited the largest concentration with 13.7 mg.g-1 DW in latitude 28'3". Palisada perforata, Gelidium floridanum, Pterocladiella capillaceae, Hypnea musciformis, Digenea simplex, Gracilaria domingensis and Laurencia sp. also presented a considerable concentration of these compounds. Our results reinforce that tropical groups developed a powerful biochemical machine to protect their metabolic environment against high irradiance. Further additional analyses are in progress considering environmental variables and algal internal nitrogen contents. Financial support: CNPq

PO-01-38

Bioactivity of fucoidan oligosaccharides from Icelandic seaweed

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Oligosaccharides from seaweeds have shown a variety of bioactivity, from immunological to oncological effects. Environmental factors can affect the composition and structure of polysaccharides from seaweed, so that seaweed harvested at different times and locations can have different effects. With that in mind, we have purified fucoidan from Icelandic brown seaweed (Fucus vesiculosus). Bioactivity assays included free radical scavenging assays (such as ORAC and DPPH) and CAA. Because fucoidan is an charged polysaccharides the metal chelation properties were also studied. In vitro studies were also conducted, including cellular antioxitant activity, anti-diabetic cellular assay and the effect on dendric cell. The results will highlight the pharmaceutical potential of poly- and oligosaccharides isolated from underutilized seaweeds.

PO-01-40

Antioxidant properties of degraded polysaccharides from the red alga Chondrus elatus

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Red alga Chondrus elatus Holmes is a local species to Japan and with 10 other species it belongs to the Chondrus genus [1] where C. crispus is the most thoroughly studied seaweed. These species are used as gelatinous food additives known as kanten in Japan [2], but the antioxidant properties of the polysaccharides from C. elatus are unknown. C. elatus contains complex polysaccharides composed of kappa, mu and lambda carrageenans. The polysaccharides were successively extracted with cold and hot MilliQ or aqueous phosphate buffer as solvents. The fraction extracted in cold water was found to contain lambda carrageenan (~50%), while the fraction extracted in hot water consisted primarily of kappa carrageenan (~75%). The remaining parts consist of nearly equal amounts of mu and either kappa

or lambda carrageenan. The polysaccharides were subjected to ultrasonic degradation for 5…300 minutes. Molecular weight of the samples were estimated with size-exclusion chromatography. The antioxidant properties of the degraded polysaccharides were evaluated by Folin-Ciocalteu, ABTS and FRAP assays. It was found that the antioxidant activity of the degraded polysaccharides from C. elatus are dependent on the polymerization degree of the galactan, but also on the conditions used to extract the polysaccharides. References: [1] Freshwater, D.W., Frederico, S., Butler, B.S., Hommersand, M.H., Chase, M.W. (1994). A gene phylogeny of the red algae (Rhodophyta) based on plastid rbcL. Proceedings of the National Academy of Sciences, 91, 7281-7285. [2] Johnston, H.W. (1966). The Biological and Economic Importance of Algae, Part 2. Tuatara: Journal of the Biological Society, 14, 30-62.

PO-01-41

Valorisation of Sargassum muticum in Normandy, France, a local answer to a global problem

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Since 2005, seaweed-catching barriers have been set up on the intertidal in an attempt to prevent Sargassum muticum (Yendo) from stranding and protect the mussel industry in Normandy. However, Those barriers set up by mussel farmers have yet to satisfy local authorities as they raise a triple challenge: monitoring and maintenance of the barriers, impact on the environment and valorisation of the biomass. The aims of the project were therefore to suggest and assess different designs, estimates the density of the harvested seaweed and provide potential valorisation avenues based on chemical analysis. Productivity of the 27-m-barriers between May and August 2015 ranged from 200 to 700 kg per harvest (every 15 days). Extraction yield were assessed and resulted in 26.89% DW for uronic acids, 10.81% DW for mannitol, 5.87% DW for Fucoidan and 3.50% DW for phenolic compounds. Variation in uronic acids, mannitol, fucoidans and phenolic compounds profiles showed strong seasonal correlation and exhibit promising active compounds for future pilot trials.

PO-01-42

Effect of solvents and pretreatment method on fatty acids extracted from Saccharina latissima

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Although levels of fatty acids in seaweeds are generally low (<10 mg g DW-1), this fraction is enriched in long chain n-3 polyunsaturated fatty acids (LC n-3 PUFA). In addition, this fraction can contain considerable quantities of e.g. vitamins, sterols and polyphenols, which still mark seaweed lipids nutritionally interesting. In the SEAFARM project, Saccharina latissima harvested from Sweden's West coast will be subjected to biorefining, with the aim of maximizing its value as a raw material for food/feed ingredients, chemicals and energy. A possible limiting step in this field is the compositional characterization of the structurally complex seaweed biomass, not least its lipid fraction. This present study aims to develop extraction methods, which maximize accurate lipid measurement. Furthermore, the applicability of different extraction methods to large-scale biorefinery scenarios is assessed, taking into account that 'wet-biomass' will mostly likely be utilised in such cases. Firstly, chloroform & methanol systems were tested for fatty acid extraction (Folch vs. Bligh & Dyer (B&D) methods) on wet and freeze-dried material, in conjunction with several pre-treatment methods. The best pretreatment was then tested using ethanol and 1-butanol. Direct transesterification was conducted as a reference method, and main responses were yield and fatty acid profile. Overall, the modified B&D method was the most effective in unassisted extractions (5.3 mg g fatty acids DW-1); microwave and sonication pre-treatments significantly improved fatty acid yields (7.3 mg g DW-1). Ultra-sonication assisted ethanol extraction performed equally as well as B&D with pre-treatment (7.6 mg g DW-1). Yields from wet biomass were generally comparable to those from freeze-dried material. Most extracts were rich in PUFA (40-50%), with up to 0.82 and 0.72 mg g DW-1 being stearidonic and eicosapentaenoic acid, respectively. Further results and insights into lipid extraction will be presented.

PO-01-43
Effect of degradation method on antioxidant activity of fuoidan
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Fucoidan is a heteropolysaccharide containing a substantial number of fucose units and sulfate groups, and is extracted mainly from brown algae such as Fucus vesiculosus and Laminaria japonica. Fucoidan has been known to have a wide variety of biological activities, including anticoagulant and antithrombotic, antivirus, antitumor, and antioxidant effects. Recently, it has been reported that the antioxidant activity of fucoidan from seaweed was enhanced by degradation. In this study, low molecular weight fucoidan samples prepared by different degradation methods were compared for their antioxidant activity. As the molecular weght of fucoidan decreased, antioxidant activities increased. But, at the same molecular weight, fucoidan degraded by ionizing irradiation showed higher 1,1-diphenyl-2-picrylhydrazyl radical scavenging activity than that observed with the acidic method.

PO-01-44
Structural characterization of fucoidan from the Norwegian brown seaweed Laminaria hyperborea
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Fucoidans are abundant sulfated polysaccharides e.g. in seaweeds. The sugar composition, glycosidic linkages, degree of sulfatation and branching points vary in fucoidans from different sources. Fucoidans have been reported to possess several biological activities such as antiinflammational, anticoagulant, antitumor activity. We have analyzed fucoidan extracted from commercially harvested Laminaria hyperborea in Norway. The fucoidan was desulfated, and monosaccharide and methylation analysis revealed that the polysaccharide consisted almost exclusively of fucose units linked through (1→3), (1→2) and (1→4) glycosidic linkages as well as a high degree of branching, which was also confirmed by NMR spectroscopy. Mass spectrometry data revealed a sulfate content of 56%, which signifies an almost full sulfation of the polysaccharide molecule. The absence of acetyl groups was confirmed through Raman spectroscopy.

PO-01-45
Phylogenetic identification and hydrocolloid characteristics of Ghanaian red seaweed
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DNA-based identification reveals new, important insights about the phylogenetic relationship and hydrocolloid properties of Hypnea musciformis and Hydropuntia dentata from Ghana. COI sequences of Ghanaian H. musciformis were compared with Genbank available COI sequence of H. musciformis and showed that it is closely related with H. musciformis collected in Brazil (KP725276) with 0.8–1.3% intraspecies divergence while from other countries the intraspecies divergences were 0–6.9%. LSU barcode showed that the closest match for Hydropuntia dentata was Gracillaria sp. a taxonomically synonymous to Hydropuntia sp. The hydrocolloids were extracted by either direct-water or combined alkali-water extraction and depending on extraction method the yields ranged from 24-27% by weight for Hypnea musciformis and 13-15% by weight for Hydropuntia dentata. HPAEC analysis revealed that galactose was the main monosaccharide for both hydrocolloids, about 72-84% dw. Gelling temperatures ranged from 33-36 °C for Hypnea musciformis hydrocolloid comparable to carrageenan, while the extracted hydrocolloid from Hydropuntia dentata had gelling temperatures of 38-52 °C indicating agar like gelling properties. The rheological analysis exhibits that the hydrocolloid obtained by alkali-water extractions from H. musciformis has kappa-carrageenan-like gel strengths (G', elastic modulus) of 6000 Pa at 25 °C, while H. dentata has gel strengths (G', elastic modulus) of 300 Pa indicating an agar-like hydrocolloid

PO-01-46
Inorganic arsenic distribution in Laminaria digitata (Phaeophyceae)

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The kelp Laminaria digitata is commonly harvested for use in products and materials for the food sector, for fertiliser and feed, in biotechnology and for many other applications. The presence of arsenic in seaweed constitutes a problem for the development of the seaweed industry and has previously led to issues regarding non-compliance of algal-based feed products with EC regulatory limits for total arsenic. Much of this arsenic is typically present as organoarsenicals whose toxicity, though not well characterised, is much lower than that of inorganic arsenic (Asi). Inorganic arsenic has been detected in a number of commonly harvested seaweeds globally. New European Union regulatory limits for inorganic arsenic in fish and seafood are anticipated. This project, 'AsMARA - arsenic in marine macroalgae and implications for commercial uses', aims to establish a reliable and simple analytical methodology for the determination of Asi in seaweed and to study the variability of total and inorganic arsenic in a range of commercially relevant species. It also aims to investigate the influence of a number of biological and environmental factors on arsenic content and speciation. Preliminary results from Irish samples suggest generally low concentrations of Asi in most seaweeds although distinct differences were noted between different parts of kelps. The distribution of inorganic arsenic through L. digitata thalli was further examined in detail using high performance liquid chromatography – inductively coupled plasma mass spectrometry (HPLC-ICPMS). Samples were collected from the west coast of Ireland. The distribution of Asi through the thallus and strategies for harvesting and processing are discussed.

PO-01-47
Metals content in macroalgas and concentrations of nutrients water coastal

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The presence of macroalgas blooms attributes to enrichment of nutrients in coastal areas. This presence of nutrients in the water has effects over the chemical presentation of metals and the availability for the organisms. Various registers show that the metals accumulation in macroalgas show the concentrations in the water. However, are few the works that explain how the nutrients concentration in the water affects to the metals accumulation in macroalgas. For that, this work has the aim to determinate the relationship between the metals content in macroalgas and the nutrients concentration in the water, with the intention to evaluate species like bio-indicators. We have with samples of Spyridia filamentosa, Ulva rigida and Padina durville like conspicuous species in La Bahía de La Paz since 2013 until 2015, as reference of few contaminated waters. We will make monitoring of this species during three periods in 2016, in three points of La Bahía de La Paz and Bahía de Guaymas, Sonora. We will study the temperature, salinity pH, dissolved oxygen, and totals suspended solids, as is the nutrients concentration in the water (nitrites, nitrates and orthophosphates). We will eliminate epiphytic and epibionts of manually collected samples of macroalgas, we will make drying and homogenization. Later, we will analyze the metals contents nickel, copper, cadmium, zinc, iron, lead and manganese, through of espectrofotometría of atomic absorption. We will analyze, if the relationship between the nutrients concentrations in the water, and the metals contents in the species indicates contamination states in water bodies coastal.

PO-01-48
Arsenic speciation on seaweeds in Korea by reversed phased column HPLC-ICP-MS

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The concern about presence of arsenic in seafood has been increasing, especially in commonly consumed seaweed in Korea. Because toxicity is dependent on its chemical form, the measurement of arsenic species in seaweeds is important. In this study, the arsenic speciation analysis in commonly consumed seaweed in Korea was accomplished with a reversed-phase column using an isocratic chromatographic method (pH 2.3). The LOD (limit of detection) and LOQ (limits of quantification) for 6 arsenic species were in the range

of 0.064-0.108 µgkg-1 0.213-0.359 µgkg-1 based on 3σ, 10σ of 1 µgkg-1 standard (n=9), respectively. For assessment of optimum extraction condition, gamma-irradiated extraction (GIE), microwave-associated extraction (MAE), heat-associated extraction (HAE), and water base sonication-associated extraction (SAE) were tested. The extraction efficiency was increased in MAE and HAE by increasing the arsenosugar-like compounds. The conversion of the arsenic species was detected in GIE. Although the SAE (In this study) was showed low extraction efficiency (21.69-35.51%) in seaweeds, recovery of arsenate (As Ⅴ) in certified reference material (7405a, Hijiki) was agreed with the certified values(>93%). In results of arsenic speciation analysis in commonly consumed seaweed in Korea, arsenobetein was shown in all samples, and the concentration of arsenate (As Ⅴ) and arsenite (As Ⅲ) were ND (below LOD)-77.53 mgkg-1, ND-1.16 mgkg-1, dry weight, respectively.

PO-01-49

Establishment of Osmundea pinnatifida mari-culture

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There is no doubt that UK coastal waters contain a large array of algal species and the use of algae in human consumption within Europe has always been at a low level, often associated with poor coastal communities. Seaweeds have formed a part of the diet of coastal dwellers in UK for more than 4,000 years. Praised for is benefits and taste, it appears that Scotland's seaweeds are set to be among the next global food trend. Sustainable production of algae for human food consumption/high value chemicals is of vital importance to the development of robust supply chains for algal products, now and in the future. This scientific challenging project represents the chance to translate research from the academic field into a commercial one, with the help of FAI Aquaculture Ltd, recognised as a world leader in the development of new aquaculture crops including seaweeds. Cultivation of algal species produces good quality material in reasonably reliable quantities. Worldwide production of seaweed has a value of US $ 5.65 billion. However, the costs associated with cultivation are high and the products need to demonstrate elevated value. This project is key to developing an underpinning infrastructure capable of supporting the enhancement of industries exploiting cutting edge macroalgae, like pepper dulse, for food and nutraceutical production. Pepper dulse is an important ingredient of Scottish cuisine and folklore. Currently, a pack of Osmundea pinnatifida retails at £12 and the demand is supplied only by natural harvesting putting pressure on natural systems. This project aims to establish tank cultivation of pepper dulse, which would potentially provide a more consistent and sustainable product. Furthermore, a key factor will be improving crop yield and developing a means of tailoring the final product according to market needs, through selection of colour and taste standards. The success of this project is only achievable by researchers and industry working together.

PO-01-50

Temperature and salinity tolerance in the different size groups of Saccharina japonica (Phaeophyta)

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The kelp Saccharina japonica is highly valued food and abalone feed in Korea. For the stable production of abalone, seaweed feed is required during the whole year, but currently between August and November production of farmed seaweed species is limited by environmental conditions and therefore harvesting from farms is normally finished in August. Between August and November, environmental conditions are variable due to a few typhoons and rain that cause temperature and salinity variation in the water and impact on seaweed cultivation. Farmers wanting to establish a year round supply of S. japonica are unable to initiate cultivation during this period as young sporophytes do not grow well at temperatures between 22~18℃. Furthermore during thier r nursery and early main cultivation period. S. japonica sporelings are also sensitive to salinity changes. The tolerance range of S. japonica to temperature and salinity was investigated under 5 temperature conditions (18, 20, 22, 24, 26℃) and 4 salinity conditions (0, 8.5, 17, 34 psu) with different developmental size groups of thalli (0.25, 1, 5, 10, 300 mm). Growth of thalli and photosynthtic quantum yield (Fv/Fm) were measured accordig to culture conditions and size groups. These results of these studies indicate the optimum temperature and salinity ranges during which to cultivate different size groups of S. japonica This study will help farmers to undertsand to optimes cultivation and will contribute to more stable seaweed production in Korea.

PO-01-51

Effect of environmental factors on photosynthetic characteristics of Pyropia yezoensis

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Pyropia is an important economical macroalgae which has two different phases. Gametophyte (thallus) lives in the intertidal zone, sporophyte (conchocelis) enters the shells and grown in subtidal zone, which indicates different environmental adaptation ability. In this research, the photosynthetic parameters of P. yezoensis, cultured under different light intensities (80, 180, 280, 320μmol m-2 s-1) and temperatures (15, 20℃), were measured. Results indicated that with the rising of light intensity, the phycobiliprotein (PBS) content in thallus decreased. The content of chlorophyll a (Chla) in thallus at 20°C decreased significantly with the increase of light intensities, while not in 15°C. The PBS content in conchocelis decreased significantly with the increasing light intensity, and it declined more obvious under 15°C. The contents of Chla in conchocelis in low light intensities were significantly higher than those in high light intensities. The change of PBS and Chla content made PE/Chla, APC/Chla and PC/Chla ratios of conchocelis at 15°C decreased obviously with the increase of light intensity, while those ratios at 20°C had little change. The ΔF/Fm′ of thallus decreased with the irradiation time. Under the same temperature, the ΔF/Fm′ of thallus in high light intensity was lower than those in low light intensity. The ΔF/Fm′ of conchocelis under high light intensities were significantly lower than those under low light intensities ($P<0.05$). In the same light intensity, the ΔF/Fm′ of conchocelis under 15°C was significantly lower than that in 20°C. According to the research, high light intensity may reduce the light use efficiency of both phases of P. yezoensis, the thallus may maintain the photosynthetic pigments content to keep relatively high light energy use efficiency from 15°C to 20°C, while the conchocelis photosynthetic efficiency reduced when temperature is lower than 15°C, and the high light intensity may exacerbate the decrease.

PO-01-52

Pilot cultivation of kelp species in Greenland

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The seaweed industry in Greenland is still very much in its infancy and cultivation of seaweed under Greenlandic conditions has never been tested before. This project aims to accomplish the cultivation process of two kelp species Alaria esculenta and Saccharina spp, in western Greenland at 64˚N. Spore release and seeding lines with the spores were accomplished in the laboratory of Greenland Institute of Natural Resources in Nuuk at 4˚C by using standard methods and locally collected fertile material. After 6 weeks in the laboratory the sporophytes had reached a length of about 1 mm. At first, hard weather and then an unusual dense fjord-ice prevented the deployment of the lines at the selected location in the field during autumn and winter. For the sporophytes to survive in laboratory they were kept at minimum light intensity and nutrient level and only after ice-break in May, the lines were deployed in the field. Data on growth and production will be presented. The initial data indicate that growth and production are comparable with results from less extreme environments, and that the main challenge is to find places for the line systems that on one hand are sheltered from the main wind directions and drifting icebergs but on the other, not too exposed to extended sea-ice cover.

