isbw12

international seagrass biology workshop WALES

CYMRU gweithdy bioleg morwellt rhyngwladol

Securing a future for seagrass

PROGRAMME

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

PROJECT SEAGRASS

Prifysgol Abertawe Swansea University

Ymddiriedolaeth Genedlaethol National Trust

Cyfoeth Naturiol Cymru Natural Resources Wales

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Foreword

On behalf of the World Seagrass Association and the conference organising Committee, I warmly welcome you to the 12th International Seagrass Biology Workshop (ISBW) and to the green hills and rugged coasts of Wales. We all feel honoured to have such a fantastic mix of seagrass scientists visiting us and helping put Wales on the seagrass map. Since the last ISBW we have been lucky enough to observe an exciting time as seagrass scientists. Never has seagrass research effort been so extensive, our community is growing, this can only be a good thing for us all. New research work on seagrass genetics is enabling us to rethink the adaptation of plants to a saline environment and consider their viability into the future. Only last week we had conclusive proof that seagrasses just like their terrestrial cousins use animals to assist with pollination. The term zoobenthophilous pollination will now slowly enter the consciousness of marine biologists around the world. Research is also helping seagrasses to be put on a pedestal for their value in storing and requesting carbon. This work is helping draw much needed resources into the world of seagrass conservation. Research across the whole seagrass food web is also now expanding and we have a much clearer understanding of how top-down drivers interact with bottom up drivers in seagrass ecosystems. Seagrass is beginning to hit the headlines with more regularity and with greater depth. But as we arrive in North Wales for what will be a great week of seagrass events we all know the challenges we face ahead to secure a future for seagrasses. There has never been a more critical time for seagrasses, their near shore shallow water distribution makes them so vulnerable to anthropogenic stress. Examples of seagrass loss and degradation are sadly not hard to find, but those examples need to spur us on as an international community of seagrass researchers and managers. We need to focus on what we can learn from those losses, and realise how we can build on the success of seagrass conservation programs globally. The problems faced by seagrass meadows are largely those that with enough effort and appropriate resources can be solved. As a seagrass research community we need to continue to work on the solutions to those problems and ensure we share that knowledge with those who can use it. I hope that the next week of events at ISBW12 help inspire that to happen. ISBW12 is also an opportunity to inspire a future generation of leading scientists. We're privileged to have the best and brightest young minds of the seagrass community attending, we need to ensure they depart from ISBW inspired.

Please enjoy the ISBW, but whilst you're all here please take the opportunity to experience Wales, experience our language, our culture and the beauty of the country (if the weather allows). Croeso y Gymru (Welcome to Wales).

Diolch Yn Fawr (Thank you very much)

Richard Unsworth
ISBW12 Convenor
President of the World Seagrass Association

World Seagrass Association Welcome

On behalf of the World Seagrass Association I warmly welcome you to the 12th International Seagrass Biology Workshop. The Association is a global network of scientists and coastal managers committed to research, protection and management of the world's seagrasses. The biennial International Seagrass Biology Workshop series is the principal official event of the World Seagrass Association. Seagrasses are facing unprecedented pressures and in this Workshop we are seeking to develop and share information on how we can improve global seagrass health.

The WSA has published several books and journal special issues highlighting the advances in seagrass research made around the world; most recently we published a special issue of Marine Pollution Bulletin on "*Seagrass meadows in a globally changing environment*" in 2014 and a consensus statement to highlight the plight of seagrasses and make a call for global conservation has been published in *The Conversation*. We are currently compiling another special issue in *Marine Pollution Bulletin* along the theme "Securing a future for seagrass" to be published in 2017.

This year it is a pleasure to be at Nant Gwrtheyrn, Wales, the first time the workshop has been held in the United Kingdom. We would like to thank WSA President and Convenor of ISBW12, Dr Richard Unsworth, and his local organizing committee for putting together the exciting program of plenary lectures, papers, posters and workshops that will make for an exciting week of seagrass science. Thank you to all the Association members who have been involved in organizing the Workshop, especially those who have reviewed abstracts for the program.

On behalf of the World Seagrass Association I welcome you to Nant Gwrtheryrn and wish you an exciting and productive workshop.

Mike van Keulen
Vice President, World Seagrass Association

World Seagrass Association Statement

One of the main themes of ISBW12 is 'Raising the profile of seagrass meadows'. To this end Project Seagrass have played a significant role in trying to promote the event and ensure that its reach is far beyond the walls of Nant Gwytheyrn. This will include an extensive social media component, an associated journal special issue together with the production of hopefully numerous important outputs from the workshops. We will also be filming the plenaries and making these available to the world daily by YouTube. Through the week we'll be releasing traditional media press releases. A centre piece of our communication work is issuing a statement of consensus from the World Seagrass Association (WSA).

The WSA committee (together with a number of members) have written a statement in order to highlight the plight that seagrass meadows face around the world with the aim of getting this in the press. As of the 7th October 100 seagrass scientists from 24 different countries had signed the statement.