PO-01-53

Chemical composition from different genetic populations of the giant kelp Macrocystis pyrifera

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Increasing human populations has driven the search for unconventional food sources. Seaweeds are potential candidates because of their richness in polysaccharides, proteins, pigments and bioactive substances like polyphenols, among others. On the other hand, there is a need for management options for a sustainable approach to the production of these marine organisms, as a source of food and bioactive compounds. We discuss small-scale production of M. pyrifera under semi-controlled systems of different genetic populations to survey for valuable biomolecules for the food industry. Three genetically distinct

populations of M. pyrifera were selected from fertile sporophytic individuals collected in three locations along the Chilean coast (Algarrobo, Pargua and Quellón). Spores were released in December 2014 and after 15 weeks cultivation under controlled conditions 26 sporophytes of 2 – 5 cm from each population were placed in 1000-L outdoor tanks in Metri, X Region. Each population were cultivated under two nutrient treatments: sand filtered seawater and wastewater from a turbot farm. After 4 weeks we surveyed the seaweeds for growth and valuable chemical compounds: carbohydrates (alginate, mannitol and glucans); pigment (fucoxanthin and chlorophyll); antioxidant (phloroglucinol) and amino-acids. In four weeks, seaweeds grew from 2 cm up to a maximum of 38 cm; maximum specific growth rate was 32.4% for the Pargua individuals in the filtered seawater treatment. Our results indicate that major differences were observed among some amino-acids and carbohydrates whereas pigment and antioxidants did not change significantly with population or nutrient treatments. Results will be discussed in light of human essential amino-acids needs but also from a feed perspective for salmon and abalone.

PO-01-54

Macroalgal tank cultivation in scotland: the s3eed project

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There is a growing demand across europe for seaweed as a gourmet food. Currently in scotland, this is supplied by natural harvesting of intertidal beds alone, however, this will soon be insufficient to meet the rising demand and could lead to significant environmental damage, and so cultivation is necessary. Three species of commercial interest are ulva lactuca, palmaria palmata and osmundea pinnatifida. The innovate uk project sustainable seaweed as a solution for economic environmental development (s3eed) was a collaboration between an established aquaculture business (otter ferry seafish ltd), a seaweed harvesting company (mara seaweed) and a marine research organisation (sams). Twelve 10m3 outdoor tanks with flow-through seawater were maintained year-round (june 2015-october 2015) for the experimental cultivation, with growth recorded every two weeks. Simultaneously, laboratory experiments were conducted to determine the optimal density, temperature, light and nutrient requirements for each species. Specific chemical decontamination protocols were also developed for each species, to reduce the occurrence of epiphytic grazing snails and the filamentous algae ectocarpus spp. and ulva intestinalis which occur in the tanks. During summer-autumn 2015, tanks maintained positive growth, with sunny weather appearing linked to the productivity of the outdoor tanks. Ulva lactuca tanks periodically became reproductive leading to tissue loss and zero or a decrease in biomass. During winter growth stalled, or was combined with tissue degradation leading to biomass loss. Additional lighting/insulation over the winter, did not appear to ameliorate this problem. The optimal physicochemical conditions for the cultivation varied between species. P. palmata suffered tissue degradation at >16oc, while u. lactuca grew well across the entire range examined (8-20oc) All appeared to prefer high light and high nutrients with n:p of ~15:1 and supplemental vitamins and iron.

PO-01-55

The Development of New Sea Vegetable Aquaculture Crops in Maine, USA

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With a well-established traditional seaweed fishery and the development of a new sea vegetable aquaculture industry, Maine is leading the nation in the production of high-quality sea vegetables. The macroalgal research nursery at the University of Maine's Center for Cooperative Aquaculture Research (CCAR) in Franklin, ME, is developing culture techniques for new native species, including winged kelp (Alaria esculenta), laver (Porphyra umbilicalis), and dulse (Palmaria palmata). A census of reproductive conditions was undertaken at three locations along the Maine coast to determine reproductive seasonality of the target species. Nursery seedstock development and seeding techniques were investigated for each of the three species, and seeded nets and lines were out-planted at sea to determine optimal culture seasons. This research will support crop diversification of sea vegetables and provide new opportunities for sea farmers in Maine.

PO-01-56

Optimization of the chemical composition of edible red seaweeds as a source of functional foods

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Seaweeds are known to contain many compounds with potential health benefits and thus have been identified as likely sources of new functional food ingredients. For example, Chondrus crispus (Carrageen moss) and Porphyra spp. (Nori, laver) are red sea-vegetables and represent species with a great potential for inclusion as functional foods, as they are currently harvested and sold locally in Ireland and accepted by Irish consumers. However their natural populations exhibit significant intraspecific variation in morphology and their potentially related chemical diversity that has not been addressed to date. Also, variation in compounds in the different life history traits of these species is poorly documented. In order to characterize and optimize through cultivation the bioactive profiles and biochemical composition (such as fatty acids, pigments and phycobilins) of those species, we determined the effects of different growth conditions (nitrogen supply, light intensity and temperature). In addition, different life history traits (gametophytes vs. sporophytes; females vs. males) were selected from both species and their chemical composition was assessed. Contents and profiles were compared between individuals from each life history trait from different sites on the Irish coast. Metabolite analyses were performed by Gas Chromatography (GC) and High-Performance Liquid Chromatography (HPLC). Data generated can be used to determine optimum conditions for biomass cultivation and the desirable bioactive composition.

PO-01-57

Caulerpa farming in French Polynesia, a new source of income for local community

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In the last 3 decades of the 20th century, aquaculture became one of the leading food industries, producing fish, mollusks, crustaceans and seaweeds. According to the latest available FAO statistics, aquaculture production reach a new record at 90.4 million tones (live weight equivalent) in 2012 including 66.6 million tons of food fish and 23.8 million tons of algae (FAO, 2014). World aquaculture is always heavily dominated by the Asia-Pacific region which represents approximately 88% of world production (FAO, 2014). In this region, several species of the green seaweed genus Caulerpa Lamouroux (1809) are very popular in human food because of their delicious taste, crunchy texture, which is pleasing to the palate, and because of their health benefits: Caulerpa contains proteins, fiber, minerals, vitamins, polyunsaturated fatty acids and bioactive antioxidants. The consumption of several species of Caulerpa is well established in local traditions in French Polynesia, particularly in Tubuai (Austral archipelago). In this context, the French Polynesia politics aims for several years to develop insular rural seaweed farming with a dual purpose: (i) to provide additional source of income for local communities and (ii) to ensure the conservation of the natural population stocks of Caulerpa. Farming trials have started with Caulerpa racemosa var. turbinata in 2014 using submerged rafts in Tubuai and are still in progress. Biochemical studies have been conducted to verify the nutritional qualities of this species and ensure its non-toxicity of heavy metals, toxins and pesticides. And finally, socio-economic studies have been undertaken to assess the potential of a supply chain and marketing of C. racemosa var. turbinata in Tahiti.

PO-01-58

Seaweed culture techniques in the Philippines

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Seaweed harvesting began in the Philippines as early as the 1970s with the collection of wild stocks. It was not until the 1980s that a farming guidebook was created. Today, there are at least four different planting techniques with varying modifications and alterations in the areas that were surveyed. As a result, different harvesting and drying methods are also being adapted as far as these modifications go. Most technique alteration or modification can be accounted for geographic isolation; however, sometimes-ingenious ideas are adapted because of its effectivity in the given circumstance.

PO-01-59

Use of AMPEP K+ and PGRs in shoot induction of Kappaphycus alvarezii (Doty) Doty

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The bio-stimulant Acadian Marine Plant Extract Powder (AMPEP) K+ with and without the addition of Plant Growth Regulators (IAA + Kinetin) were used to induce the formation of direct, erect shoots of Kappaphycus alvarezii. IAA + Kinetin at 1 mg L-1 were added to the different concentrations of AMPEP K+ and a Control without the addition of PGR were used in the study. Three replicates were used for each concentration with 20 segments grown in UV-treated filtered seawater in a 200 mL Erlenmeyer flask, incubated at 23-24° C, 13h D:11hL photoperiod, light intensity at 30-40 µm m2 sec-1 and mild aeration. Length (mm), number of direct erect shoots and % number of sections with direct erect shoots were measured after 45 days of incubation. Results showed that AMPEP K+ with the PGR combination produced significantly longer erect shoots than without addition of PGR (P 0.05). Results suggested that 0.5 AMPEP K+ without PGR was comparable with the results obtained with AMPEP K+ with PGR and could be used also to induce direct erect shoots for the micro-propagation of K. alvarezii plantlets under laboratory conditions.

PO-01-60

Cultivation of Kappaphycus striatum in the Huanghai sea of China

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The kappa-carrageenan-producing seaweed K. striatum were firstly cultured in the Huanghai sea of China during July to September. The algae were tied to the nylon rope (each rope 5 m) and then the two ends of nylon rope were tied to two different kelp raft frame (each seedling weighing between 100 to 150 g, each rope 25 plants, 50 cm between two near-by ropes). The growth rate of the K. striatum is 2.5% d-1 during July, 3.1% d-1 during August, 7.1% d-1 during September. The K. striatum grew well and no pests were found during the whole culture season in the Huanghai sea of China. In case of the serious juvenile siganids problem in the eucheumatoid farm in Hainan province China, we suggest the farmer bring the algae to the Huanghai sea to conserve seedling. The success of the culture in the Huanghai sea would be a great help for the scaling of the K. striatum in China.

PO-01-63

FLOATING CAGE : NEW METHODS FOR CULTURE AND SEAWEEDS MANAGEMENT IN INDONESIA

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Currently, cultivation of seaweed using floating cages was limited reported before. This study aims to reveal growth of K. alvarezii reared in new cultivation methods as floating cages and compared with traditional methods as longline. The study was conducted in cultivation areas in Southeast Sulawesi, Indonesia. Total growth rates in average of K. alvarezii in floating cages and longline are 22,5 ± 1.40 kg, 5 kg and 38,8 ± 1,6 kg, from 5 kg in first weigh (Wo) in 40 days of cultivation, respectively. The growth rate of thallus of K alvarezii also performs in this experiment. During August, the increasing of growth rate from 50 g was 132,0 ± 8,0 g and 218.8 ± 8,6 g at longlines and floating cage, respectively. SGR of K. alvarezii was high during August, 3.69 %.d-1 and 2.43 %.d-1 cultivated on floating cage and longline, respectively. During August, thallus look more dense and healthy in floating cage and looks chipped and cut off due in longline. Floating cages was also useful to cultivate various seaweed aside K. alvarezii. This new methods performs as suitable instrument in seaweeds cultivation and management in Indonesia.

PO-01-64

Growth of New Strain Eucheuma Denticulatum in Floating Cages in Indonesia

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Seaweed cultivation is most popular in Indonesia. This study aims to reveal the growth of new strain E. denticulatum in floating cage and longline. This study was conducted in one of cultivation areas in Southeast Sulawesi, Indonesia. This research was carried out by comparing the growth rate of E. denticulatum, which cultivated with floating cage and longline. This study revealed that the growth rates of E. denticulatum by floating cages are much better compared than longline. The results showed that the growth rates of E. denticulatum in floating cage was slightly faster and appeared to be better in thallus morphology. Average total growth rate of E. denticulatum which was cultivated in longline and floating cage during 50 days in 5 kg of first weight (Wo) are 23,7 and 38,9 kg respectivelly. Specific growth rate (SGR) of E. denticulatum cultivated on floating cage was the highest in June as 3.32% day -1. And using a longline, the SGR in July was the highest with 2.91% day -1. The cultivation by using floating cages proved to be better in growth rates with no effect of herbivorous attacks.

PO-01-65

Laying the foundation for an integrated industrial sector: Kelp cultivation in Quebec (Canada)

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In the past years, grow-out trials of sugar kelp (Saccharina latissima and S. longicruris) and winged kelp (Alaria esculenta) in open water farms of Quebec have proved successful and shellfish growers are now interested in diversifying their production through kelp cultivation. In this context, the Cegep de la Gaspésie et des Îles obtained an NSERC grant in March 2014 for a 5 year program entitled OPTIMAL. This program, coordinated by Merinov in collaboration with Cegep de la Gaspésie, OLEOTEK and Cegep de Thetford, aims to support the development of an integrated industrial sector for the commercial exploitation of cultured sugar kelp. OPTIMAL is structured along three axes of research: the improvement of seaweed culture productivity, the development of high value end products and the use of seaweed processing co-products, with a zero-waste objective. In the first two years, large quantities of culture ropes were seeded and kelp plantlets were cultivated in a private marine hatchery. In late fall, the ropes were transferred to several shellfish grow-out sites in the Gulf of St Lawrence in order to compare production levels under different oceanographic conditions. Various density control strategies were applied on the longlines and growth parameters were followed from spring to summer. Part of the biomass produced on these farms was sent to various research partners working on the second and third axes of the program. Throughout this two-year period, work was also carried out in our research facilities in order to optimize and mechanize culture operations of the hatchery. Results from the first years have helped produce a physicochemical portrait of four marine farms and has allowed to select the best areas for kelp growth, the optimal density strategy as well as the most favorable schedule for harvesting. Possible ways to reduce costs associated with the disinfection of water and the nutrient enrichment of culture medium in the hatchery have also been identified.

PO-01-66

Examining the effect of seaweed associated bacteria on the growth of two seaweeds in culture.

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The normal development and growth of seaweed thalli is influenced by a multitude of factors such as light, temperature and nutrient availability but recently it has been discovered that most seaweeds are also dependent on the presence of epiphytic bacteria as they play an important role in development and growth of their seaweed host. Both endophytic and epiphytic bacteria contribute to the growth and development by releasing plant growth regulators (PGR's) in additon to fixing nitrogen which in turn is utilised by the seaweed. Bacterially produced PGR's by marine bacteria, such as the phytohormone auxin, possess the capapbility to regulate the growth and morphology. Indole-3-acetic acid (IAA) has been identified as one of the most common auxins produced and regulates cell elongation, division and differentiation in plants. In

this study, we tested the effect of isolated epiphytic and endophytic bacteria on the growth of Porphyra umbilicalis and Ulva lactuca and concurrently examined all bacterial isolates for IAA production and N2 – fixation. A pre-study established a successful sterilisation protocol for both species and seaweed health after sterilization was assessed using pulse-amplified modulation (PAM). Growth trial results indicate that there are several bacterial isolates (species still undetermined) significantly increase growth rate compared to the control. All isolates were tested for IAA content using Sahlkowski reagent and analysed with (TOF)-LC-MS and HPLC (results yet to be analysed). Nitrogen fixation will be analysed using Nessler's reagent and measured using spectroscopy. Once all results have been analysed, we aim to provide results showing that seaweed associated bacteria are correlated with growth and normal development of the tested seaweed species.

PO-01-67

Effects of plant growth regulators in the carrageenan-producing red alga Sarcothalia crispata

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Sarcothalia crispata (Bory) Leister 1993 is an endemic species from Chilean coast, and produces carrageenan used mainly by food industries. Recently, this marine resource is exploited from natural populations, and investigation on vegetative propagation is required to improve its cultivation. The objective of the present study was to evaluate the effects of plant growth regulators (PGR) on the development and morphogenesis of plantlets originated from carpospore germination. S. crispata was collected from Astillero, Pargua, southern Chile (41°45'49.48" S 73°36'31.27" W). Two auxins, índole-3-acetic acid (IAA) and 2,4-dichlorophenoxyacetic acid (2,4-D), and two cytokinins, benzylaminopurine (BA) and 2-isopentenyladenine (2iP), were tested alone or in combination (IAA + BA, and IAA + 2iP) in concentrations of 1.0 and 10.0 µM. These PGR were added to seawater enriched with a quarter strength of Provasoli´s solution, and solid medium was gelled with 0.6% agar. Treatment control (without PGR) was conducted simultaneously. Each treatment was tested with three replicates of 8 carposporelings. Culture conditions were salinity of 32 ± 1 psu, temperature of 10 °C, 16:8 h light: dark cycle, and irradiance range of 4.95-14.51 µmol m-2 s-1. Explants were cultured in solid medium for 25 days, and afterwards, they were transferred to liquid medium, and cultured for 5 weeks. Combinations of auxin and cytokinin (IAA+BA) and 2,4 D and BA inhibited growth, and high concentrations of IAA+BA stimulated branch formation. Carposporelings showed depigmentation when cultured in liquid medium with addition of IAA (10.0 µM), BA, 2,4-D (1.0 and 10.0 µM), or 2iP (1.0 µM) for one week, and did not survive after two weeks. Our results indicate that auxin and cytokinin influence the carposporeling development and morphogenesis, and could be useful to improve S. crispata cultivation in the Chilean coast. Financial support: Project Fondef ID 14I10127

PO-01-68

New Applications: Cryopreservation of Macrocystis pyrifera (L.) C. Agardh (Phaeophyceae)

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Cryopreservation is a technique that keeps cells without altering their genotypic and phenotypic development. Macrocystis pyrifera is a giant kelp commercially exploited. It has been described as structuring of subtidal benthic communities, and relevant for protecting seaweed beds. Reproductive specimens were collected from two sites in southern Chile (41°S), and transported to the laboratory. Sporulation was stimulated through dehydration, and zoospores were cultured in Provasoli medium at 10 °C, light: dark cycle of 16:08 h, and photon irradiance of 23 µmol m-2 s-1. After 7 days, the initial gametophytes were cryopreserved, and gametophytes without cryopreservation were also cultured as a control. DMSO (20%) was used as cryoprotectant, and gametophytes were pre-frozen for 30 minutes, and after this, they were incubated in liquid nitrogen (-196 °C) for a period of 15, 30, 60 and 730 days. In each treatment, thawing was performed using water baths (temperatures of 38 °C and 4 °C respectively) for some minutes. Thawed samples were incubated in growth chambers, and culture medium was renewed weekly. Formation of gametophytes and sporophytes, reproductive development, and growth rates (%) were evaluated in different treatments. Results showed normal development of gametophytes in the cryopreserved samples at different cryopreservation periods, compared to the control. Development of

cryopreserved gametophytes showed lower percentage of female gametophytes (39-46%) than the control (48%). After three weeks, gametophytes formed reproductive structures in all cryopreserved treatments, while the gametophytes of control remained vegetative. After 30 days, percentages of reproductive development were 45-65% and 0% in, respectively, cryopreserved treatments and in the control. Growth rates of sporophytes varied from 5% to 8%. This study demonstrates the viability of M. pyrifera gametophytes after long cryopreservation periods.

PO-01-69

Calcium propionate treatment on oomycete diseases in Pyropia sea farms of Korea

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The red rot disease and Olpidiopsis blight caused by oomycete pathogens, Pythium porphyrae and Olpidiopsis pyropiae are two major plagues causing economic loss in Pyropia farms of Korea. To get rid of these oomycete pathogens and other epiphytic algae sea farmers use the acid-wash treatment immersing cultivation nets in acidic (pH 2-5) solution for 20-30 s. The use of inorganic acid like HCl, however, is currently banned by law because of environmental concerns. To develop non-acidic treatment for these diseases various calcium salts were tested for the infectivity of P. porphyrae and Olpidiopsis sp. on Porphyra baldes. Among them calcium propionate was the most effective. When the Porphyra blades were immersed to 0.1 M calcium propionate for 30 s prior to the inoculation with P. porphyrae the infection rate dropped to 5.86% of control in 3 days. Calcium propionate was also effective in blocking the progress of infection. The infected area of Porphyra blades was reduced to 14.3% of control in 3 days after the treatment of 0.1 M calcium propionate for 30 s. Cytochemical study showed that calcium propionate effectively inhibits the development of germinating tube and the growth of fungal mycelium. Field test of calcium propionate treatment was performed in the cultivation beds (12,000 m2) of Pyropia farm for two years. The average infection ratio of two oomycete diseases dropped to 20% of control indicating the treatment of calcium propionate is effective in the field too.

PO-01-70

Production of Kappaphycus alvarezii (Doty) Doty clones by micropropagation

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Tissue culture technique has proven to be a reliable method to mass produce certain crops. This method was also tested in macroalgae to produce clones for seaweed farming. Callus production and shoot regeneration from protoplast has established protocols for some seaweed species and Kappaphycus alvarezii. Cells and larger tissues whether in solid or suspension media were used to propagate clones were tested for suitability for farming and successful. However, the length of culture in-vitro limits the production process making the growing of Kappaphycus in vitro an expensive technique to produce clones. In this study, Kappahycus alvarezii (KA) was grown in-vitro to obtain a more efficient protocol for the production of clones. Small sections of Kappahycus were grown in suspension for one month under the same light and salinities. Media, source of explants, length of explants, and stocking density were determined to obtain higher growth rate and survival rate. Growth rate of KA is significantly higher in media with Grund medium + organic nitrogen than Grund medium only and Ascophyllum nodosum media. Shoots develop in explants from tips is significantly faster than sections from older branches. Growth rates of explants approximately 3 and 5 mm are significantly higher than 10 mm sections. Growth rate of KA grown at 10, 15, 20, 25 individuals per 200 mL of media are not significantly different. The appearance of shoot primordia as early as 7 days was observed in the media with higher nitrogen concentration. This protocol could be adapted to reduce the time of culture in-vitro and make propagules for farming affordable to the stakeholders.

PO-01-71

Marine phycoculture in China

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In China, the utilized and cultivated seaweeds mainly include Saccharina, Undaria, Pyropia, Kappaphycus, Gracilaria, Gelidium, Sargassum and Macrocystis. About 1,856,804 ton of commercial seaweeds were produced in China in 2013. Saccharina is most important commercial seaweed in China, with the cultivation area of 37,282 ha and the yield of 1,017,737 ton dry weight in 2013. For the other commercial seaweeds, such as Undaria, Pyropia, Gracilaria, Kappaphycus the yields were 170,111, 113,900, 246,112, 9,256 tons respectively. Saccharina sporelings are cultured in 6-9 ℃, 1500-3000 lx in glasshouse for about 70 days, and then they are transferred to the sea for one month intermediate culture. Next, the sporelings were cultivated

in the sea using the floating raft culture method which is wildly adopted in seaweed culture. The floating rafts are usually about 60m in length, and the space of two floating raft is about 5m. Saccharina culture laid a foundation for Chinese aquaculture industry. Although Saccharina can't distribute in south part of China owing to high water temperature in summer, they are artificially cultivated in Fujian, Zhejiang and Jiangsu provinces by adopting some techniques, such as techniques for parent plant maturing, for summer seedling production, for intermediate culture, for floating-raft cultivation. With these technologies the cultivation area and yield increased. Now, 80% Saccharina is used for human food consumption, and about 20% Saccharina is used to extract algin, iodine and mannitol for industry purposes. Saccharina also can poly-culture with scallop or abalone, even poly-culture with Undaria or Gracilaria. Other commercial seaweeds productions are also adopted floating-raft culture method, similar to Saccharina. Seaweed productions bring out not only enormous benefit in economy, also important effect in ecosystem as well.

PO-01-72

Intra-organismal genetic heterogeneity in Gracilaria chilensis and its relation with cultivation

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In Chile, the commercial culture of Gracilaria chilensis uses both spores and vegetative propagation. While no genetic information is available on the type of crops derived from spore culture, those from fragmentation show intraclonal variation, possibly due to the mosaicism that may result from postzygotic mutation arising from different culture conditions. This study aims to determine the existence of intra-organismal genetic heterogeneity in natural populations of G. chilensis and whether changes are affected by using different types of spore cultures. To achieve this, we used 6 microsatellites for genetic characterization of tissues at the holdfast, basal and apical axes of 15 plants collected from Maullin's natural population. Additionally, we generated an experimental set of clonal, mosaic and chimeric plants, these combined from a diverse number of spores (1, 10, 20) and different-coloured strains (red vs green). Plants were cultured in the laboratory for 160 days and were then genetically characterized, similar to the method used for the natural population plants. Our results evidenced that natural plants showed genetically heterogeneous individuals due to both mosaicism (33.3% of the collected plants) and chimerism (6.7%). Unisporic plants showed less weight and number of axes compared to multisporic plants and maintained genetic homogeneity among tissues extracted from the holdfast, base and apex. Multisporic plants, on the other hand, showed intra-organismal genetic heterogeneity due to both mosaicism and/or chimerism. However, mixed characteristics occurred only in the first generation of axes. These results suggest that unisporic culture is the recommended method for maintaining pure strains, while multisporic coalescence is better for increasing growth (number of axes and biomass). In the latter, the occurrence of chimerism and its mixed characteristics due to coalescence of genetically different spores is reversed after the first generation of axes.

PO-01-73

Isolation of an improved strain of Pyropia chauhanii with high-temperature resistance

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The blades of the wild-type strain (PC-WT) of Pyropia chauhanii were irradiated with 60Co-γ rays and cultured at a high temperature (29 ℃) for 10 days. The survived somatic cells were isolated enzymatically and regenerated into whole blades and screened at 29 ℃. A homozygous conchocelis strain of TR-5 was obtained through parthenogenesis from a vigorously growing blade. The rates of survival, division and rhizoid germination of conchospores were not significant different between TR-5 and PC-WT at 18 and 23 ℃, but the survival rates were 261.2 and 329.3% higher, the division rates were 42.8 and 72.6% higher, the rhizoid germination rates were 94.3 and 199.5% higher in the former than in the latter at 27 and 29 ℃, respectively. When F1 gametophytic blades of PC-WT and TR-5 were firstly cultured at 23 ℃ for 30 days and then cultured at 18, 23 and 27 ℃ for another 10 days, the absolute growth rates of TR-5 blades were 4.4, 4.3 and 10.4 times, and the relative growth rates were 1.1, 1.1 and 2.0 times as those of PC-WT, respectively. The apical and middle parts of PC-WT blades were disintegrated due to release of a large number of monospores after cultured for 15 days at 27 ℃ or 10 days at 29 ℃, and only the basal parts of the blades remained intact. On the other hand, TR-5 blades grew rapidly with normal color and shape without releasing monospores, and were slightly curled even being cultured for additional 30 days. In addition, the contents of three major photosynthetic pigments (Chl. a, PE and PC) and the conchospore

numbers in TR-5 at a suitable temperature (23 ℃) were 66.7, 244.2, 115.7 and 92.0% higher than those of PC-WT, respectively. Meanwhile, the blades of TR-5 were 23.2% thinner than those of PC-WT. The above results indicated that TR-5 has thinner blade, higher contents of the major photosynthetic pigments, faster growth speed, higher-temperature resistance, larger number of conchospore release and no monospore release as compared with PC-WT.

PO-01-74

Pyropia yezoensis ST I: A new cultivar in China

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Pyropia yezoensis ST I is a high-light tolerant cultivar mutated by 60Co-γ-ray from the wild type and subsequently selected through four generations by high growth rate. In industrial cultivation, its production increased by 37.8% and 18.6% compared with WT and traditional cultivar. The blade of Pyropia yezoensis ST I is thinner and has higher protein content by 15.4% than WT. For these superior characteristics, Pyropia yezoensis ST I has become a new cultivar in laver cultivation of China.

PO-01-76

COMMERCIALLY IMPORTANT TROPICAL AND TEMPERATE RED ALGAE: ARE THEY REALLY DIFFERENT?

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Seaweed aquaculture worldwide has increased significantly in the last decade (~24 million metric tons) with a value of ~US $7 billion, whereas harvesting has remained stagnant at ~ 1 Mt/year for the same period. Production is dominated by Asia, Africa and South America, both in tropical and temperate oceans. Although 33 countries reported seaweed farming only nine countries (four temperate and five tropical) produced 99.3% of farmed seaweed output. Red seaweeds represent 54.4% of reported farmed tonnage. In tropical waters carrageenophyte species including Kappaphycus and Eucheuma species (Elkhorn sea moss, spiny eucheuma, Eucheuma seaweed) account for over 64% of the production, while in temperate waters it is associated to Gracilaria spp (warty Gracilaria known as G. verrucosa and G. chilensis) and to nori (including Porphyra and Pyropia species) that accounts for 21% and 14% of the production, respectively. Minor values include Palmaria palmata and Chondracanthus chamissoi. Due to the growing importance of seaweed aquaculture future scientific and technical challenges should be solved. Moreover, seaweed production of additional species is commonly reported in growing numbers though often in reduced scale or preliminary form. In this paper we discuss on the published information for commercially farmed red algae species, and for some potential species from both tropical and temperate habitats, to identify physiological differences, such as those in relation to higher/lower light and temperature tolerances, and on their differential chemical constituents, from the particular polysaccharides of temperate species to the bioactive compounds found in tropical red algae. Finally, the aquaculture technological advances, gaps and constrains are also presented and the information suggest that the cultivation approach used depends principally if the species have clonal or not capacities, independent from the habitat (temperate vs. tropical).

PO-01-77

Spawning techniques for Phyllospora comosa integrated aquaculture in southern Australia

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Seaweeds have complex life cycles but with significant variations amongst different taxonomic groups. Because of the sheer diversity of southern Australian seaweeds, the life history dynamics are poorly understood for many species of potential commercial value. There are many factors that can affect the yield and quality of seaweeds grown in aquaculture, including Integrated Multi-Trophic Systems. In order to maximize sustainable yields and nutritional quality of seaweeds in aquaculture it is essential to identify the ideal growth conditions and any factors that may adversely affect production at all stages of the life cycle. It is known that environmental triggers are drivers for reproduction in plants, therefore it is firstly important to understand and pin point shifts in temperature, pH, nutrients and light in the natural aquatic environment throughout the year whilst conducting germination experiments to be able to identify if a shift

in an environmental parameter does in fact lead to a reproductive event. To date some work has been completed for Ecklonia radiata but little is known for another potentially economically important species, Phyllospora comosa. We will endeavor to identify the optimal spawning time for potential broodstock of P. comosa located within close proximity to the designated aquaculture zones in Port Phillip Bay, Victoria, as well as the most effective spawning method. This project aims to explore germination success whilst environmental parameters are monitored. Three spawning techniques; desiccation, temperature and light shocking will be tested monthly for the duration of a year to identify when spawning success will be at it's highest. It is predicted that optimal broodstock will occur in the spring and summer months when the growth period slows and energy is focused on reproduction, similar to other fucales. This presentation will cover the preliminary results of field surveys and germination experiments of P. comosa.

PO-01-78

A comparison of the bioremediation potential of five seaweed species in a land-based culture system

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The bioremediation potential of five seaweed species (Codium fragile, Ulva pertusa, Ecklonia stolonifera, Saccharina japonica, Gracilariopsis chorda) was compared in a fish-seaweed integrated culture system to select an appropriate seaweed species as biofilters for the effluents from black rockfish (Sebastes schlegeli) tanks. U. pertusa and C. fragile showed highest total ammonia nitrogen (TAN = NH3+ + NH4+) biofiltering efficiency (> 80%). Total oxidized nitrogen (ToxN = NO3– + NO2–) biofiltering efficiency of all species ranged from 28% in U. pertusa to 50% in E. stolonifera and S. japonica. TAN removal rates were highest in U. pertusa (9.21 g TAN m-2 day-1) and lowest in E. stolonifera and S. japonica (6.27 and 5.76 g TAN m-2 day-1, respectively). Two brown seaweed species (E. stolonifera and S. japonica) showed highest in ToxN removal rates highest (3.91 and 3.06 g ToxN m-2 day-1, respectively). This suggests that seaweeds may select nitrogen sources fitting their storage capacity. In contrast, G. chorda showed the highest nitrogen yield (8.94 g N m-2 day-1) estimated by the biomass yield and tissue nitrogen content. In E. stolonifera, S. japonica and G. chorda, the nitrogen yield was higher than TAN removal rates. These results were related with high ToxN removal rates of two species. The biofiltering efficiency for phosphate (PO43–) of five species was over 60%. C. fragile exhibited the highest phosphate removal rates (1.07 g P m-2 day-1) compared to other seaweed species. In contrast to the nitrogen yield, the phosphate removal rates were higher than the phosphate yield during the experimental period. In this study, all species efficiently removed enriched nutrients from the fish tank effluents. These results provide valuable information for selecting optimal seaweed species in fish-seaweed integrated systems.

PO-01-79

Algaplus: Production of Sustainable Seaweeds and seaweed based-products

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Algaplus is a company that produces and commercializes seaweed and derived products. Our sustainable and organic certified seaweed are based in the integrated multi-trophic aquaculture (imta) concept, which allow us to increase biomass yields and sustain production when the wild resource is unavailable. All production phases are carried out in-house: biomass production, processing (washing, drying, milling) and packaging. In the food sector, we sell dried (whole, flaked and flour) and fresh seaweeds that are used as ingredients in restaurants and agro-food companies seeking a natural ingredient assured with quality, traceability, stability of supply and a small carbon-foot print that can help to differentiate their products. These sea vegetables are an excellent source of minerals, vitamins, fibre and low calories, contributing for a healthy and balanced diet. Aware of the nutritional qualities of these sea vegetables we foster its regular consumption and we are committed to develop food products which lead to a healthier nutrition. Therefore we own the brand tok de mar for restaurants and retail that presents a variety of seaweed species and seaweed-based food products. We also work on the development of new seaweed-based food products in partnership with already established food companies. The company also invests in r&d activities that contribute to find high-value applications to the seaweed biomass that is, or may be, produced by algaplus. Innovation is carried out in-house and with national and international scientific institutions and private companies. The idea behind it is to add value to traditional products through the nutritional and bioactive properties unique to seaweeds.

PO-02-01

Chromatographic analysis for low molecular weight saccharides in edible seaweeds

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Saccharide is a main component in edible seaweeds, because saccharide contents are in the range from 38% to 64% on a dry basis according to Japanese food composition database. Chlorophyceae, rhodophyceae, and phaeophyceae differ in free saccharides (i.e. they are reserve substances of low molecular weight) and in storage polysaccharides. Most chlorophyceae contain starch, glucose, fructose and sucrose, because chlorophyceae metabolism is essentially the same as land plant metabolism. Level of starch, glucose, fructose and sucrose contained in rhodophyceae are very low in comparison with those in chlorophyceae. Most phaeophyceae possess hardly any or none of the free saccharides and storage polysaccharides which appear in rhodophyceae and chlrorophyceae. Thus, low molecular weight saccharides in food derived from seaweed vary with the original edible seaweeds. On the other hand, high performance liquid chromatography is one of the most practical tools for saccharide analyses. In order to develop a simple rapid technique in normal phase partition chromatography for low molecular weight saccharides in edible seaweeds, we made a comparison between an amino-silica column and an amide-silica column. We also investigated microanalysis for reducing saccharides by using high performance liquid chromatography with postcolumn fluorescence derivatization. An amino-silica column, a TSKgel NH2-100 column, with 80% acetonitrile as a mobile phase was judged to be the best column for low molecular weight saccharide analysis in edible seaweed. On the other hand, an amide-silica column, a TSKgel Amide-80 column, was judged to be the best column for microanalysis for reducing saccharides in edible seaweeds. The present technique was successfully applied to the analysis for low molecular weight saccharides in edible seaweeds and seems to be useful for automated microanalysis of reducing low molecular weight saccharides in edible seaweeds and in foods derived from seaweeds.

PO-02-02

Amino acid content of green, brown and red seaweeds from the Magellan Strait, Southern Chile

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Seaweeds are commonly consumed by humans in many countries such as Japan, Korea or China, and are also used as a source of polysaccharides for food and pharmaceutical uses. Algal proteins are an important source of amino acids, which profiles vary according to species, genus and class. We determined the amino acid profiles and total proteins of marine seaweeds from the Magellan Strait, in Southern Chile. These samples included nine genera of the Rhodophyta, six of the Chlorophyta and three of the Ochrophyta divisions. The protein crude content was higher than that obtained for the sum of all amino acids (total AA). Significant differences ($p<0.05$) between the seaweed divisions (red, green and brown) were detected in the mean protein concentrations obtained by both methods of determination. The consumption of a serving (≈30 g of dry seaweed) of brown, red and green seaweeds provides an average of 4.2, 6.1 and 6.7 g of proteins, respectively. Brown seaweeds had lower ($p<0.01$) total AA content, essential amino acids, non-essential amino acids and crude proteins than those found for red and green seaweeds, without significant differences between the latter two. Also, brown seaweeds had lower ($p<0.05$) mean content of aspartic acid, serine, glycine, arginine, threonine, alanine, proline, valine, isoleucine and leucine than those obtained from red and green seaweeds.