The statement is as follows and is available on the following URL:

http://wsa.seagrassonline.org/securing-a-future-for-seagrass/

SECURING A FUTURE FOR SEAGRASS

The international seagrass research and conservation community together with the World Seagrass Association calls on all governments and global institutions to take local, regional and global action to ensure the future survival of seagrass meadows. These important ecosystems can no longer be ignored on the conservation agenda, they need to be increasingly managed, protected and monitored. We need the world's media to highlight why these marginalised ecosystems need urgent conservation attention.

GLOBAL IMPORTANCE

Seagrass meadows are of fundamental importance to the human planet. They exist on the coastal fringes of almost every continent on earth where they and their associated biodiversity supports fisheries productivity. These powerhouses of the sea create life in otherwise anoxic muddy environments where they stabilise sediments, filter vast quantities of nutrients and provide one of the most efficient oceanic stores of carbon on earth. The loss of seagrass from common human induced impacts such as poor water quality, coastal development and destructive fishing leads in turn to the loss of most of the fish and invertebrate populations that they support. To help stabilise our climate and to help ensure we have long-term food security we need to protect seagrasses and promote their renewal and recovery.

Seagrass meadows are important fish nurseries and key fishing grounds around the World. The loss of seagrass puts the livelihoods of hundreds of millions of people at risk and exposes many people to increasing levels of poverty. Seagrass loss also places the viability of our remaining populations of Green Turtle, Dugong and species of seahorse at risk. Seagrass loss should not be an option.

CHANGES IN SEAGRASS OBSERVED OVER THE LAST CENTURY

There exists extensive global evidence of seagrass loss. Back in 2007 a global review of available seagrass data clearly articulated the rapid loss of seagrass (Waycott et al. 2009). Since that review of the data there exists growing records of historic, recent and current seagrass loss, degradation and fragmentation around the world. For example, a loss of 2.6km2 of seagrass in Biscayne Bay (Florida, USA) between 1938 and 2009 (Santos et al. 2016). Other recent examples in the literature come from a lagoon in SE of France where up to 38% of the seagrass may have been lost since the 1920's (Holon et al. 2015) and from the nearshore waters of Singapore where some 45% of seagrass has been lost over the past 5 decades (Yaakub et al. 2014). Similar examples of extensive loss have been reported from Canada (Matheson et al. 2016), and the Caribbean (van Tussenbroek et al. 2014). In the British isles seagrasses have been found to be in a widespread perilous state (Jones & Unsworth 2016). Even the Great Barrier Reef Marine Park has suffered periods of widespread decline and loss of seagrass over the past decade; particularly along its central and southern developed coasts. These declines were a consequence of multiple years of above average rainfall, poor water quality, and climate-related impacts followed by extreme weather events. The most recent (published) monitoring surveys (McKenzie et al. 2015) showed that the majority of seagrass meadows across the GBR (which cover a total of some 3,063 km2) remain in a vulnerable state, with weak resistance, low abundance and a low capacity to recover (McKenzie et al. 2015).

CURRENT AND FUTURE THREATS

As our human population rapidly grows and the economies of many countries expand rapidly there is increasing anthropogenic pressure in our coastal zone. We need to find ways to ensure that this coastal expansion doesn't negatively influence seagrass meadows. We already recognise that poor water quality, specifically elevated nutrients, is the biggest threat to seagrasses. These problems are particularly acute in many developing nations with rapidly growing economies, where municipal infrastructure is often limited and environmental legislation are largely weak. Coastal development is a global problem facing seagrass, from Wales to Indonesia there is increasing competition for finite space in the coastal zone. Boating, tourism, aquaculture, ports, energy projects and housing are all placing pressures on seagrass. These local and regional threats to seagrass all exist with a backdrop of the impacts of environmental change and sea level rise. Seagrasses need to be subjected to reduced local human impacts so that they have the capacity to remain resilient to the impacts of these global longer term stressors.

REASONS TO BE OPTIMISTIC

Although seagrass meadows are threatened the world over, we recognise that some significant positive changes are taking place. A brighter future can exist for seagrass. Throughout the world, communities, NGO's and governments are beginning to embrace the monitoring of seagrass meadows, we have increasing evidence of successful seagrass restoration, our knowledge of the ecology of seagrasses is rapidly improving, and the worlds media are picking up on their plight. In places such as Tampa bay in Florida and the Chesapeake Bay we've seen genuine large scale seagrass recovery. We also now have greater appreciation for the value of seagrass in the global carbon cycle and there is a willingness of governments to include seagrass conservation in ways to mitigate carbon emissions. These successes are commendable, but are only a mere initial foundation from where scientists, conservationist, policy makers and managers worldwide should embark on a course of targeted strategic action in order to achieve a brighter future for seagrass.