PO-02-03

Nutritional properties of the Prepared Dishes using sub-Antarctic macroalgae

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Sub-Antarctic macroalgae are rich in soluble dietary fibers, proteins, minerals, vitamins, antioxidants, phytochemicals, and polyunsaturated fatty acids, with low caloric value. Green, brown, and red algae contain various organic and inorganic compounds that are beneficial to human health due to their high nutritional value and their healing properties for many diseases. The aim of this study is to determine the chemical composition of some dishes based on marine algae harvested in the Strait of Magellan in order

to promote the use of sub-Antarctic macroalgae as food. Luche pesto and parsley, huiro breadsticks, huiro fritter, cochayuyo fetuccini, cochayuyo hamburguer and cochayuyo bread were prepared using Macrocystis pyrifera known as “huiro”, Pyropia columbina known as “luche” and Durvillaea antarctica commonly known in Chile as “cochayuyo” as ingredients, Subsequently the nutritional value of these preparations was determined. The species of macroalgae were collected monthly throughout the Strait of Magellan. The chemical composition, including carbohydrates, proteins, lipids, fiber, sodium, sugar profile, and fatty acid content, was examined. The content of protein was 4.1-12,7%, with cochayuyo hamburguer having the highest value on dry weight (dw). The highest carbohydrate and sodium content was measured in huiro breadstick (58.1 % and 0.947% dw respectively). Cochayuyo fetuccini was found to be the dish richest in fiber (18.9% dw), while luche pesto and parsley showed the highest content of total fat (23.1% dw). The most abundant saturated fatty acids were palmitic (C16:0) and myristic acid (C14:0), with values ranging from 1.59 to 23.26 %. The most abundant monounsaturated fatty acid was oleic acid (C18:1) at 52.66%. The highest levels of polyunsaturated fatty acid were observed for linoleic acid (C18:2ω6) and a-linoleic acid (C18:3ω3). Sub-Antarctic macroalgae have food products might be an interesting potential source of healthy food and human nutrition

PO-02-04

Fermented seaweed sauce prepared from nori Pyropia yezoensis

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Origin of fermented sauce is high-salt content gravy products, which was described for the first time in Chinese old manuscript, written over 3000-years ago. Fermented sauce products are usually produced from soy and fish, but that from seaweed have not been developed.
High-salt content seaweed sauces were prepared for the first time by fermentation using nori (Pyropia yezoensis) and characterized. Components and taste of the two nori-sauces (NSs) prepared separately were compared with those of soy and fish sauces. The NSs were rich in total nitrogen compounds (1.5 g N/100 g on average) and potassium (880 mg/100 g). As for free amino acid composition, the NSs were richer in aspartic acid (an umami element), threonine, alanine, and glycine (sweetness elements), while less in phenylalanine and alginine (bitterness elements), explaining its unique taste as evaluated by a taste sensing system. As for its food function, inhibitory activity of angiotensin-converting enzyme was observed. As for food safety, arsenic was detected at a 0.8 g/100 g level in total, but inorganic arsenic was not detected (<0.05 mg/100 g). Allergy-causing substances contained in wheat flower, soy beans, and crustaceans were not detected (<0.1 mg/100 g) by immunological detection assays. These results suggest that the nori-sauce has a high potential as a novel nutritional source for humans.

PO-02-05

Microwave Assisted Freeze Drying of Sugar Kelp (Saccharina latissima) to improve product quality

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Sugar Kelp is one of the seaweeds (sea-vegetables) that belongs to the brown algae family and grows in extreme low intertidal and shallow sub-tidal zones. Seaweed does not only provide benefits to other marine creatures but to the humans that consume it. Recent interest among consumers in no added chemical additives/preservatives into food products, the potentials of sea-vegetables as a source of natural and health food became widely recognized and studies on the nutritional values of sea-vegetables have become more widespread. The state of Maine, in the United States of America has many companies that harvest sugar kelp from the North Atlantic Ocean. However, sugar kelp needs to be dehydrated/dried and processed to preserve for off-season use or for various value-added products. A novel processing method (microwave assisted freeze drying) was tested and compared to a traditional method of processing (oven drying) for various quality parameters such as color, moisture content and water activity of the dried products. Sugar kelp samples dried for four hours had on average moisture of 10% more than Samples using microwave assisted freeze-drying. It was observed that the addition of short-term microwave usage on seaweed samples increases the drying potential compared to samples dried with just one method of drying without inhibiting product quality.

PO-02-07

Utilization of brown seaweed for single-cell protein production

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Single cell protein biomass in the form of yeast produced from brown seaweed could offer the fish industry a novel alternative feed. In this study, enzymatic hydrolysis of Saccharina latissima was carried out by a commercial cellulase cocktail comparing wet sample and samples dried at different temperature. The maximum enzymatic glucose released was 96.5% of the theoretical yield of 30°C oven dried SL. The reaction conditions were pH 6.2, 50°C for 20h, substrate loading 5% (w/v) and enzyme dosing at 7 mg of protein/g of dry matter SL. The enzymatic hydrolysis was further optimized by investigating kinetics, enzyme dose and inclusion of alginate lyase. At high solid loading 15% with optimal enzyme conditions with inclusion of 10% alginate lyase in cellulase enzyme produced maximum concentration of total sugars 51 g/L. The ability of different four yeast strains to convert D-glucose to single cell protein was screened.

PO-02-08

Nutritional and antioxidant activity of 7 different seaweeds from Madeira Archipelago

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The biochemical composition and antioxidant activity were determined in 7 selected seaweeds from Madeira Archipelago, Portugal. Green (Ulva lactuca L.), red (Asparagopsis taxiformis D., Chondrus crispus S., Galaxaura rugosa J.V.L., Grateloupia lanceola J. A. and Nemalion helminthoides V.) and brown seaweed (Zonaria tournefortii L.) were used in this work . All of the analysis conducted were in 100g of material in a dry basis and these seaweeds showed between 16.57 and 84.25 g of total mineral content. Organic matter was composed by fibber (8.11 and 54.34 g), starch (1.83 and 26.29 g), protein (3.72 and 24.46 g), fat (1.39 e 12.96 g) and soluble sugars (0.13 and 0.88 g) by decreasing significance of fractions. These results demonstrate high variability of these seaweeds biochemical composition. Among the analysed seaweeds, Asparagopsis taxiformis D., was found in this work to have substantial quantities of protein (24.15 g) and a good quantity of fat (6.62 g), fibber (31.91 g) and starch (8.03 g), compared to the other seaweeds. The analysis of pigment fraction included the measurement of chlorophyll (chlorophyll a - 0.03 and 0.25 mg, chlorophyll b - 0.03 and 0.27 mg), total carotenoids (0 and 0.31 mg) and total flavonols (0 and 0.64 mg QE) of which the highest values were obtained by Zonaria tournefortii L. in chlorophyll a (0,24 mg) and total carotenoids (0.30 mg). Ulva lactuca L. had the highest values for chlorophyll b (0.26 mg) and total flavonols (0.63 mg QE). Zonaria tournefortii L. was found to possess the highest antioxidant activity, due to the highest values obtained in total phenolic content (2.25 mg GAE), ferric reduction antioxidant potential (66.83 mg AAE), ferrous ion chelating (81,29 % chelating activity), β-carotene bleaching (495,61 % antioxidant activity) and antioxidant activity (5.62 x 103 mg AAE). This seaweed is present in some abundance and found to be extensively understudied due to the extremely scarce data published.

PO-02-10

Developing an integrated approach to seaweed resource assessment in Ireland

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Due to the ecological and economic importance of seaweed there is a need for cost effective and efficient methods to collect quantitative and qualitative information about macroalgal benthic communities, to underpin their efficient assessment, monitoring and management. Most recently, growing interest in the utilisation of seaweed sources in a range of biotech sectors has increased the pressures on natural populations. This project adopts distinctly different approaches to assess 1) intertidal and 2) subtidal macroalgal communities in pilot sites on the Irish west coast, with a view to extend application of the methods developed on a larger scale in the future. Intertidal resource mapping is conducted using drone/aircraft mounted technologies, focussing on the commercially and ecologically important species Ascophyllum nodosum. On Irish shores, this species is locally abundant but may exhibit a patchy distribution and be commonly interspersed with other fucoid species. Remote sensing technologies are combined with in situ groundtruthing of fucoid distribution, biomass and population characteristics. For subtidal species, ship-based acoustic assessment employing single and multi-beam echo-sounders are used; data obtained from acoustic signals are related to water column data and kelp species-specific biomass and population

characteristics derived from destructive and non-destructive sampling of kelp habitats conducted by dive surveys. This project will develop new methodologies and create first data on distribution and biomass of selected key macroalgae, which will be essential for future Irish marine ecosystem monitoring and management, as well as the development of coastal industries.

PO-02-11

Induction and isolation of Porphyra lucasii pigmentation mutants by gamma irradiation

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The present study describes the isolation of Porphyra lucasii pigmentation mutants induced by gamma irradiation. Gametophytic blades were irradiated with 60Co for doses of 100-1000 Gy. The survival rate and growth of the irradiated blade cells, suggested that a dose of 500Gy or less is suitable for the isolation of P. lucasii mutants. After irradiation, red-colored gametophytic blades developed from archeospores that were released from each of the mutated cell clusters of various color, and a red mutant strain (500GR) was established as a conchocelis colony in culture. The blade of the mutant strain was characterized based on antioxidant activity, photosynthetic pigment contents, and 2D electrophoresis analysis and compared with the wild-type (WT).

PO-02-13

DNA barcoding on brown algae from the intertidal zone of Shandong Peninsula, China

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DNA barcoding was conducted on the intertidal brown algae collected in the costs of Shandong China, from March 2012 to October 2013, using three DNA markers: partial mitochondrial cytochrome c oxidase subunit I gene (COI), partial large subunit rRNA gene (LSU) , and the internal transcribed spacer (ITS). The results showed that COI was a sensitive marker at species level, with interspecies diversity from 1.96 to 10.74% and intraspecies diversity from 0 to 0.58%, except in the case of Sytosiphon where variation within species was 0.93%. LSU had the capacity of distinguishing at genus level, with interspecies diversity from 1% to 2.9% and intra-species diversity from 0 to 0.55%. ITS performed similarly with COI, but with lower intraspecific divergences (0% and 1%) and averagely higher inter-specific divergences (3.6% and 10.2%). However, ITS was handicapped to be as suitable marker for barcoding due to its inability on providing a reliable alignment of ITS sequences across a divergent set of taxa and its substitution saturation. It suggested COI and LSU as the optimum DNA markers for brown algae, instead of ITS. Bayesian and neighbor-joining (NJ) distance analysis revealed phylogenetic relationships between species based on COI and LSU sequences, respectively. The close clustering of Ectocarpales and Scytosiphonales in NJ trees corroborated the proposal of combining the two classes into Ectocarpales sensu lato.

PO-02-15

Evolutionary significance of the discovery of (1→3)(1→4)-β-D-glucan in brown algal cell-walls

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Brown algae are photosynthetic multicellular marine organisms that are phylogenetically distinct from green algae, red algae and land plants. However, all these groups possess carbohydrate-rich fibre composite cell walls. Brown algal cell walls are composed predominantly of sulfated fucans, alginates and cellulose, but their detailed compositions and architecture are still unclear. Using high throughput carbohydrate microarray technology we have conducted a wide-scale analysis of cell wall polysaccharides in diverse brown algal species. The analysis is based on the sequential extraction of polysaccharides which are then spotted as microarrays prior to probing with antibodies to reveal the relative abundance of epitopes across the sample set. One unexpected outcome of this work was the ubiquitous discovery in all the species analysed of mixed linkage (1→3)(1→4)-β-D-glucan (MLG), subsequently confirmed by detailed enzymatic analysis. This polysaccharide is a dominant hemicellulose in certain land plant taxa and has recently been showing to be widespread in green plants. MLG is an important structural polymer in planta, and furthermore has attracted interest related to its health benefits. MLG consists of 'blocks' of contiguous 1,4-linked glucose residues joined by intermittent 1,3-linkages and the distribution of these linkages is known to influence functionality. The fine structure of MLG will be discussed within the context

of brown algal cell wall architectures. This discovery is significant as it implies the convergent evolution of an important and abundant polysaccharide in lineages very distant in the kingdom of life. The prospect for exploring the genetic basis of MLG in brown algae using the genome sequence of model brown alga Ectocarpus siliculosus will be addressed.

PO-02-17

Establishment of a genetic transformation model for green seaweed Ulva

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Species belonging to green seaweed Ulva usually have great capacity of growing fast with high protein content, and the potential for Ulva to be cultured in closed land-based tank has been verified to make commercial production available. However, technical improvements to develop genetic engineering for Ulva have long been ignored. Here, we report a transformation model for Ulva in which the in situ germination of vegetative cell of fronds was proved as an effective generation pathway for seedlings of transformants, and herbicide Basta as a screening reagent. Following above process, completely stained seedlings in blue colour could be obtained after the introduction of GUS reporter gene by particle delivery system, which exhibiting the expression and potential integration of foreign gene at one-cell stage.

PO-02-18

Hybridization among ectocarpus siliculosus and e. crouaniorum

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The filamentous alga ectocarpus is the model organism for genetics and genomics of brown algae. Phylogenetic studies based on worldwide collections of ectocarpus have demonstrated that this genus is a complex of closely related species separated by various degrees of intersterility. In the field, putative hybrids have been documented between the two cosmopolitan species e. siliculosus and e. crouaniorum, which makes the two species suitable for studying hybridization and the evolution of mechanism of reproductive isolation. In this work, we studied 9 populations (8 european atlantic and 1 mediterranean) in several of which the two species co-occur. We used a set of 13 microsatellite loci on a total of 759 e. siliculosus and 509 e. crouaniorum clonal cultures isolated from field samples. We tested if there is hybridization in the field, the direction of the hybridization and if there are different kinds of individuals of mixed ancestry. The results suggested the occurrence of hybridization at all sites where the species were present in sympatry, with 5 to 13 % of the populations consisting of hybrids. Interspecific hybrids contained cytoplasm of either e. siliculosus or e. crouaniorum, revealing no preferential directionality in interspecific crosses. The hybrids were heterozygous for the two parental nuclear genomes and no signature of recombination was observed. We conclude that a strong post-zygotic barrier, probably at meiosis, prevents recombination between the two parental genomes.

PO-02-19

Diversity and phylogeny of the agarophyte Gelidiellaceae, Rhodophyta based on multigene analyses

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The agarophyte family Gelidiellaceae is the poorly known group in the Gelidiales that is distributed from tropical to subtropical waters. Approximately 26 species in two genera, Gelidiella and Parviphycus, have been described in this family, however, there is much confusion in generic status and species circumscription. In order to resolve these taxonomic issues, we analyzed plastid-encoded rbcL and psaA and mitochondria-encoded cox1 genes from fresh collections and herbarium specimens. Because G. ramellosa from western Australia was consistently placed outside Gelidiella, we propose to describe a new genus to accommodate G. ramellosa and an unidentified species from Singapore. Parviphycus was also not monophyletic in the multigene phylogeny including the generitype, P. adnatus, proposing taxonomic revision at genus level. The species number of the Gelidiellaceae may increase to more than 30 species, including new species found in our study. The implications of taxonomic revision including new genus and new species, supplemented with morphological data, are discussed here.

PO-02-22

The reproductive pathways of floating Ulva prolifera and the response mechanisms to stress

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In nature environments intact thallus of floating Ulva prolifera is easily cut into fragments by seawater flow, gnawing of animal, and ship propeller. Those thallus fragments are an important origin that results in rapid biomass accumulation of Ulva prolifera. When fragments excised from intact thallus were cultured in laboratory, the cell in thallus fragments changed greatly. Those cells developed into sporangium after 48 h culture. Subsequently, spores were released form those sporangia. The cells in fragments of floating Ulva prolifera were vegetative during 0-48 h culture. Meanwhile photochemical quantum yield of PS I [Y(I)]and effective PS II quantum yield [Y(II)]were relatively stable and the variation tendencies between them were similar. The formation of sporangia and spore release occurred after 48 h and spore release reached maximum degree at 60 h in culture. At 48 h Y(II) dropped to its lowest level, while Y(I) rose to its highest level. Those changes suggested that linear electron flow (LEF) declined while cyclic electron flow around PS I (CEF) was enhanced markedly at sporulation onset. U. prolifera thalli in free-floating mats could be separated into three groups according to color: light green, intermediate green, and dark green. The Y(II) of the light green thalli cells had the highest value, which usually are exposed to the air for long periods of time, and is difficult for them to acquire dissolved inorganic carbon from the seawater. During desiccation, the PSI-driven CEF in U. prolifera increased significantly. In addition, the activity of PSI was restored faster than that of PSII during re-hydration. Based on these results, we propose that the physiological tolerance and stability of photochemical systems, especially PSI-driven CEF, might be one of the most important factors that make U. prolifera well suited to withstand repeated cycles of desiccation and re-hydration during daily low and high tides.

PO-02-23

A new candidate species in epi/endophytic genus Ulvella (Ulvellaceae, Chlorophyta) from Korea

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Micro-filamentous green algae in the Ulvellaceae are very difficult to identify because the morphology of many epi/endophytes is relatively simple and their diagnostic characters are absent. Recently, we isolated an epi/endophytic alga from Bryopsis sp., which collected from Jeju shore and cultured in the laboratory in order to examine morphological characteristics. And a phylogenetic analysis based on chloroplast-encoded elongation factor tufA gene was performed to identify this epi/endophytic alga. In the culture, this epi/endophytic alga was filamentous and formed small round clumps. Branching was irregularly alternate, central cells were rounded and branched filaments were cylindrical cells. Each cell had several pyrenoids without hairs. As they grew up and matured, sporangia formed from the rounded cells and/or the cylindrical cells. In a phylogenetic reconstruction based on the chloroplast-encoded tufA gene, the sequences for the Ulvella sp. species were clearly distinct from any other Ulvella sequence available for this gene. Ulvella sp. was placed in a clade together with Ulvella endozoica. But the sequence divergences between the Ulvella sp. material and those of the U. endozoica were 5% for tufA gene. Their phylogenies support the taxonomic status of Ulvella sp. as a new candidate species.

PO-02-25

Sex specific importin alpha homology in male and female gametophyte of Bostrychia moritziana

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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 homologues were specifically expressed in male and female gametophyte, respectively. Female specific homologue of importin alpha (ISGT_8297) was expressed in female gametophyte as well as carposporophyte. Two sex-specific importin alpha homologues showed 76% 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 (ISGT_8297) 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.

PO-02-26

NEPTUNA – applying novel extraction processes to algal source materials

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The increasing demand for novel compounds from natural sources has recently focused on the production of new high value chemicals from algae including macroalgae. However, to exploit the rich chemical diversity of algae efficiently and cost-effectively, and to reduce the amount of raw materials required, there is a need to develop new technologies that allow maximisation of extraction yields and ensure maintenance of chemical integrity of valuable compounds. NEPTUNA is an NUI Galway-lead project funded under the Marine Biotechnology ERA-NET involving other Irish, Belgian, UK and Norwegian partners. The project aims to develop novel enzymatic extraction techniques for high value compounds from a range of different algal groups. Species of interest include selected macroalgae, Cyanobacteria and microalgae which contain valuable compounds with applications in the aquaculture/animal health and home/personal care product ranges. Enzyme-assisted extraction techniques are compared with traditional methods that are typically inefficient and low-yielding, to extract and identify new compounds with anti-oxidant and anti-microbial activities. Biomass of selected algal species is sourced from natural habitats with anticipated high bioactivity potential, and chemical profiles are additionally enhanced by stress conditions to maximise outputs.

PO-02-27

Biorefining of macroalgae using hydrothermal processing: Analysis of product streams.

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Hydrothermal processing of macroalgae results in a process water rich in soluble organic hydrocarbons containing C6 sugars and organic acids. This study compares the composition of the process water from the processing of a kelp (Saccharina latissima) and a fucoid (Ascophyllum nodosum) following hydrothermal processing at different temperatures. Hydrothermal processing was performed using a high pressure batch reactor at temperatures ranging from 150-250oC. Analysis of the process water is challenging and a number of analytical techniques have been investigated to identify different compound classes. These include the use of HPLC, GC-MS following injection by purge and trap and GC-MS following injection by solid phase micro extraction (SPME). An assessment of the degradation pathways of the main seaweed polymers has been performed using model compounds studies. This investigation has resulted in a greater understanding of the degradation routes of seaweed polymers under hydrothermal conditions and identified the potential for production of high value chemicals

PO-02-28

Fermentation of Saccharina latissima as a viable storage process?

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The use of ensilage as a preservation methodology for freshly harvested seaweed is not commonly used. Spontaneous fermentation is rare because of quite high pH value (pH > 7) of seaweed, low content of fermentable carbohydrates, presence of sugar alcohols and uronic acids rather than hexose sugars and low levels of epiphytic lactic acid bacteria. The aim of the present study was to study the stabilization of fresh seaweeds Saccharina latissima by fermentation and to evaluate this process as a viable storage solution. Based on literature, experiments were conducted on fresh chopped seaweeds where different lactic acid bacteria were inoculated. Different conditions and lactic acid bacteria were tested and the performance of fermentation was analysed by physico-chemical and microbiological parameters like degree of acidification, sugar profile and lactic acid bacterial growth, The results of this study indicate the potential of fermentation of Saccharina latissima using lactic acid bacteria. A good acidification is obtained after 4-5 days of anaerobic conditions showing a partial consumption of free sugars/polyols and glucose polymers.

Preserving fresh seaweeds with lactic acid bacteria without using polysaccharides hydrolyzing enzymes could lead to a viable storage of the raw material for industrial alginate extraction. Other applications can be explored like the development of a range of functional foods and new fermented food products. Study performed within the IDEALG project, Grant n° ANR BTBR-10-04

PO-02-29

Biochemical composition of red, green and brown seaweeds common at the Swedish west coast

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Fossil resources are still important to provide fuels and commodities in our society. However, a transition to bio-based fuels and chemicals are needed. In Sweden, e.g. biofuels still account for 4 % of the total petroleum consumption. About two thirds of our consumed biofuels are made using domestic rapeseed, wheat, barley and left-over wine as raw materials, while the rest is imported. All of these resources are from traditional agriculture and requires land, fertilizers, and freshwater. While these types of biomasses will surely play a role in a sustainable future, making not only transport fuels, but also fine and bulk chemicals as well as materials, other biomass alternatives are also needed. Macroalgae require no arable land and need no other fertilizer than what the sea provides naturally. However, to realise algae bio-products targeted technological research efforts regarding cultivation and refining processes are required. To further explore the potential of the sea and the use of marine resources for biorefining, further knowledge on biochemical content of algal biomass is needed to be gathered. This is especially true for the Western coast of Sweden. Filling these knowledge gaps will give the opportunity to find novel utilizations of macroalgae, making it possible to find new species suitable for food, feed, chemical or biofuel production. In this project, 23 seaweed and filamentous algae species of green, red and brown algae have been collected from and around the national park of Kosterhavet. The biochemical content of these has been determined to gain knowledge regarding the variation in biomass composition between algae species in Swedish waters. Analyses have been conducted for both elementals (C, H, N, S, P and metals) and macromolecular composition (total carbohydrates, total proteins, ash) as well as dry weight. Hopefully, our data can result in future research leading to novel applications and potential marine industries.

PO-02-30

What to do with all these seaweed's industrial waste?

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In present scenario complete usage of total biomass of any feedstock for integrated production of various products such as food, energy and other useful products become a novel idea. Bio-refinery based on zero waste concepts is a relatively new area of research where much literature is not available. Information on alginate, agar and carrageenan structure, biosynthesis and function alongwith other useful produts are easily available. Moreover fragmented data are available on analysis of leftover pulp after extraction of these polysaccharides from seaweeds. Seaweed industrial wastes i.e. the remaining pulp after extraction of high value polysaccharides still contain high amount of carbohydrates and other nutrients which may be used as a source of raw material for various industries especially biofuel and bio fertilizers. In the present report a thorough study has been done on biochemical composition of these leftover pulps and a conceptual biorefenry has been designed to lay the foundation for the future study .

PO-02-31

Combined ethanol, butanol, and fish feed production from brown algae - a biorefinery concept

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Due to a still growing demand on energy and food supply, seaweed has gained more and more attention as feedstock for bio-energy carriers and value-added products such as proteins. A biorefinery concept has been developed and tested in pilot scale using brown algae i.e. Laminaria digitata grown in the North Sea in wild habitat as substrate for ethanol, butanol, biogas and fish feed production. The biomass

composition of seaweed has big variations depending on many factors such as seaweed species, growth conditions, as well as harvesting times. This wild-growing Laminaria digitata was harvested at the Danish North Sea coast in August 2014 with high glucose content (i.e. 49.1% glucose, 8.5% mannitol, 5.0% protein). 30 kg dried seaweed biomass (i.e.~ 103 kg fresh weight) was processed in pilot facilities in DTI i.e. in a 800 L thermo-controlled stirring reactor with 600L working volume by enzymatic hydrolysis using commercial enzyme mixture i.e. NS81016. 55% of glucan (mainly laminarin) in the brown algae was hydrolyzed to glucose monomers after 24 hours. The hydrolysate was easily separated by simple filtration into liquid and solid fractions. The liquid fraction (containing 14 g/L glucose) was further utilized for either ethanol production by yeast fermentation (at yield around 0.4 g/g -glucose), or butanol production by Clostridium strains (at yield around 0.3 g/g -glucose). The enriched-protein solid fraction (enriched by 72%) was further prepared for fish meal by extrusion, and tested in real fish trials. Acknowledgements: This work was financially supported by the Danish Council for Strategic Research as part of the MacroAlgaeBiorefinery (MAB3) project, and by European Union's Horizon 2020 research and innovation programme under grant agreement No 654010 as part of the MacroFuels project.

PO-02-32

Aquaculture, Valorization and Management for Seaweed Sustainability in Indonesia

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Marine seaweed is one of marine resources that are ubiquitous and cultivated in Indonesia. Coastline and biodiversity are two remarkable potentials for the seaweeds development. Nevertheless, until present, only the two red genera Kappaphycus and Gracilaria still become the main commodity that is mostly cultivated compared to other Indonesian living species. In the other side, this makes Indonesia as the largest exporting country of raw seaweed for carrageenans extraction. Despite this noticeable fact, the valorization of Indonesian marine seaweeds is still limited to direct applications as traditional food and simple processing for local consumption. Currently, through the Ministry of Marine Affaires and Fisheries, Indonesia applies three basic strategies to manage and develop seaweeds farming and processing: extensification, intensification and diversification. In this last strategy, information about seaweed species and environmental factors affecting their growth is essential for determining which seaweed species can give optimum advantages in terms of quality and quantity based on seasonality, environmental conditions and geographical distributions. The extensification and diversification strategies are realized in some activities within the project INDESO (Infrastructure Developent of Space and Oceanography). The INDESO project aims to manage and develop seaweeds aquaculture in Indonesia with the help of Earth Observation technology. Therefore, general presentation concerning the Indonesian seaweed potential, cultivation method and future application will be further reviewed. In this review, management perspective based on the approach of comprehensive potency, preferential location and proper season of cultivation as well as conservation through the diversification strategy, added-value of exploration for optimization and sustainability of marine seaweed in Indonesia will be illustrated.

PO-02-34

Mechanisms and heritability of disease resistance in brown algae

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Brown algae (Phaeophyta), in addition of having an important ecological role as predominant primary producers in temperate and cold coastal seas, are of increasing relevance to the rapidly-expanding aquaculture industry. Like any other organism, brown algae are plagued by a variety of phylogenetically different pathogens. However, the mechanisms of disease resistance in brown algae are poorly known, in contrast to the well-studied hypersensitive response in terrestrial plants. We previously established as suitable pathosystem and identified clonal brown algal strains that exhibit differential disease susceptibility to the obligate oomycete pathogen Eurychasma dicksonii. Here we show that resistance to infection is evoked by the hypersensitive death of single algal cells attacked by Eu. dicksonii. These cells express the

programmed cell death marker metacaspase. Further conserved markers of the hypersensitive response include the deposition of blue-fluorescent metabolites and beta- 1, 3-glucan, the production of reactive oxygen species, and the fragmentation of DNA characteristic for programmed cell death. This hypersensitive response was observed in ten algal species belonging to four different orders, demonstrating its broad conservation among brown algae. In addition to the description of disease resistance mechanisms we have furthermore investigated the heritability of this trait on our model pathosystem using several genealogies of Ectocarpus fasciculatus.

PO-02-35

Seaweed industry in Indonesia : Challenges and Prospects

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As an archipelagic country, Indonesia has a potential resources of seaweed such as Euchema sp, Gracilaria sp, Gelidium sp, Hypnea sp, and Sargasum sp. The country also as a major exporter of raw material of seaweed in the world. Total production of seaweed year 2015 is 11.6 million ton for Euchema sp and Gracilaria sp (wet basis). The production of raw material tend to increase anually. Inspite of as an exporter of raw material of seaweed, in the country also develop the seaweed processing industry to produce Alkaline Trated Carageenan (ATC), Semi Refined Carageenan (SRC), Refined Carageenan (RC), Agar, and other product for food or non food. The type of seaweed industries was established in Indonesia are in three group of processing such as carageenan, agar, and formulated products with the total number respectivelly 21, 14, and 10 processing plant. The industries mainly located in Java and celebes Island. Contrary as a main producer, Indonesia currently imported end products of seaweed from several country to fulfill domestic demand. Particularly on alginat, the processing industry not develop yet eventhough the supply of raw material avalaible annually. The total export of dry sargasum on 2012 is 20,000 MT per year. On the other hand, Indonesia still import of sodium alginat 3,000 ton per year. UN Comtrade (2015) reported that the value of sodium alginat which is imported by Indonesia on 2012 to 2014 respectivelly 7.04 million, 7.286 million, and 8.576 million US$. Its conclude that Sargasum sp industry which produce sodium alginat and other products remain undevelop due to seaweed local industries focused on Euchema sp and Gracilaria sp. Key Words: Seaweed industry, Alkaline Treated Carageenan, Semi Refined Carageenan, Refined Carageenan, and Sodium Alginat

PO-02-36

Investigating potential effects of hypothetical large scale macroalgae farms

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Macroalgae are regarded as a promising source of natural energy-rich material to supplement fossil fuels. One of the key issues that needs to be addressed before large scale production of macroalgae becomes a reality is the potential for wider ecosystem effects as production is scaled-up. Macroalgae require dissolved nutrients for growth and metabolic processes. Large-scale farming could lead to the removal of nutrients in competition with phytoplankton and other aquatic plants, potentially resulting in lower productivity of the marine system. On the other hand, seaweed can act as biofilters, reducing nutrients released from fish and crustacean farms or riverine sources, helping to decrease the effects of anthropogenic nutrient-enrichment in coastal waters. Here we present 2 model approaches to assess the potential environmental effects of hypothetical macroalgae farms: a Combined Kelp Phytoplankton (CKP) compartment model and a 3-D coupled hydrodynamics biogeochemistry model. The CKP model was developed to include a macroalgae growth model, whereas the 3D model was equipped with a nutrient sink to simulate the presence of a macroalgae farm. The models estimated the nutrient requirements of hypothetical seaweed farms and whether the farmed seaweeds would compete for dissolved nutrients with phytoplankton and natural kelp populations. We conclude that effects of farming activity could be 'marginally significant' and given a sufficient high level of farming activity the effects might become significant. The observable effects of nutrient removal would be a lower nutrient concentration in the water, decreased natural productivity and energy fluxes through the pelagic system, decreased flux of organic material to the seabed, and subtle alterations to the community structure. These changes would occur in the long term against a background of considerable natural variability, and it would require a dedicated monitoring programme to detect effects.

PO-02-37

Mapping of kelp forest using integrated data from sonar and underwater video on GIS

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Saccharina kelp is commercially important in northern part of Japan. Most part of wild harvest of Saccharina kelp is in Hokkaido. The wild kelps occur at rocky shore where sessile organisms including algae may compete strongly for attachment space on the substrate. As the kelps have relatively short life spam, maintenances of the shore are important to prevent leading to climax vegetation. Thus mapping and biomass estimation of kelp and also competitive vegetation are required for proper management and sustainable utilization in the coastal area of Hokkaido. Survey methods on benthic vegetation can be divided in two category, one is optic and another is acoustic. The former includes satellite and airborne imagery, underwater video, and even visual observation using scuba. And the later includes sonars with different swath size, single-beam, multi-bean and side-scan sonar. Each method has both advantages and disadvantages. The optics potentially could identify species by color or spectral. On the other hand the acoustics potentially could trace three-dimensional structure. Therefore the integration of both survey method is expected to achieve better results than with each single method for mapping. In this study we used combination of conventional single-beam sonar and low cost underwater video system. The data from both systems were integrated using geographical information system (GIS). We conducted the survey using this integrated system at kelp forest in Erimo, Hokkaido, Japan in 2013 and 2014. Saccharina angustata and Phyllospadix iwatensis were dominant in shallow waters. Spatial interpolation of cover and thickness revealed the occurrences of each species were mutually exclusive. Annual harvested volumes in given small area of the kelp forest were also estimated as the difference of the volumes before and after harvesting of the kelp. These values were concordant with actual annual harvest of the kelp in entire harvesting area.

PO-02-38

Exploring and understanding the seaweed marketing system in malaysia

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The sustainability of seaweed industry is dependent on price stability, so constant price fluctuations are a threat to its viability. A study on the seaweed marketing system was conducted in Semporna district, the major seaweed producing area in Malaysia. Perceptions of seaweed marketing obtained from the interviews, Focus Group Discussions and household surveys among seaweed stakeholders using a mixed-methods approach, revealed price fluctuations were influenced by three factors: global carrageenan demand; seaweed quality; and farmer's relationships with middlemen. There are different levels of middlemen; the first level is Collectors (C), the second is Buyers (B), and the third level is Traders (T). Market governance between the processors and the middlemen has shifted from the provision of incentives, to penalties for poor quality and mistrust. Other findings showed seaweed farmers perceived the middleman was the only marketing outlet and source of information. The processors set the price based on the current seaweed prices from counterparts in the Philippines and Indonesia, but the middlemen will determine the price at farm level because they will provide services such as informal credit to the farmers and transportation to bring the seaweed to the mainland. There are occasions when the farmers choose the middleman who offers the highest price.Malaysia has laid down seaweed standards on seaweed cultivation, dried seaweed and semi-refined carrageenan. The price of dried seaweed is determined by using dried seaweed from carrageenophytes to meet the standard. However, the certification scheme is voluntary, and farmers and processors can choose whether they want to participate or not. Seaweed marketing channels involve multiple layers of middlemen before seaweed is sold to the local processors, export or smuggled to the foreign market. The result of the study provides a better understanding and knowledge of the seaweed marketing channels in Malaysia.

PO-02-39

The Introduction of Seaweed Cluster Project (SCP) to Optimise Seaweed Production in Malaysia

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Kappaphycus farming was introduced to Malaysia in the late 1970s to help meet the growing demand for reliable carrageenan supply chains. Malaysian state authorities, working alongside commercial partners, developed policies and programmes to enable coastal communities to participate in seaweed farming by providing training and farming inputs. However, there remain numerous governance, economic, social, cultural, environmental and technological challenges preventing the seaweed industry from achieving its full potential. The Seaweed Cluster Project (SCP) was introduced in 2012 to address some of these issues. Thus far, the SCP does not appear to have met expectations; however, an independent evaluation of the programme's performance is lacking. In the present research we sought to evaluate the effectiveness of the SCP in delivering its central objectives. Community and industry perceptions of the SCP were evaluated using a mixed-methods approach. Interviews (n=42) were conducted with government officials (n=19), seaweed buyers (n=15) and processors (n=3), community (n=2) and SCP leaders (n=2), and an NGO representative (n=1). Surveys of 144 households were conducted in 7 communities. Interview respondents felt that seaweed farming is very important for coastal communities and that they were informed of the interventions but were unsure of the impact of the programme. They perceived that they were not involved with decision-making at the national level but were later involved at the state or district levels. There were conflicting views on SCP outcomes, but they were generally negative. It remains to be seen whether the SCP will deliver on its objective to enable self-sustaining commercial-scale seaweed farming in Malaysia. These results advocate some essential improvements for future planning and development of the Malaysian seaweed industry.

PO-02-40

Macroalgae exhibit non-invasive, reversible chimerisms

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Chimerism is produced by the somatic fusion of two or more conspecific, genetically different individuals. In animals, the main cost of fusion is that it gives rise to competition between genetically different cell lineages and the probability of original cell-line replacement by more competitive invasive lines (= invasive chimerism). In land plants and macroalgae, the rigidity of the cell walls prevents cell motility and limits the spread of potentially invasive cell lines (=non-invasive chimerism). Coalescence is widespread among red and brown seaweeds, but their genetic effects have only recently been explored. Most somatic fusions occur in the holdfast. Upright axes emerge from the chimeric holdfast by proliferation and vertical growth of discrete cell groups, including just one or a few of the cell lineages that exist there. Subsequently, differences in growth rates between genetically different cell lineages help to segregate them along the axes. Therefore, the resulting axes may be genetically heterogeneous at their basal portions, but tend to be homogeneous in the more apical portions where reproductive structures differentiate. This is expressed in a vertical gradient of allele abundance, which decreases from the chimeric holdfast towards the genetically more homogeneous apical portions of the thallus. This is a unique pattern of post-fusion growth, allowing for the reversal of chimerism by repeated branching, a significantly different response from those described for animals and land plants.