A CALL FOR SEAGRASS CONSERVATION ACTION

We call for action to be taken to secure a future for seagrass. This means improving local water quality, preventing damage from destructive fishing practices, including seagrasses in MPAs and ensuring that fisheries aren't over exploited. Seagrasses also need to be managed effectively during coastal developments and bold steps need to be taken to ensure the recovery and restoration of these habitats in areas where losses have occurred. We as a scientific community need to be more united, sharing global datasets, making information open access and becoming a team of scientists fighting for the survival of seagrasses. This means as scientists engaging further and more actively with the general public, coastal managers and conservation agencies. For our proposed actions to take place we need seagrass ecosystems to fully pervade the policy sphere around the globe as well as the consciousness of our global coastal communities. This needs genuine committed support from global institutions, the world's media, governments and funders. We need to ensure that seagrasses become part of the environmental education world and that the world's media build on recent progress so that people begin to recognise the need for sustained commitment to seagrass conservation.

Organisers


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PROJECT SEAGRASS


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Swansea University


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SEACAMS


seagrass
ECOSYSTEM
RESEARCH GROUP


Ardal Cadwraeth Arbennig Pen Llŷn a'r Sarnau Special Area of Conservation


WORLD SEAGRASS ASSOCIATION

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Laura Govers *University of Groningen*
Jennifer Verduin *Murdoch University*
Paul York *James Cook University*
Adriana Verges *University of New South Wales*
Siti Yaakub *DHI Water & Environment*

ISBW12 Program

M = Meeting, WS = Workshop, CT = Contributed Talks

SUNDAY 16th OCT.

11:00	**Registration**
11:20	11am onwards
13:00	
14:00	WS1: Social media for seagrass
18:30	**Welcome Drinks**
	CSI Stall (WS2)
19:30	
20:30	**Plenary 1: Duarte**

MONDAY 17th OCT.

08:30	**Plenary 2: Macreadie**	
09:15	**Coffee**	
09:30	CT: Blue Carbon	CT: Ecosystem Services
11:00	**Coffee**	
11:20	CT: Blue Carbon	CT: Ecosystem Services
13:00	**Lunch**	
14:00	WS3: Seagrass restoration WS4: Physical stressors WS5: Boating impacts WS6: Seagrass ecosystem services	
18:30	**Dinner**	
19:30		
20:30	Shuttle bus to local pub/bar	

TUESDAY 18th OCT.

08:30	**Plenary 3: Alcoverro**	
09:15	**Coffee**	
09:30	CT: Resilience	CT: Faunal ecology
11:00	**Coffee**	
11:20	CT: Resilience	CT: Faunal ecology
13:00	**Packed lunch**	
14:00	Field trips	
18:30		
19:30	**Posters and Buffet Dinner**	

WEDNESDAY 19th OCT.

08:30	**Plenary 4: Olsen**
09:15	**Coffee**
09:30	CT: Genetics & adaption
11:00	**Coffee**
11:20	CT: Mixed session
13:00	**Lunch**
14:00	WS7: Timing and triggers WS8: Omics for all WS9: Ocean optimism
18:30	**Conference Dinner**

THURSDAY 20th OCT.

08:30	**Plenary 5: Eklof**	
09:15	**Coffee**	
09:30	CT: Resilience	CT: Physiology
11:00	**Coffee**	
11:20	CT: Resilience	CT: Climate change adaptation/faunal ecology
13:00	**Lunch**	
14:00	WS10: Seagrass ecosystem resilience WS11: SE Asian seagrass WS12: Bio-indicators Texte	
18:30	**Dinner**	
19:30 **20:30**	M1: WSA Meeting M2: IUCN Redlist	

FRIDAY 21st OCT.

08:30	CT: Restoration
09:15	**Coffee**
09:30	CT: Restoration
11:00	**Coffee**
11:20	CT: Restoration
13:00	**Lunch and ISBW Close**
14:00	**All participants depart by 2pm**

Plenary Talks

All plenary talks will be filmed and uploaded daily to Seagrass YouTube Channel. Please share these talks far and wide.

Prof Carlos Duarte – Securing a future for seagrass meadows

Room: Main Hall Sunday, October 16, 2016; 19:30 – 20:15

Carlos M. Duarte is the Tarek Ahmed Juffali Research Chair in Red Sea Ecology at the King Abdullah University of Science and Technology (KAUST), in Saudi Arabia. Before this he was Research Professor with the Spanish National Research Council (CSIC) and Director of the Oceans Institute at The University of Western Australia. Duarte has published over 560 papers on marine ecology with a particular focus on seagrass ecology. Duarte served as President of the American Society of Limnology and Oceanography, and member of the Scientific Council of the European Research Council (ERC), is Editor in Chief of Frontiers in Marine Science, and was editor-in-chief of Estuaries and Coasts, as well as associate editor for a number of journals.

He has received many honours for his work including the G. Evelyn Hutchinson Award from the American Society of Limnology and Oceanography in 2001, the National Science Award of Spain (2007) and the King James I Award for Research on Environmental Protection (2009). In 2009, he received the Silver Medal Cross of Merit from the Guardia Civil, Spain, for his service to environmental protection. In 2011, he also received the Prix d'Excellence, the highest honour awarded by the International Council for the Exploration of the Seas (ICES). He has received honorary doctorates from the Université de Québec a Montrèal (Canada) in 2010 and Utrecht University (The Netherlands) in 2012. He has been ranked within the top 1% Highly-Cited Scientist by Thompson Reuters.

Dr Peter Macreadie – Seagrass carbon storage

Room: Main Hall Monday, October 17, 2016; 08:30 – 09:15

Macreadie's research interests are in the fields of marine ecology and coastal biogeochemistry. During 2010-13, Macreadie held a University of Technology Sydney (UTS) Chancellor's Postdoctoral Fellowship followed by an Australian Research Council (ARC) Discovery Early Career Researcher Award (DECRA) Fellowship (2013-2016). He is currently a Senior Lecturer and Head of the Blue Carbon Lab (www.bluecarbonlab.org) at Deakin University. Macreadie has >60 publications, mostly in 'high quality' journals (e.g. Nature Climate Change, PNAS, Frontiers in Ecology and the Environment, Global Change Biology). Macreadie serves on the Victorian Coastal Council Science Panel and several other Australian Government working groups related to blue carbon. In 2011, Macreadie was listed in The Sydney Magazine's top 100 most influential people in Sydney. He has received 22 Awards/Fellowships, with recent one's

including: 2016 Deakin Vice Chancellor's Award for Research Partnerships, 2016 David Syme Prize, 2015 AMP Foundation Tomorrow Maker Award, 2014 Victoria Innovation Fellowship, 2014 Australian Museum Isobel Bennett Marine Biology Fellowship, and the 2013 NSW Tall Poppy Award.

Prof Teresa Alcoverro Pedrola – TBC

Room: Main Hall Tuesday, October 18, 2016; 08:30 – 09:15

Teresa Alcoverro Pedrola's current research interests at the Blanes Centre for Advanced Studies examine (1) the role of biotic processes, and human perturbations, in controlling the flow of energy among trophic levels both within and between marine habitats, with emphasis on submerged vegetated habitats, (2) the use of biodindicators in seagrass ecosystems to detect water quality assessment and ecosystem change. Much of the emphasis of the first objective is on experimental assessments of grazing and predation intensity in temperate and tropical seagrass habitats, the responses of temperate and tropical seagrasses to this trop-down control, the population dynamics of the main herbivores (sea urchins, herbivorous fish, green turtles and dugongs) and the role of the seascape in changing the trophic interactions (including behavioural) in marine systems. The second objective is mainly focused on the development of indexes for water quality assessment using bioindicators from the molecule to the ecosystem. The overall significance of this research lies in its attempt to understand the processes that control the distribution and productivity of seagrass dominated habitats. Because of the widespread occurrence of these habitats, the extraordinary productivity and richness of their associated biota and the services they provide, the understanding of the factors controlling their distribution and the effect of human perturbations on those controlling factors is essential to our understanding. Both approaches clearly define good objectives of a better management and conservation.

Prof Jeanine L. Olsen – Leveraging "Omics" for Seagrass Biology

Room: Main Hall Wednesday, October 19, 2016; 08:30 – 09:15

MarJeanine Olsen is Professor of Marine Biology and Chair of the Genomics Research in Ecology and Evolution in Nature (GREEN) group within GELIFES at the University of Groningen. Her interests lie in molecular population genetics/genomics of marine algae and seagrasses with emphasis on population-level processes that affect genetic and spatial structure including phylogeography, and the genomic basis for adaptation under climate change. She is also interested in the role of genetic diversity in ecosystem function and member of the US-NSF funded Zostera Experimental Network (ZEN).

Her lab helped to pioneer population genetic studies in seagrasses and continues to encourage genetic surveys for establishing baseline conditions that help to inform seagrass mitigation and restoration projects. She has published >150 papers with >30 in seagrasses. She led the Zostera marina genome sequencing consortium (Nature 2016) and is encouraging colleagues in other areas of plant sciences to broaden their research to include seagrasses.

Dr Johan Eklof – Resilience and Seagrass Ecosystem Feedbacks

Room: Main Hall Thursday, October 20, 2016; 08:30 – 09:15

Johan Eklof is an ecologist at Stockholm University interested in the relationships between biodiversity, community structure and ecosystem processes, primarily using coastal benthic ecosystems as a model. Much of his recent work deals with interactions between aquatic macrophytes and associated organisms, and can be divided into three themes; i) feedback mechanisms between foundation species, consumers and abiotic conditions, ii) how biotic interactions and environmental conditions interact to affect ecosystem structure and processes, and iii) how we should manage biodiversity to sustain ecosystem services in an increasingly changing world.

Events

Silent Auction

Room: Main Hall October 16-21, 2016

Silent Auction (Sunday October 16th, 6:00pm until Friday 21st October, 9:30am)
Hosted by the World Seagrass Association, our silent auction will run throughout the week.

If you haven't been to a silent auction before, it is like a normal auction but bids are written for the items on sale on a sheet of paper. At the predetermined end of the auction, the highest listed bidder wins the item.

Items for auction have been donated by fellow ISBW12 delegates. We're expecting artwork, gift certificates, books, scientific instrumentation and other fun items to be up for sale.