PO-02-41

Comparing bacterial-induced morphogenesis between Ulva species

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The green marine macroalgae, Ulvaphte, represent fascinating model systems for investigating growth, development and evolution. They are valuable resources for food, fuel and high-value substances and they play a vital role in aquatic ecosystems. However, they can cause massive nuisance blooms in shallow environments. For deep understanding the biology and physiology of Ulva sp., in particular their development, morphogenesis, life cycle regulation and life-history strategies, controlled laboratory-based culture of these organisms is required. Ulva sp. like other macroalgae, harbor a rich diversity of epiphytic bacteria with functions related to host growth and morphological development. In the absence of bacteria, algal germ cells are developing into "atypical" colonies including of undifferentiated cells

with abnormal cell wall. A breakthrough in this research was the establishment of a standardized tripartite community consisting Ulva mutabilis (Føyn) and just two isolated strains, Roseobacter sp. and Cytophaga sp. instead of whole complex microbial flora. Employing this standardised tripartite model system, our research aims to determine the specificity of bacteria-induced morphogenesis of Ulva by cross-testing of two very well investigated Ulva species, the emerging model system Ulva mutabilis and the cosmopolitan and economically important species Ulva linza for the first time.

PO-02-42

An overview of introduced macroalgae in Norway

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There are at present ten recorded introduced macroalgae in Norway, and two cryptogenic introduced ones (i.e. it is uncertain if the spread is caused by anthropogenic activity). In the Norwegian Black List, four of the introduced macroalgae are regarded to have a high or very high risk of causing negative influence on the native bentic communities (Sargassum muticum, Dasysiphonia japonica, Codium fragile subsp. fragile and Bonnemaisonia hamifera). Of these, Codium fragile subsp. fragile and Bonnemaisonia hamifera have been present for a long time in Norway, and they are also widespread in both North- and South-Norway. Bonnemaisonia hamifera was first recorded in Norway in 1902, and genotyping herbarium samples show that C. fragile subsp. fragile also has been present in Norway since 1902. Sargassum muticum, C. fragile subsp. fragile and B. hamifera can form large patches in the upper part of the sublittoral in Norway, while D. japonica is more common growing deeper, for example on maerl bottom. Large variation in occurrences and abundances can be observed between years in all four species, suggesting that variation in environmental conditions influence their local abundances. A red alga, Gracilaria vermiculophylla, has recently spread to Norway, and has the potential to become invasive.

PO-02-43

Seasonal chemical ecology of introduced Sargassum muticum and Codium fragile in Brittany

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Alien seaweeds represent one of the largest groups of marine aliens in Europe. Facing climate change, species can change their phenotypes to match with the new environment, or adapt through genetic changes to the new conditions. Moreover, to colonize their novel environment, introduced species have to adapt their chemical defenses against epiphytes and grazers. Often a trade-off between allocating primary production to growth or production of secondary metabolites for defense is evident in seaweeds. This suggests that abiotic factors regulating primary production, such as seasonal variations in temperature and luminosity, can influence the biochemical acclimation in alien seaweeds. In this context, this study assessed seasonal variations in macromolecules produced by the two alien species, Sargassum muticum and Codium fragile, living on rockyshores from Brittany coasts. Pigments were quantified using HPLC. Moreover, chemical footprintings of samples were obtained by HRMAS 1H NMR. In parallel, the phenology, i.e. density, size, reproductive status and specific morphological caracteristics of both species was seasonally monitored during one year on three sites in Brittany. Both species were present all around the year: Sargassum muticum , an abundant alien species, with a maximum of biomass in summertime contrary to Codium fragile less abundant, more present in wintertime. This species grows mainly deeply on rockpools, away from light. Moreover, metabolomic analysis showed that site and seasons significantly affected pigments contents for both species. Our results are discussed in regard to the intra-, interspecific and seasonal variabilities of molecules in relation with ecological variables in both seaweeds. This work was financed with the support of the EU FP7 ERA-NET Program, Seas-Era INVASIVES project nr. ANR-12-SEAS-0002.

PO-02-44

Copper impedes meiospore development of Macrocystis pyrifera and Undaria pinnatifida

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Copper is essential for cell metabolism but in high concentrations it becomes toxic to marine organisms, including to the macroalgal early life stages. Our aim was to evaluate the effects of copper on meiospore development of the native kelp M. pyrifera and the invasive U. pinnatifida. After settlement, meiospores were exposed to five nominal copper concentrations (control, 100, 200, 300 and 400 µg L-1 Cu) for 9 days. Analyses of total dissolved copper (CuT) concentrations in the blanks showed that nominal copper concentrations were reduced to 54, 91, 131 and 171 µg L-1 CuT (i.e., > 50% of the CuT was adsorbed onto the culture vessel walls). In the media with meiospores, the CuT aldo decreased: to 39, 86, 97 and 148 µg L-1 CuT in M. pyrifera, and to 39, 65, 97 and 146 µg L-1 CuT in U. pinnatifida (i.e., 6 – 15% of the dissolved copper was adsorbed by the cells). Meiospore germination decreased with increasing copper concentrations but gametogenesis was arrested under al copper treatments. The effective copper concentration causing 50% of arrested germination (Cu-EC50) was higher for U. pinnatifida (231 µg L-1 CuT) than for M. pyrifera (157 µg L-1 CuT), suggesting ecological success for the invasive species in copper polluted environments; however, the subsequent inhibition of gametogenesis under all copper treatments indicated no difference in copper tolerance between both kelp early life stages. The reduction of CuT during this experiment occurred because copper may be adsorbed onto glass and/or plastic and this can be avoided using a proper trace metal clean procedure. We performed a literature review on trace metal clean protocols (i.e., laboratory–ware used, glassware vs plasticware; methods of cleaning the laboratory–ware, acid soaking and ultrapure water rinsing; stock solution preparation, acid stabilization) used in copper ecotoxicological studies performed on marine macro- and microalgae, and the measurement and reporting of dissolved copper concentrations.

PO-02-45

Study of microbial diversity in Ulva lactuca from North West Coast of Gujarat, India

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Seaweeds form economically important component of marine ecosystems worldwide. A wide range of beneficial and detrimental interactions exists between seaweeds and epiphytic as well as endophytic bacteria. Diversity study can be used to retrieve ecological information about community partner that relates the degree of stability of that community. The present work deals with the study the microbial diversity of Ulva lactuca. Epiphytic and endophytic bacteria were isolated from U. lactuca. Total of 7 bacterial isolates were obtained from this seaweed. Among them 4 (VP1, VP2, VP3 and VP4) were endophytic bacteria and 3 were epiphytic bacteria (VP5, VP6 and VP7). Gram staining and biochemical tests for identification of microorganisms were performed. On the basis of colony morphology and biochemical tests, VP2, VP4 and VP6 were identified as Enterobacter aerogenes, Bacillus cereus and Staphylococcus aureus respectively. Out of 7, 4 isolates could not be identified on the basis of biochemical tests performed. Hence, molecular characterization was attempted by targeting 16S rDNA sequencing for rest four isolates (VP1, VP3, VP5 and VP7). The amplified product was sent for sequencing and further characterization. Bioactive compounds can be obtained from this seaweed associated bacteria for industrial applications.

PO-02-46

Variability in populations of Macrocystis pyrifera in the Chilean sub-Antarctic region.

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Understanding the mechanisms that limit the geographic distribution of the species has been key for both, ecology and evolutionary biology, being generally accepted that multiple parameters (biotic and abiotic) interact synergistically. However, physiological limitations may restrict the distribution range and abundance of organisms. Understanding spatio-temporal effects of environmental factors on fitness,

growth, survival and reproduction of species is lacking. The dynamics and spatio-temporal variability of marine ecosystems, especially irradiance, temperature and salinity of sea water, seems to be driving distribution, abundance and productivity of Macrocystis pyrifera. The Magellan and Chilean Antarctic Region, is the World´s largest area with Sub-Antarctic environments; with a heterogeneous environment of fjords and channels, formed by erosional processes during the Last Glacial Maxima in the Quaternary. In this ecosystem of fjords and channels, temperature, salinity and photoperiod are key abiotic variables affecting survival, reproduction and development of different macroalgae and geographical distribution gradients of many Sub-Antarctic and Antarctic species. We examine development of M. pyrifera populations in sites with environmental differences of temperature and salinity to identify morphological and reproductive variability in M. pyrifera. Preliminary results suggest significant statistical differences in the percentage of sori coverage among M. pyrifera between four of the five localities studied: Skyring Sound and Otway Sound ($p = 0.00001$); Skyring Sound and Paula Bay ($p = 0.03$); Otway Sound and Puerto del Hambre ($p = 0.009$). Our results are relevant in suggesting notable morphological and phenological variability among populations of M. pyrifera co-inhabiting the same ecoregion, potentially due to this species´ acclimation and adaptation capabilities in environments, with marked salinity and temperature differences.

PO-02-47

Seasonal photosynthetic performance of Macrocystis pyrifera in Puerto del Hambre, Subantarctic Chile

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The seasonality of abiotic parameters, such as light intensity, water temperature or nutrients, determines in large part the metabolic and photosynthetic processes of macroalgae. Macrocystis pyrifera, characteristic of the fjords and channels of southern Chile, shows environmental adaptability. We examined the difference in photosynthesis and pigment composition of M. pyrifera over variable seasons during the year (spring, summer, autumn, winter), among different individuals from Puerto del Hambre (South 53°37' West 70°52') in Southern Chile. Seven apical fronds of M. pyrifera were collected. They were acclimated for 24 hours in seawater, temperature 6.5°C, light intensity 4.8 µMol photones m-2 s-1 and photoperiod 12:12 Light:Dark. Using a Walz Diving-PAM we measured photosynthetic parameters; using dimethylsulfoxide we examined pigments contents, and by the non-parametric test of Kruskal-Wallis we compared all measurements across seasons. The highest ETRmax were measured in spring, with significant differences between seasons, showing similar trends in ETRs (highest in spring). The αETR showed no significant differences between seasons, but the saturation point (Ik) was also highest in spring (460.84 µMol m-2s-1) and the lowest in summer. The pigment content of M. pyrifera is higher in autumn (Chl a = 0.322 ± 0.018 mg / g DW ± SE; Chl c = 0.181 ± 0.110mg / g DW ± SE; and Fucoxanthin = 0.139 ± 0.036 mg / g DW ± SE) with significant differences between autumn and winter (lowest concentrations in winter: Chl a = 0.087 ± 0.027 mg / g DW ± SE; Chl c = 0.019 ± 0.003 mg / g DW ± SE; Fucoxanthin = 0.044 ± 0.010 mg / g DW ± SE). Photosynthetic parameters and pigment concentration varies seasonally in M. pyrifera, with winter being a key season during development. Photosynthesis in spring showed the highest IK probably due to the change of light intensity and photoperiod at this time of the year.

PO-02-48

Morphology-physiology of two morpho of the genus Durvillaea in the sub-Antarctic ecoregion of Chile

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The Chilean Sub-Antarctic ecoregion is influenced by three oceans: Pacific, Atlantic and Southern, and it is characterized by its environmental heterogeneity (fjords, channels and post-glacial lakes), which result from shaping effects of post-glacial events during the Last Glacial Maximum (between 23Ky-19Ky BP). This has allowed for high degree of endemism in macroalgae, and among those which dominate the exposed sub-Antarctic intertidal, are large populations of Durvillaea antarctica. In Chile, its distribution extends from Coquimbo to the Diego Ramirez Islands, but recenlty a new morphotype encountered of the genus Durvillaea in the sub-Antarctic ecoregion might constitute a new species or a new morph of D. antarctica. We examine the morphology and ecophysiology of (i.) a morphotype of D. antarctica with short-stipe, wide laminar frond and usually occupying protected habitats; and of (ii.) a morphotype with cylindrical, elongated fronds, commonly called "knife or blade" dwelling in places exposed to waves and corresponding to the species described for the Chilean coast. We randomly collected 20 adult individuals of each morphotype during spring 2015. We measured several parameters morphometric from the macroalgae. Morphotypes were statistically compared (two-tail t-Student test). The "laminar" type showed higher average fresh

weight (□=3190 gr), frond width (□=103 gr), frond weight (□=2880 g), stipe width (□=5 cm) and injuries (□=35). The "elongated cylindrical" morphotype had a higher average maximum length (□=299 cm), frond length (□=276 cm), thickness (□=1 mm), stype length (□=5 cm), stipe weight (□=24 gr) and disc weight (□=329 gr). The morphological characteristics are relevant results to determine the taxonomy of macroalgae. We expect to have results of physiology experiments for the Symposium in June 2016. Different photosynthetic parameters were studied by Walz Diving-PAM and analyzed by the equation of Platt et al. (1980).

PO-02-49

Reproductive biology of Durvillaea antarctica (Chamisso) Hariot in southern Chile

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Durvillaea antarctica (Chamisso) Hariot, is a giant kelp commonly found in exposed areas of the Chilean coast line. It is endemic to the Southern Hemisphere and is used for direct consumption in the human diet both in Chile and other countries; it is commonly known as "cochayuyo", "coyoi", "coyote", "ulte" or "huilte". The species occurs in the subantarctic region; it is found from Coquimbo (30°S) to Cap Horn (54,9° S). This study investigates and defines the reproductive strategies of Durvillaea antarctica located in the far south, in the region of the Magellanes, during the period of a year. Samples were taken in quadrants of 10 m2 parallel to the coastline in the intertidal zone of Southern Chile. Both the phenological stages and the different states of maturity in individuals were determined. These findings were used to describe the main characteristics of the reproductive cycle and the spatial heterogeneity that may exist between the reproductive processes within each area that was studied. The results indicate that in all three populations of D. antarctica there are reproductive individuals present throughout the year. The largest amount of reproductive individuals tends to exist in autumn and winter, with the numbers subsequently decreasing in spring and summer. In all of the populations it was possible to identify male and female non-reproductive individuals. The largest number of male and female plants in the populations, which were studied, was found from autumn to winter, but there were shifts in the proportions during these periods, leading to an increase in male over female fronds. In all of the populations both male and female individuals in different stages of maturity were found, with the level of maturity depending on locality and season. Mature fronds were found more frequently during autumn and winter although the measures of maturity vary between different populations.

PO-02-50

Recovery of seaweed beds under different sea urchin density regimes in the existing barren area

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In the east coast of Korea, urchin barrens are common along the shallow subtidal areas and the phenomenon has been persisted since 1990s, mainly due to the absence of natural enemy of sea urchins. This study is designed to investigate how seaweed community assemblage responds in the different levels of urchin density which is manipulated manually. The study site is located in Samchuk, Gangwon Province, where several subtidal rock beds are clustered with sandy bottom boundaries (about 10 m in depth). All rock beds are already barren with an average urchin density of 7.56 ind./m2. Three experimental conditions were applied: all urchins removed (A), 50% urchins removed (H: remaining 4 ind./m2) and control groups (C: no removal). The average algal coverage before treatment was 23.9% and there was no significant difference existed among the 3 experimental groups. At one month after urchin removal, all groups showed an increase of total algal cover: 38.6% for C-group, 52.7% for H-group, 56.3% for A-group (C < H, A; p H-group (35.8%) > C-group (24.9%). Species-level responses in the assemblage showed a diverse pattern. Ulva pertusa gradually increased in A-group, whereas they increased until the 1st month and then decreased until 3rd month in both H- and C-groups. Acrosorium polyneurum decreased in all groups, but then increased in C-group. These diverse patterns at species level may reflect urchin's feeding habits. This research was started in April, 2015 and still on-going. We will present the results at ISS-2016 including the data of spring season of 2016, which is the active growing season of most macroalgae in this area

PO-02-51

The effects of eutrophication and acidification on the physiology of seaweeds

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We examined the effects of eutrophication and acidification on the physiology of seaweeds. The experiments were conducted in media prepared by addition of ammonium and/or injection of CO2. We measured pH change, ammonium uptake rates and oxygen evolution with Slender Wart Weed (Gracilaria sp., red alga). The pH changes were biggest at low pH and high ammonium condition. The pH decreased under dark condition. The ammonium uptake rates were highest at low pH and high ammonium condition. The rates of oxygen evolution were higher at low pH and high ammonium condition than those of control. We speculate the rates of photosynthesis and ammonium uptake could be enhanced at higher ammonium concentration and lower pH condition with elevated CO2 concentration by increased photosynthetic activities.

PO-02-52

Restoration trials of an endangered brown alga, Silvetia siliquosa

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A brown alga, Silvetia siliquosa(Fucales, Phaeophyta) is found in the intertidal zone of rocky seashores of Korea and grows up to 5cm in length. Previously, S. siliquosa is widely distributed on the western and southern coasts of Korea, but the population is continuously decreased from the mid of 1990`s. The cause of sudden decrease in S. siliquosa population is unknown and now the distribution of species is limited to offshore islands of South Sea. The species grow with variety of seaweeds in the mid and low intertidal zone of moderated wave exposed shores. In this study, we examined the seawater temperature, salinity, water velocity, nutrient concentration, and chlorophyll a concentration in order to know the environmental condition of S. siliquosa habitat of 3 southwestern islands in Korea. S. siliquosa occurs mainly on the rock type of quartzite. The restoration shores of Silvetia population have littoral current flows from north to south by northwest-southwest winds and relatively strong wave action and less polluted areas. At S. siliquosa restoration site, humidity was about 81%(39-94%)and wind speed was 4.37㎧ (with the maximal wind speed of 16㎧). Air temperature was ranged between 15.5~18.6℃, the average wave height is 1.07m(0.5~3.5m), and seawater temperature was in the range of between 11~21℃. Nutrients such as nitrogen and phosphorus are very important for the growth of S. siliquosa, but their concentrations in the seawater were relatively low. seawater retention time and the current intensity might be crucial environmental factors determining the growth of the S. siliquosa. In conclusion, transplantation methods by using rope and natural rocks are good for increasing S. siliquosa population, which is naturally declined because S. siliquosa plants transplanted grew well and produced spores in the new habitats.

PO-02-53

Comparison of effects of the Great East Japan Earthquake on two kelp bed ecosystems

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On March 11, 2011, the North Pacific coast of Honshu Island, Japan, was hit by a massive tsunami triggered by the great earthquake. In order to reveal the impact of the tsunami on kelp bed ecosystems, we conducted a study in Tomarihama in Oshika Peninsula and Nagane on Otsuchi Bay, both along the Sanriku coast. In Tomarihama, which is dominated by Eisenia bicyclis, a large perennial brown alga, the detachment and loss of E. bicyclis individuals due to the tsunami was limited. On the other hand, sea urchins, the primary herbivores, which had previously occurred at high densities, decreased drastically after the earthquake, and a large occurrence of juvenile E. bicyclis was then observed owing to a decrease in grazing pressure.