The ISBW12 Silent Auction is a great way to support student members of the World Seagrass Association. All auction proceeds will go the WSA Evamaria Koch Student Travel Award to support student participation and development activities.

The History of Nant Gwrtheyrn & Introduction to the Welsh Language

Room: Main Hall Monday Oct. 17, 2016; During & after dinner

During dinner, or immediately after, local citizens will give a talk on the history of beautiful Nant Gwrtheyrn. In addition to the history of the old quarrying settlement, you will have the chance to learn the Welsh phrases to keep you going for the week!

Field Trips

Tuesday October 18, 2016; 12:00 – 18:30

1 - Historical trip to Caernarfon Castle

This castle is a World Heritage Site and one of the most renowned castles in Wales. Situated close to the sea in the mouth of the river Seiont, it was the site of a Roman fort and early Norman castle before King Edward I commissioned its construction from 1283-1330. During construction, city walls were built around the town of Caernarfon which became the Capital of North Wales. The castle was involved in many battles between the English and Welsh until the English Civil War in the mid 1600s. In 1911, Caernarfon Castle was used for the investiture of the Prince of Wales for the first time for Prince Edward (later Edward VIII), eldest son of the newly crowned King George V. This was repeated in 1969, with the investiture of Charles, Prince of Wales. Caernarfon Castle is managed by Cadw (English: to

keep), the Welsh Government's historic environment division. The castle houses the Royal Welch Fusiliers Museum and has several exhibits and video displays.

2 - Local guided walk around Nant Gwrtheyrn

The ISBW16 is held at a unique conference venue, Nant Gwrtheyrn, located in a former quarrying village on the northern coast of the Llŷn peninsula in North Wales. Nant Gwrtheyrn was developed between 1860 – 1920 when over 2000 people worked in the granite mines to supply stone for houses and roads in nearby cities. Stone was transported from the site by boats. The village was abandoned in the 1970s following the closure of the granite quarries and transformed to a conference centre a few years ago. The 250 acre (100 ha) conference site includes beach and woodland as well as coastal walks; it is situated on the round Wales coastal path. The walk from the conference centre is one of the most spectacular in North Wales, taking you from the conference centre to the top of the valley where you will enjoy views along the coast and, at points, across to the island of Anglesey. The walk returns back to the conference centre in a circuit that takes you past the ruins of the village.

3 - Porthdinllaen nature walk and seagrass bed visit

Porthdinllaen is an old fishing village and harbour now owned and managed by the National Trust. The harbour was once the main port of call for shipping routes between London and Dublin at the turn of the 18th Century. This activity will include a circular walk that will start at Morfa Nefyn and take you through the golf course turning off to join the coastal path and view of the small bay of Borth Wen. The walk will continue around past the lifeboat station along the coast and dips down into the village of Porthdinllaen. Here there will be the opportunity to view the eelgrass bed as the tide is going out, look at the host of intertidal rocky shore species on the rocky outcrops and breakwater and visit the well-known Ty Coch pub for refreshments. The walk will then continue again at approximately 17:15 which will take you through the village of Porthdinllaen along the beach back towards Morfa Nefyn where you will be picked up. The walk itself will take around 1.5 hours, but will involve a stop for lunch and a long stop at Porthdinllaen itself for investigating the village and its wildlife including the Zostera marina bed.

4 - What does a UK seagrass meadow look like?

This activity will involve the group taking part in a field survey looking at variation within the eelgrass bed at Porthdinllaen. The survey will involve two parts. Participants in pairs will randomly place a quadrat and count shoot density, leaf length, leaf width and associated flora and fauna within. The other part of the survey will involve looking at fish and other fauna that are found in the Zostera marina bed by identifying and measuring what has been caught in the fyke nets that will have been set that morning.

Information for Presenters

Poster Session

Room: Main Hall Tuesday, October 18, 2016; 19:30 – 21:30

All posters will go on display for the poster session at 19:30 on Tuesday 18th October, when everyone will get the chance to read them over buffet food and drinks. Presenters will be required to be available at their posters for presentation during the poster event. Poster abstracts are included in this booklet.

Poster presenters, you will be able to put your posters up in the Main Hall from 4pm on October 18th. If you are going on a field trip you will have time to put your poster up before the session starts.

Oral Presentations

All presentation files will need to be uploaded at registration, the day before your talk. This will need to be done at the registration desk upon arrival or at times that will be specified throughout the week. Presentations will need to be in a windows PowerPoint format. Please ensure that any talks requiring video have the files available locally (rather than streamed) as the WIFI may not run at suitable speeds to support it.

Ten Useful Welsh Phrases

Iechyd da = Cheers/Good health

Hwyl = Good bye

Bore da = Good morning

Nos da = Good night

Please = Os gwelwch yn dda

Diolch = Thanks

Good luck = Pob lwc

Excuse me = Esgusodwch fi

I love you = Dw i'n dy garu di

Seagrass = Morwellt

Nanhoron Arms and Nefyn

Due to the enthusiastic response to the ISBW, Nant Gwrtheyrn could not accommodate all workshop participants, for this reason we have used the Nanhoron Arms in Nefyn as satellite accommodation. We also understand some people have arranged their accommodation and catering elsewhere. At the hotel, participants will be provided with breakfast, however lunch and dinner will be served at Nant Gwrtheyrn.

The hotel has basic facilities including a restaurant that's open to the public and two bars. The lounge bar in the main hotel is open to non-residents and the second is situated at the back of the hotel with an accompanying beer garden.

Minibus services

To ensure that no participants struggle with transport we are providing the following:

Ad hoc Minibus service

An *ad hoc* minibus service throughout the day and evening that can ferry people between Nant Gwrtheyrn and the Nanhoron Arms. This will be driven by Steven Budgen (Budge) who will do his best to help people and accommodate varied needs. He will leave a chalkboard placed near to the chapel to communicate his whereabouts and the next available bus time. Please be patient, Budge will be working long hours throughout the week to help ensure everyone gets where the need to go, but there may be periods when he's not onsite so you may have to wait a while for a lift. His phone number is: +447928697511

Additional morning buses

To ensure that everyone staying at Nanhoron can get on a minibus for arrival at the plenaries in the morning we have booked an additional morning minibus every day. These will leave the Nanhoron Arms at 07:50. Please be on time.

Additional needs or emergencies

We understand that Nant Gwrtheyrn is in an isolated location so will do our best to support any additional transport needs of participants (within reason). Any problems please speak to one of the team. We do have an additional small people carrier available that can help with transport needs if necessary.

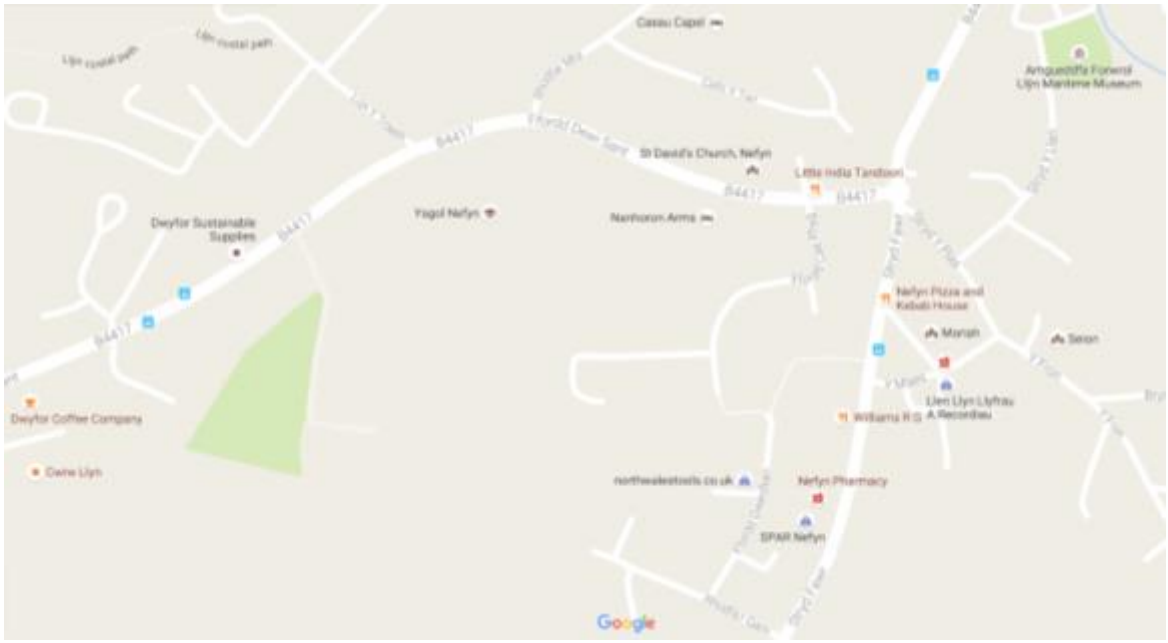
Local facilities in Nefyn

Those staying in Nefyn will have the advantage that there are a number of local amenities available, this includes some additional food options such as the Little India tandoori, Nefyn

Pizza and Kebab House, and Nefyn Fish& Chip shop. In addition there is a reasonable convenience store called 'the Spar' and a pharmacy.

In addition there is a beach at Nefyn and two small tourist attractions, the Maritime Museum and the Brewery. Cwrw Llŷn Brewery is where the beer sold in Nant Gwrtheyrn is brewed, they have a small café and run tours around the facilities (see http://cwrwllyn.cymru). The maritime museum is also located in Nefyn (http://www.llyn-maritime-museum.co.uk) and provides a rich description of the local history that has been dominated by maritime activities.

Map of the village of Nefyn



Forthcoming Journal Special Issues

It is our aim as organisers to find ways to assist ISBW participants with finding appropriate avenues for the publication of research presented at the conference. Two special issues are currently being finalized. The first, in Marine Pollution Bulletin is directly relevant to the themes of the ISBW, the second, to be published in Frontiers in Plant Science is broadly appropriate as it will focus on the conservation ecology of aquatic plants, but has no direct link to the WSA or the conference.