Some of these juvenile E. bicyclis survived to grow into adults, and the E. bicyclis beds expanded into deeper areas. After that, the sea urchin density was observed again to increase. While in Nagane, the large annual brown alga Saccharina japonica var. religiosa was dominant and the biomass showed no significant change between before and after the earthquake. The biomass of S. japonica var. religiosa in Nagane is considered to be influenced by the seawater temperature in winter of each year, more than by the biomass of sea urchins. Thus, the effect of the earthquake and tsunami on these two types of kelp ecosystem was different.

PO-02-54

Population biology and long-term mariculture studies in the brown alga Lessonia trabeculata

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Lessonia trabeculata is one of the most valuable seaweeds in Chile, especially in the northern zone where its harvest has been going on for decades. A population dynamic study was carried out in the Atacama Desert coast (Bahia Chasco), in order to assess its productivity under natural and disturbance (harvesting) scenarios. L. trabeculata population showed very slow but consistent growth, during 18 months of observations (1 – 2 cm/month) and density (3 – 4 individuals/m2 with no monthly variation). However, after harvesting, L. trabeculata exhibited different recovery patterns. Its recruitment was season-specific, with exceedingly higher values in autumn (80 indiduals/m2 in 5 months) and total absence of recruits in summer. As the months passed, density values tended to stabilize to growth rates under un-altered conditions. In parallel, pruning systems at three different thalli levels (frond meristem base cuts, removal of the half and total of the canopy) demonstrated to be not only economically inefficient but also harmful for the individuals treated, because i) the biomass takes longer to be harvested, ii) individuals finally do not recover and die off and iii) after senescence they do not detach easily from the substrata, delaying the recovery under the canopy by the bank of microscopic forms. Some of these results coincided with growths observed in long-term culture attempts with the same species, where 26 months were needed to obtain 100-cm long plants. From our results we can conclude that better management of the seaweed beds needs to be taken place otherwise the harvesting will be detrimental for survival of the industry. This project was funded by the Regional Government of Atacama, grant FIC 2013 33-91-243.

PO-02-55

Morphology as a long-term monitoring tool for calculating individual biomass in Ecklonia cava

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Kelp forests are highly productive ecosystems engineers in marine benthic ecosystems, providing food, shelter, and nursery areas for commercially and ecologically valuable marine organisms. Since kelps biomass contributes to the abundance and production of myriad animals and plants in coastal marine ecosystems, the measurement of kelps biomass is critical to the evaluating of the impact of macroalgae on marine and aquatic habitats. In this study, we investigated relationships among morphological characteristics to develop non-destructive method for calculating Ecklonia cava biomass in long-term monitoring. Approximately 100 sporophytes of E. cava were collected with various stipe size gradients. Stipe diameter, blade number and total length (stipe + longest blade length) showed a significant relationship with stipe length. When stipe length was more than 13 cm, the length of primary and longest blades declined due to the formation of lateral blade. The length and diameter of stipe, longest blade length, blade number, total length × blade number (TL × BN), thallus height and total length exhibited a significant relationship with individual weight. In particular, length and diameter of stipe, blade number, TL × BN and total length accounted for over 80% of the variation in individual weight. The strong concordance correlation between individual weight estimated using TL × BN and total length parameters and measured individual weight demonstrated the reliability of predicting individual weight from TL × BN and total length. Considering the cost and time of fieldwork, we recommend that total length can be used as a non-destructive monitoring tool for calculating individual weight of E. cava.

PO-02-56

Meta-analysis of upwelling effects on marine producer-herbivore interactions

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Nutrient subsidies may affect all aspects of food-web dynamics in recipient ecosystems. Recent empirical studies from a range of marine habitats demonstrate that nutrient subsidies from upwelling events strongly influence spatial and temporal patterns of marine producer abundance and community composition, as well as herbivore abundance and effects. Sufficient studies now exist to begin testing the generality of those subsidy effects, and examine how they vary among producer functional groups, habitat types, and geographic regions. Spatial and temporal variation in upwelling activity can generate spatiotemporal patterns of algal abundance and community structure in coastal ecosystems. By analyzing relative differences in algal abundance among sites varying in exposure to upwelling, or within sites during upwelling and non-upwelling periods, I assess how upwelling activity influences the abundance of producers, and determine how the magnitude of responses to upwelling varies among algal functional groups. Nutrient subsidies may also indirectly influence herbivore populations, and influence plant-herbivore interactions. Ecological theory predicts that high primary productivity in upwelling sites should support high herbivore abundance. Further, herbivore effects in marine systems are thought to be weakest in areas of high background productivity, likely as a result of algae compensating for herbivory through increased growth rates. The second goal of this analysis is to determine if herbivores are more abundant in areas exposed to upwelling, and how the effects of herbivores vary among sites as a function of exposure to upwelling. This analysis will allow a better understanding of how large scale oceanographic processes, such as upwelling, can shape local community structure and algal-herbivore interactions on coastal ecosystems.

PO-02-57

Seaweed diversity in Teluk Awur Jepara, Indonesia

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Teluk Awur in Jepara is one of area in Central Java that has big potential in marine resources. The purpose of this study was to determine the seaweed diversity start from density, relative frequency, diversity index, uniformity index, and dominance index of seaweed Teluk Awur Jepara. This research using quadrant transect method to collecting seaweed and conducted on December 13, 2014. The results showed that Halimeda laccunalis, Halimeda micronesica, Caulerpa racemosa, Caulerpa lentillifera, Caulerpa serrulata, and Galaxaura rugosa can be found in Teluk Awur. The highest density is 75.33 found in station 3 and the lowest density si 8.67 at station 4. The highest relative frequency is more than 70% found at the station 5. The highest diversity index are at station 3 with a value of 1.3 and the lowest with a value of 0.5 found in the station 5. The highest dominance is 0.7 in the station 5 and the lowest in the station 3 with a value of 0.3. The index value is affected by environmental factor, both physics nor chemistry. Physical and chemical factors such as temperature, salinity, brightness, phosphate and nitrate.

PO-02-58

Morphological plasticity of brown alga Sargassum thunbergii along the Korean coasts

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Intraspecific variations in morphological characteristics are widespread among seaweeds and respond to local environmental conditions. In this study, we examined morphological variations of fucoid Sargassum thunbergii that associated with multiple environmental factors. A total of 21 morphological characteristics of S. thunbergii were investigated from 15 locations on rocky intertidal shore of Korea in spring 2011. The results of the cluster analysis based on morphological characteristics showed the existence of three groups, which was related with local environmental conditions. Group A was composed of the populations in the northern east coast, which showed thicker stipe and shortest lateral branch. Group B was composed of the populations of the west coast, which exhibited shorter branch and stipe, softer texture, and thinner. Group C included the populations from southern east coast to south coast (with Jeju Island). The populations of this group showed longer thallus height and lateral branch. Principal coordinates analysis of morphological variations revealed that the populations of Group A and Group B were mainly affected by high wave energy and high tidal range, respectively. However, the populations of Group C were primarily affected by warmer temperature and higher irradiance. This study suggests that morphology of S. thunbergii reflects and adapts to local environmental conditions.

PO-02-59

Genome analysis of potential vegetation of a limpet dominant on urchin barren ground

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Even on urchin barrens, many species of macroalgae are present in the state of small generation or germlings whose growth is suppressed by grazing and/or oligotrophic conditions. Detection of such potential vegetation gives clue to select sites for the restoration of algal beds on barren grounds before introducing elaborate works like removal of sea urchins or manuring. Previously, this effort was achieved by keeping barren boulders without herbivores in enriched seawater. The authors planned to apply genome analysis instead of the above culture works. We chose a limpet Niveotectura pallida, dominant on barren grounds in northern Japan. The limpet lives on NCA and exposes its cony shell just above the barren bottom so that potential vegetation on the shell may represent the counterpart on its habitat. The limpet is easier for collection than heavy cobbles or expensive abalones, and epiphyte on the white shell is. In the preliminary study, DNA was extracted from debris scraped off from 16 limpets (29.7±4.3mm in shell length) collected at an urchin barren in Onagawa in September 2013, northeastern coast of Honshu. On these shells, 3 taxa of green algae, 1 species Rugulopteryx okamurae and 3 taxa of brown algae and 1 species Chondracanthus intermedius of 2 taxa of red algae were observed by naked-eye. Analysis of rbcL data sets revealed the presence of 7 species of brown algae (Scytosiphon gracilis, Dictyota dichotoma, D. pardalis, R. okamurae, Sphacelaria yamadae, Punctarias latifolia, Undaria pinnatifida) and 3 species (Erythrocladia irregularis, Peyssonnelia japonica, C. intermedius) and 2 taxa of red algae. This technique promotes accurate identification of the micro-stages of epiphyte on the benthic shell as potential vegetation on barren grounds. Furthermore, it is useful for prediction of algal beds after restoration techniques have been practiced on the selected sites.

PO-02-60

Diversity Of Seaweed Communities At Krakal Beach, Gunung Kidul, Yogyakarta

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Gunung Kidul is surrounded by beautiful beaches and because of that fact it has made it one of the most popular tourist destinations in Yogyakarta. Unfortunately having too much tourist will give it such a side effect on the physical and chemical characters of the coastal waters and also on the biotas living there. Therefore it is necessary to investigate the dominant biota especially the seaweeds that occupy Krakal Beach, one of the beaches at Gunung Kidul. The aim of this research is to discover all kinds of species, diversity index (H'), uniformity index (E), and dominancy index(C) including the factors that effects the seaweed growth.The method choice is transect sampling by using an 1meter x 1meter transect in 3 different areas.There are ten species out of three divisions which consists of five Chlorophyta species, two Phaeophyta species and three Rhodophyta species found that were at Krakal Beach Area. The result of diversity index (H'), uniformity index (E), dominancy index (C), and water quality control shows that the ecosystem is a stable condition and suitably for seaweeds to grow.Among the species that were found, Ulva which is the division of Chlorophyta was considerably dominant in the area. Many of these species are very important for the economic sectors. Such as for food processing, sources for industrial products such as polysaccharides, bioactive and nutritional natural products. But, to keep a balance environment, seaweed framing is presently one of the most productive and environmentally friendly forms of livelihood for local coastal populations. Keywords: Diversity, Gunung Kidul, Seaweed

PO-02-61

Intraspecific crosses in Saccharina latissima and opportunities for artificial selection

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The rising interest of many industries for Saccharina latissima pushes French growers to develop their activity as they currently exploit wild populations. In order to initiate artificial selection programs, it is first needed to well understand and control the breeding process and the compatibility between populations. Even if the question of intraspecific hybridization has been explored in several kelps such as Saccharina japonica and Undaria pinnatifida, a lack of works about S.latissima is observed in literature. Previous studies show that S.latissima populations from South Brittany to Norway are genetically highly

differentiated. In addition, the limited dispersion and the "in patch" distribution of French populations let us suspect a strong local adaptation. In that case, we can suppose that: On one hand, parents that are too similar genetically may suffer from reduced crossing compatibility due to inbreeding depression by accumulating deleterious mutations. On the other hand, crosses between parents that are too different genetically may lead to an outbreeding depression by disrupting adaptive complexes. Then, we expect that, to be stable, populations need an intermediate optimal outcrossing distance. Here, we propose one experimental approach combining self-fertilization, intra population and inter population crosses between gametophytes from close and distant wild populations. The aim of this work is to evaluate the reproductive success and the inheritance of traits for all those kind of crosses. Such a study may help growers in the choice of the wild populations they should use for artificial selection programs.

PO-02-62

Temporal variation in patterns of macroalgal assemblages in two localities in the Magellan Region

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The area of channels and fjords characteristic to the sub-Antarctic Magellan region of Chile, has a high diversity of macroalgae in relation to the temperate areas of South America. Geomorphological changes, the geographical position in a high latitude together with the environmental changes in this region create a series of coastal marine habitats of notorious heterogeneity, where a diverse benthic marine flora take place, having evolved adaptively to these changes. The present study examined macroalgal species richness and temporal abundance on the rocky coast of Puerto del Hambre in the Strait of Magellan and West from it, in Otway Sound. Macroalgae samples were collected in winter and summer in both localities. Three intertidal levels (high, middle and low) were examined at each locality, and in Puerto del Hambre also two subtidal levels (1m and 5m) were sampled following the NaGISA protocol. Three samples (quadrats of 50 cm × 50 cm) were placed randomly at each level, three times per season. Of the 79 macroalgae taxa identified, 23% were Chlorophyta, 18% Ochrophyta and 59% Rhodophyta. In general, the average dry biomass of the macroalgae assemblage, per quadrat (2500 cm2), in both localities showed a significant increase during summer, with the greatest richness and abundance at the middle intertidal level (p0.05). The multivariate analysis showed significant differences in the assemblage composition of macroalgae between the two localities at each intertidal level and season ($p<0.05$).These results suggest no detectable general pattern in the vertical zonation of macroalgal assemblages in these two localities. The local environmental heterogeneity likely plays a role in structuring ecological assemblages and communities in Sub-Antarctic marine channels.

PO-02-64

Detection of brown algae Sargassum species in high turbid waters of Kuwait bay

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Encountering the two species of Sargassum (S. angustifolium, and S. oligocystum) in the highly stressed hypersaline (~44 PSU) environment of Kuwait Bay was studied using acoustic method and underwater quadrat sampling method. Sargassum existed in Kuwait bay despite the environmental pressures and the high turbidity (5 to 40 NTU). Scattered batches of Sargassum was observed in Kuwait bay. These batches covering areas size between 10,000 and 50,000 square meters with a proximate distance of 500 meters from the beach. The most abundant epifauna harbored the Sargassum species were shrimp (penaeus semisulcatus), pearl oyster (Pinctada radiata), and different species of amphipod. The investigation revealed that the high turbidity, high salinity, high water temperature, and human pressure due to tremendous coastal development, did not prevent the growth and production of Sargassum species in this harsh marine environment.

PO-02-65

Benthic marine macroalgae off the Northern coast of the Yucatan Peninsula, Mexico

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The aim of this study was to analyze the communities of macroalgae off the Northern coast of the Yucatan Peninsula, Mexico. We compiled information on specimens collected between 1955 and 2015, contained in four herbaria and also included in 56 published articles and 7 theses. Information was classified according

to specimen, taxonomic affiliation, location, georeference (latitude and longitude), habitat, type of substrate, collector, source of collection, and year of collection. We found 3,537 specimens (of submerged aquatic vegetation) with 3447 specimens belonging to four algal divisions: Rhodophyta, Ochrophyta (Phaeophyceae), Chlorophyta and Cyanophyta. These divisions contained 30 orders, 74 families, and 503 species of macroalgae (211 Rhodophyta, 163 Chlorophyta, 76 Phaeophyceae, and 53 Cyanophyta) distributed in 27 localities. The Arrecife Alacranes National Park contains the highest number of species with 250, followed by Telchac with 146 spp. The habitat with more number of species is the coral reef, followed by the coastal zone. We consider that although there are many works on benthic macroalgae, the knowledge on this is sparse. Some geographic areas have more intensive sampling than others, which is reflected in the number of specimens and species collected by location. Many areas remain with little or no surveys at all while some studies carried out in natural protected areas, coastal lagoons, and coral reef areas. Surveys on algal resources, at different levels of complexity from floristic listings to models explaining abundance and distribution, are very scarce. Consequently, it is necessary to expand as they should be considered as strategic information for any country that owns them.

PO-02-66

Latitudinal variability of Chilean Macrocystis populations post 1997-1998 El Niño

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An integrated synchronic study was made on the interactive effects of the El Niño Southern Oscillation (ENSO) of 1997-1998 with mesoscale coastal upwelling processes on distribution and abundance patterns of the kelp Macrocystis pyrifera at seven locations spread along 1500 km of the Chilean coastline between 18°S to 32° S. The effects of a moderate intensity 1998-2000 La Niña event were included as well. Seasonal monitoring of the adult and juvenile sporophytes was carried out in the field between 1996 and 2000, and correlations were made with the several different climatic indices (MEI, SOI, OET) which have been internationally established for rating the magnitudes and other characteristics of ENSO events. Our own continuous monitoring of sea surface temperatures was used to pinpoint local ENSO events. The ENSO event studied produced high mortalities of M. pyrifera at lower latitudes (18°-21°S), associated with decreases in upwelling events. At latitudes near 23°S, the abundance of adult sporophytes decreased during the ENSO without causing local extinctions, correlated with the persistence of upwelling and latitudinal decreases in surface warming. An increase in upwelling in spring 1997 during the ENSO event favored recruitment of juvenile kelp in all the populations observed, although this recruitment did not produce a full recovery in M. pyrifera abundance. We concluded from the results that differences are produced by the oceanographic climate in the life strategies of M. pyrifera between northern (18°-21°S) and central (30°-37°S) populations in Chile, as well as with populations of M. pyrifera located south of 40°S.

PO-02-67

Population dynamics of kelp Macrocystis pyrifera (ecomorph integrifolia) in northern Chile

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This study evaluates the abundance and distribution of juveniles and adults, reproductive phenology, and frond growth of sporophytes of Macrocystis pyrifera (ecomorph integrifolia) in different populations located in northern Chile. Protected and exposed sites were selected at three locations between 28º and 30º S, and populations were monitored monthly at each site between 2000 and 2003. These observations were accompanied by simultaneous measurements of seawater temperature, nutrient concentrations, and salinity. In northern Chile, Macrocystis sporophytes were reproductive throughout the entire year, producing continuous, low-density recruitment. Occasional episodic and synchronic high-density recruitments were also observed. Juveniles of Macrocystis showed high mortality during the first months, but when the survivors reached reproductive maturity the annual mortality decreased considerably, with an average longevity of two years. In this way one-year-old sporophytes could be considered perennial with a life expectancy of up to 3-4 years. The different population parameters of Macrocystis presented greater temporal than spatial variability. The frond production and growth of Macrocystis was significantly greater and temporally more extensive at sites more productive, directly associated with the low seasonality of abiotic factors (e.g. nutrient availability and seawater temperature). Finally, under normal or La Niña conditions the variability of Macrocystis populations is reduced to restricted dynamic including perennial sporophytes with high life expectancy, and with a high rate of replacement throughout the year.

PO-02-69

Development and transfer technology to repopulate red seaweeds in Chile

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Chilean coastline is home for several seaweed commercial resources being collected by artisanal fishermen and their families. To increase abundance of some resources, techniques were developed to repopulate and restore patches of Chondracanthus chamissoi, Sarcothalia crispata and Mazzaella laminarioides (Rhodophyta, Gigartinaceae) in the Centre-South region of Chile (Project Fondef -Huam AQ12I0004). Techniques had to be effective, simple, low cost and respecting environment and natural habitat. Plus, "capacity building" concept was applied to drive training and favor acceptance and application by artisanal fishermen. Small scale systems were installed in areas managed by artisanal fishermen (Biobio Region, Chile, 36°S). For C. chamissoi, blades were directly seeded on small boulders, favoring the formation of secondary attachment discs. For S. crispata, spores were seeded from mature seaweeds tied on small "curtains" raising from the sea floor. For M. laminarioides, spores were seeded on artificial substrata and incubated in laboratory, then juveniles were transferred in drilled perforations on the intertidal rocks. For the training, evaluation sessions were carried on to measure capacity building level developed. Constant training support was given to reinforce basic knowledge on seaweed resources and repopulation techniques proposals. Results have shown similar trends between life-cycle phases, sites and seasons. C. chamissoi formed generally 10-40 secondary discs per boulder which survived for a year. Seeding of S. crispata produced 10-80 juveniles per 100 cm^2. For M. laminarioides, most transplanted substrata were recovered after a year and still presented juveniles, although only 12,5% showed growing blades. On training, progressive improvement of fishermen skills were reported. Various levels of engagement and knowledge were distinguished in the course of the project with variation in between members of a similar management area and between management areas.

PO-02-70

Impacts of Eucheuma denticulatum seaweed farming on seagrass meadows of Zanzibar, Tanzania

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Farming of the red seaweed Eucheuma denticulatum is a major economic activity for several villages in Zanzibar, Tanzania. This aquaculture activity has been thought to be sustainable, however, its impact on the environment has not be extensively studied. Nevertheless, it has been reported that seaweed farming may affect the seagrass meadows surrounding the farms, either by direct shading or by trampling. To test these potential effects of seaweed farming on seagrasses in Zanzibar, areas covered by the seagrass Thalassia hemprichii were selected in Chwaka Bay (eastern side of Unguja Island, Zanzibar) for the building of the following treatment plots: full seaweed farm (shading and trampling effect), a positive control (seaweed farm without seaweed, but including the trampling effect) and a negative control (a seagrass plot without a seaweed farm, but of the same size). Percentage cover of seagrasses and macroalgae, shoot density of the seagrasses, leaf area, canopy height, and above and belowground biomass were measured over 14 weeks to assess the effect of both shading and trampling on seagrasses; Reduction of light as the seaweed biomass accumulated was recorded as well as other environmental factors (temperature, pH and dissolved oxygen) in order to avoid confounding factors. The results show that in the areas covered by the seaweed farms there is a decrease in belowground biomass and a higher variability of Thalassia hemprichii shoot density, while leaf area and canopy height are not altered. In addition, cover of other macroalgae decreased. On the other hand, the positive control shows an increase in shoot density of Thalassia hemprichii, while the rest of parameters are unaffected. Overall, the study shows that seaweed farming affects the total biomass of seagrass and the cover of macroalgae through shading, and that the trampling alone can increase the shoot density of an area as a low impact disturbance.

PO-02-71

Protype Design of the House of the Seaweed Farmers in Indonesia

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Initially from the anxiety of a paradox about the paradigm of the lives of seaweed farmers in Indenesia. Who are struggling with poverty amid natural potential is actually abundant!. The purpose of writing this article are : (1) Research and Assessment is intended to make the arrangement of houses of farmers

seaweed livable . (2) It is expected that they can live a healthy life in a community that is sustainable seaweed cultivation. Based on analyzing the data can be summarized as follows : (1) Supporting to raise the dignity of the seaweed farmers in a dwelling that is inhabitable , have sanitation, have interaction, also have space and full harmony. (2) Currently the seaweed farmers enjoyed a glimmer of hope seaweed business in the future with “Let’s save our farmers”. Key words : prototype design, house, seaweed farmers *) Architects and NGO’s activist in Kendari, Southern of Sulawesi, Indonesia (djusdiman.arch@gmail.com) **) The Chairman of the Indonesian Seaweed Association (ARLI) (safari@arli.or.id) ***) Deputy of Bosowa Agro Group, Makassar, South Sulawesi, Indonesia (djusdil,karim@bosowa.co.id)

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Index by Country

Costa Rica
Radulovich, Ricardo

Denmark
Andersen, Jette
Bak, Urd
Boderskov, Teis
Bruhn, Annette
Eriksen, Mikael
Haukaas, Morten
Hermund, Ditte
Holdt, Susan L.
Hou, Xiaoru
Jacobsen, Charlotte
Jarlbaek, Henrik
Larsen, Lisbeth
Ludvigsen, Helle
Marinho, Goncalo Silva
Moller, Jens
Moller, Jens
Mouritsen, Lone
Mouritsen, Ole G.
Møller Nielsen, Mette
Naseri, Alireza
Nielsen, Ruth
Olsen, Helle
Porse, Hans
Rasmussen, Michael Bo
Rhein-Knudsen, Nanna
Rudolph, Brian
Schultz-Johansen, Mikkel
Sejberg, Jimmy
Sloth, Jens
Stougaard, Peter
Thomsen, Marianne
Thygesen, Anders
Wagenen, Paul
Wegeberg, Susse

Ecuador
Rincones, Raul

Estonia
Kaimer, Priit
Lipp, Maido
Robal, Marju
Tuvikene, Rando

Faroe Islands
Mols-Mortensen, Agnes

Fiji
De Ramon N'Yeurt, Antoine

France
Ar Gall, Erwan
Bedoux, Gilles
Boulho, Romain
Bourgougnon, Nathalie
Brebion, Jeremy
Burlot, Anne-Sophie
Connan, Solène
Danjon, Marc
Grimaldi, Aurelia
Guzinski, Jaro
Hardouin, Kevin
Hennequart, Franck
Jacquemin, Bertrand
Jan, Sebastien
Le Gélébart, Erwan
Loaec, Aurélie
Malmezat, Barbara
Marfaing, Hélène
Pierre, Ronan
Puspita, Maya
Queguineur, Benoit
Rossi, Nadège
Setyawidati, Nur Azmi Ratna
Surget, Gwladys
Terme, Nolwenn
Wijesekara Liyanage, Isuru Wijesekara

French Polynesia
Zubia, Mayalen

Germany
Ahrens, Mirko
Dohmen, Marianne
Schulz, Andé

Ghana
Mensah, Moses

Greenland
Lund, Nuka

Hong Kong
Kam, Haren

Iceland
Árnason, Finnur
Gunnarsson, Karl
Jónsdóttir, Rósa

Kuttner, Eva
Maack, Maria

India
Anantharaman, Perumalpillai
Balendiran, Sowmya Lakshmi
Bast, Felix
Baweja, Pooja
Kumar, Sawan
Meenakshisundaram, Ganesan
Nori, Sri Sailaja
Ramani, Shilpa
Ranjalkar, Hrishikesh
Subramanian, Vasuki
Suryanaryan, Shrikumar
Vadassery, Nelson

Indonesia
Adnan, Hariadi
Aslan, Laode
Harjanti, Elma
Kasanah, Noer
Merdekawati, Windu
Neish, Iain
Paravano, Lino
Patadjai, Rahmad
Sabiladiyni, Humairah
Sunjoto, Budhi

Ireland
Campbell, Ross
FitzGerald, Richard
Kirke, Dara
Kraan, Stefan
Maguire, Julie
Millard, David
O'Callaghan, Charlotte
Popper, Zoe
Stack, Julianne
Stengel, Dagmar
Tobin, Paul
Varela-Álvarez, Elena

Israel
Neori, Amir

Italy
Giacchetti, Cinzia
Sciulli, Luisa

Japan
Adams, Eri
Akita, Shingo
Arimoto, Asuka
Aruga, Yusho
Fujita, Daisuke
Hayakawa, Yuhi
Hayashizaki, Ken-ichi
Iwamoto, Katsuaki
Kakita, Hirotaka
Muraoka, Daisuke
Nishimura, Mitsumasa
Nishitsuji, Koki
Santiañez, Wilfred John
Sato, Yoichi
Shoguchi, Eiichi
Uchida, Motoharu
Yotsukura, Norishige

Korea
Hwang, Eun Kyoung
Kim, Chansong
Kim, Jeong Ha
Kim, Young Sik
Moon, Kyounghyoun
Ogandaga, Cyr Abel
Park, Chan Sun

Kuwait
Alenezi, Yousuf

Macau
Tagulao, Karen

Madagascar
Frederic, Pascal
Olivier, Meraud

Malaysia
Matanjun, Patricia

Mauritius
Subramaniam, Saraspadee

Mexico
Carmona, Gustavo
Freile Pelegrín, Yolanda
Marcos, Roberto
Ortegon, Ileana
Pliego, Hugo
Robledo, DANIEL
Rosas Alquicira, Edgar

Sánchez Palestino, Susana
Trejo-Méndez, María
Zertuche-Gonzalez, Jose

Morocco
Noureddine, Falil

Netherlands
De Bok, Lilo
Jamalzadeh, Elaheh
Lubsch, Alexander
Schipper, Job
Timmermans, Klaas
Van den Heuvel, Freek
Van der Kaaij, Ward
Van Hal, Jaap
Van Swam, Koen
Verbruggen, Marian

New Zealand
Stephens, Tiffany

Nigeria
Agbonkonkon, Hayford
Anokwuru, Christopher
Iheanacho, Tochukwu

Norway
Armitage, Caroline
Bakken, Pål
Carvajal, Ana
Chapman, Annelise
Feng, Yiming
Forbord, Silje
Fredriksen, Stein
Funderud, Jon
Handå, Aleksander
Haugland, Barbro
Hogstad, Solbjørg
Horn, Svein
Husa, Vivian
Indergaard, Mentz
Kopplin, Georg
Matsson, Sanna
Netland, Thomas
Neumann, Frank
Rebours, Céline
Roleda, Michael
Rød, Kaia
Sharma, Sandeep
Simoes, Artur
Sjøtun, Kjersti
Skjermo, Jorunn
Steinhovden, Kristine
Stévant, Pierrick
Sveier, Harald
Varum, Kjell
Aasen, Inga Marie

Peru
Dupuy, Juan
Villena, Gunter

Philippines
Baricuatro, Farley
Cequina, Arnulfo
Dakay, Mary Anne
Dakay, Pierre
Ferrer, Ma. Salvacion
Hurtado, Anicia Q.
Lirasan, Tirso
Radier, Richard
Rula, Najeen Arabelle
Togonon, Demosthenes
Wee, Lee Hiong
Wee, John Stanislaus

Portugal
Abreu, Helena
Araújo, Rita
Da Costa, Elisabete
Engelen, Aschwin
Kaenel, Sonia
Melo, Ricardo
Nunes, Nuno
Serrao, Ester
Ventura, Sónia
Vieira, Flávia

Russia
Streletskiy, Sergey
Vasilev, Aleksandr

South Africa
Bolton, John
Duven, Kai
Rothman, Mark

South Korea
Boo, Sung Min
Choi, Han Gil
Choi, Seong-yeong
Choi, Jong-il
Chun, Sook-jin
Chung, Ik Kyo

Im, Soo Hyun
Jong young, Kim
Kang, Yun Hee
Kim, Jongseok
Kim, Ro won
Kim, Gwang Hoon
Kim, Hyung Geun
Lee, Jin Ae
Shim, Eun Young
Son, Kwang-Tae
Song, Do-jin
Yoon, Minchul

Spain
Fernandez, Javier
Gonzalez, German
Salling, Peter
Sanchez, Pedro

Sweden
Albers, Eva
Eimer, Friederike
Harrysson, Hanna
Olsson, Joakim
Ometto, Francesco
Pavia, Henrik
Pettersson, Jonas
Sjögren, Linnea
Thomas, Jean-Baptiste
Undeland, Ingrid
Visch, Wouter

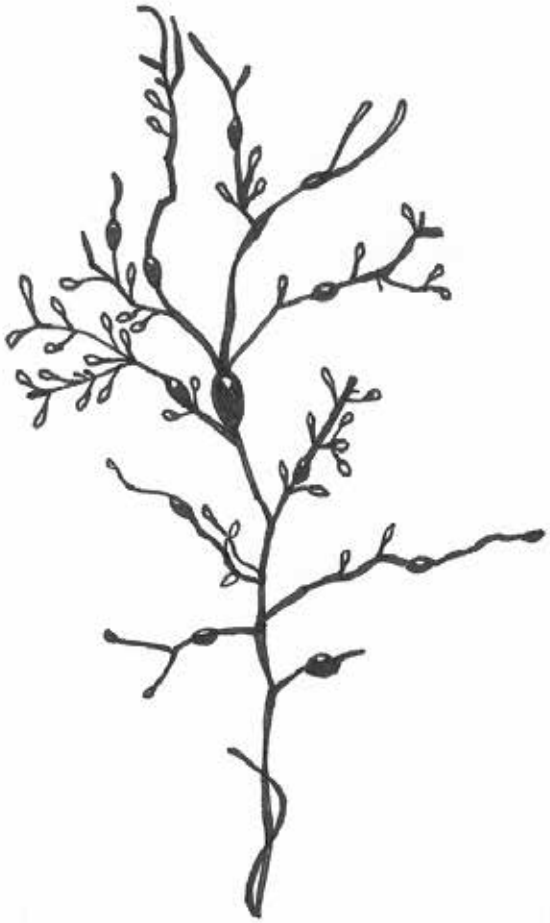
Taiwan
Huang, Roger
Lin, Showe-Mei
Liu, Li-Chia

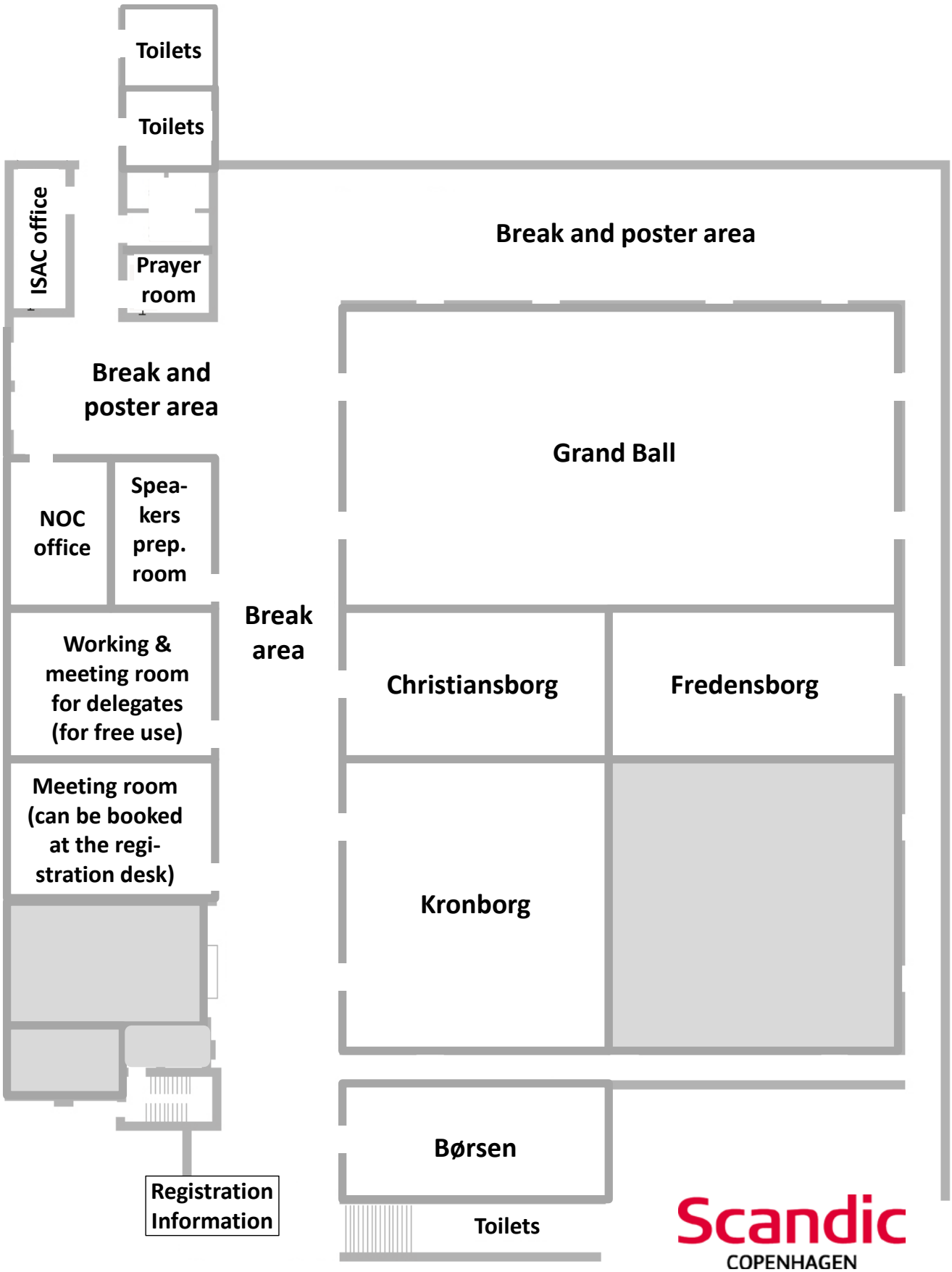
Tanzania
Al rawayh, Hamil
Chau, Wema
Fazal, Murtaza
Githire, Adam
Morre, Roger
Sinani, Raymond

Thailand
Boonprab, Kangsadan
Chankaew, Wanninee
Ruangchuay, Rapeeporn

United Kingdom
Adams, Jessica
Akinmosin, Lucy
Badis, Yacine
Barrento, Sara
Biancacci, Cecilia
Capuzzo, Elisa
Finnerty, Gillian
Fletcher, Harriet
Gachon, Claire
Ghaderiardakani, Fatemeh
Hoggarth, Dan
Hutchison, Shona
Kerrison, Philip
Macquarrie, Duncan
Md Nor, Adibi
Morrison, Michelle
Munoz, Liliana
Murua, Pedro
Pollard, Iain
Rolin, Christine
Ross, Andrew
Smith, Aidan
Stanley, Michele
Strittmatter, Martina

United States
Ask, Erick
Bixler, Harris
Hanisak, Dennis
Hardy, Jessica
Johndro, Kevin
Levine, Ira
Melton, James
Nayak, Balunkeswar
Peters, Winfried
Redmond, Sarah
Rogers, Shane
Rust, Michael
Teas, Jane

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