Securing a future for seagrass – Marine Pollution Bulletin

Mike van Keulen, Lina Mtwana Nordlund, Leanne Cullen-Unsworth,

Our aim is to create a special issue focused on all aspects of seagrass in the spirit of #oceanoptimism, a theme that we are introducing through the World Seagrass Association. Seagrasses are unquestionably valuable to humans and play a multifunctional role directly and indirectly. Seagrass ecosystems are being lost at a rapid rate around the globe from a range of human impacts, and we need to act urgently if we want to continue to enjoy the services seagrasses provide. There are good examples and ideas about how to improve the situation for seagrass ecosystems, and we hope this special issue will be a forum to share these possibilities, recommendations and best practices to secure a future for seagrasses. The proposed special issue will be an initiative of the World Seagrass Association and will especially cover the following areas:

- Resilience and a changing environment
- Ecosystem services
- Restoration and management
- Raising the profile of seagrass meadows

The main reason we chose to approach MPB is because of the wide variety of categories of articles. We believe that a special issue about 'Securing a future for seagrasses' demands more than just traditional reports and reviews. We as editors will encourage submission of a variety of article types, including 'News', 'New Products', 'Conference Reports', 'Correspondence' and 'Book Reviews' to capture and share a contemporary and optimistic message about seagrass and its future. We will be inviting submission of relevant manuscripts from the wider membership of the World Seagrass Association to ensure a broad coverage of contemporary seagrass research.

Proposed timetable: TBC

Conservation ecology of aquatic plants: Frontiers in Plant Science

Richard Unsworth, Janne Alahuhta, Liesbeth Bakker, Peter Macreadie

Aquatic plants are important ecological components of rivers, lakes, wetlands and coastal to marine environments. They create habitats ranging from seagrass meadows and mangrove forests to free-floating communities in freshwater ponds and lakes. These valuable ecosystem service providers play a major role in the structure and functioning of these environments. For example, they provide food and cover for fish and aquatic invertebrates, help oxygenate the water, moderate nutrient enrichment, and limit erosion. There exists widespread evidence of the global loss and degradation of these systems and an urgent need to halt this loss, necessitating research into the conservation ecology of these species. Water quality, land use change, coastal squeeze and a range of other localised stressors are putting their future viability in doubt. It is therefore critical that we learn more about the interactions between aquatic plants and future global change. Conservation management of environments now and in the future requires increased knowledge of how aquatic plants respond to anthropogenic change, and how they can be managed to be resilient to these changes. This research topic will bring together these themes to aid knowledge development that transcends disciplines, environments, habitats and species. The research topic will encourage submissions on applied as well as theoretical content and embrace interdisciplinarity.

In this Research Topic we seek to build a collection of articles addressing how aquatic plants respond to their physical and biological environment and the factors influencing their loss and recovery. This includes focus on how top-down and bottom up processes interact to control aquatic plant communities, particularly with respect to biodiversity-ecosystem functioning and what aspects and traits of the communities facilitate ecosystem resilience. This will include submissions on reproduction, connectivity and dispersal with respect to their implications for conservation biology. It will also include submissions on the floral-faunal interactions. We also welcome submissions that relate to indicators and thresholds relevant to ecological assessment and conservation management of these systems. Importantly, aquatic plants are part of linked social-ecological systems and as such their conservation management is as much about understanding human-environment relationships. We therefore encourage interdisciplinary submissions at the edges of conservation biology and socio-economics.

Proposed timetable: TBC

Workshops

WS1
Social Media for Seagrass Researchers

Room: Plas 1Sunday, October 16, 2016; 14:00 – 18:00

If used effectively, social media can be rewarding and informative for scientists and conservation professionals, including those working with seagrasses. Social media is a significant means of communication for the general public, organisations and agencies. In fact, recent polls have shown that internet-savvy adults (and children) get a substantial portion of their news via social media and the web. Social media campaigns can take advantage of built-in audiences and the ease with which those people can share and promote your message, increasing the reach of your outreach. Social media and internet resources can also be used effectively for data collection and citizen science campaigns. We will discuss the importance of conservation communication and having an online and social media presence. We will also give how-tos and tips on successfully using various online tools and social media outlets. We will walk participants through setting up accounts with different social media outlets, the benefits of each and tips on successfully utilising each outlet. We will help each participant set up desired accounts for themselves or their organisations – including:

- Twitter
- FaceBook
- Instagram
- Snapchat
- WordPress (blogging software)
- Periscope
- Storify

They will be provided with all the information necessary to use these new, or their existing, social media accounts at #ISBW12.

Organizer(s):
Lilley RJ & Hind-Ozan EJ.

WS2
Community Seagrass Initiative – An Overview

Room: Main Hall October 16-21, 2016; Exhibition stall.

The Community Seagrass Initiative (CSI) is a Heritage Lottery funded project spearheaded by the National Marine Aquarium in Plymouth. The CSI focuses on 19 subtidal Zostera marina beds between Looe and Weymouth on the South Coast. For 3 years the CSI aims to highlight the importance of the U.K's most bio-productive marine habitat by providing community outreach and opportunities for volunteers to gain new skills to help monitor these important ecosystems.

Within the catchment of the CSI 16 of the 19 Z.marina beds are named features positioned within Marine Conservation Zones, Special Areas of Conservation or Sites of Special Scientific Interest, however these beds still experience anthropogenic pressures. The intention of the CSI is to provide opportunities for local community to explore and understand the significance of named features of conservation areas. The CSI aims to involve citizens in science to help explore the significance of the named features within conservation areas by monitoring subtidal seagrass beds. The goal is to gain further knowledge on the habitats' ecological state to advise government based environmental groups on conservation efforts.

Implementing citizen science monitoring on a subsurface habitat comes with additional challenges. Monitoring techniques and volunteer involvement has required additional thought with recruitment from specific targeted groups; divers, sailors and kayakers. Creation of bespoke equipment has been needed to collect the information for the project. Creating solutions for the challenges has been rewarding and the delivery team will talk through these solutions and the monitoring techniques. One of the greatest challenges has been training the volunteers. While the project aims to develop skill sets and offer new experiences to facilitate learning of the marine environment, volunteer experience can compromise the data quality. For example: talking to a diver whilst underwater requires specialist equipment and is not feasible within the confines of the CSI so discussions regarding data cannot take place at the time of recording. The delivery team will share experiences and learnt lessons using examples from the delivery of the project. For data quality and validity we can make comparisons between biologically trained volunteers and non-biologically trained volunteers with no previous experience, then discuss the data trend between the two groups.

The performance of a task to engage and interact with the natural environment has provided an immersive learning experience for the volunteers involved in the project. The CSI offers incentives for those volunteers by providing the learning and resource opportunities. However it is intended that through involvement, the largest rewards are intrinsic and instil a sense of environmental stewardship.

The CSI team will provide an overview of the project, some of the initial findings and share the experiences of one of the U.K.'s most exciting public marine monitoring projects.

Organizer(s):
Parry M.

WS3
Seagrass Restoration: Techniques to Restore Feedbacks and Spread Risks

Room: Chapel Monday, October 17, 2016; 14:00 – 18:00

Seagrass meadows and the ecological and economical services that they provide are declining worldwide as a result of human perturbations. This decrease has lead to many restoration programs but their success rate is low. This is likely due to (i) regime shifts and feedback mechanisms that prevent natural recovery (ii) natural variability. Seagrasses are ecosystem engineers as they significantly modify the abiotic conditions of their ecosystem to benefit their own success, by reducing hydrodynamics, stabilizing sediments and trapping inorganic and organic material. Positive feedbacks described for seagrass meadows is for example sediment stabilization, which improves light conditions for plant growth. Regime shifts in seagrass beds are characterized by a collapse of the seagrass dominated ecosystem and a transition into an alternative state. After an ecosystem has shifted into a new regime, it might be difficult to restore it due to feedbacks that prevent seagrass establishment. For example, after the vegetation cover is lost, sediments can easily be re---suspended, causing high turbidity preventing recovery.

Natural variability in the characteristics of a particular bay may cause large differences in the success between replicate plantings. In addition, climate factors such as storms or heat waves can provide variability over time. As natural variability acts at different spatial and temporal scales, planting efforts should be also spread over multiple temporal and spatial scales to spread the risks. To restore feedbacks
of the seagrass state, planting large plots or area might be needed, supplemented by measures to support the feedbacks. Although planting large plots at different locations and times could have an initial high cost, it might increase the chances of success. Restoration success could be increased by making trade-offs between planting over a large spatial scale needed to break antagonistic feedbacks (e.g. sediment resuspension), and the need to spread the risk by planting over multiple sites and times (which would decrease the scale, Fig. 1).

Effective management it is necessary to **(i) identify dominant feedback mechanisms (ii) to develop restoration techniques to support feedbacks and (iii) to effectively spread risks, at the appropriate scale(s)**. With limited amount of funds for restoration, trade---off between investing in the recovery of the feedback and spreading of risks should be made saliently.

This workshop aims to assess the relevance of feedbacks in global restoration projects, as well as techniques that are presently used to support feedbacks effectively and spread of risks. The scientific novelty is the focus on **(i) tipping points at the restoration end; how to**

restore the feedbacks (usually focus is on the collapse end) and (ii) how to deal with natural variability at the appropriate scales. These issues are also paramount in other ecosystems, particularly in the high stress high dynamic environments like coastal areas, and seagrass ecology is presently one of the front-runners. The workshop aims to lead to a scientific publication as we intend to prepare a partially filled spreadsheet prior to the workshop. We encourage participants to bring data from all their failed (and possibly not published) restoration attempts that relate to spreading of risks, and restorations focusing on restoring feedbacks. We aim at a high impact journal due to its relevance and globality (e.g. J. Appl. Ecol).

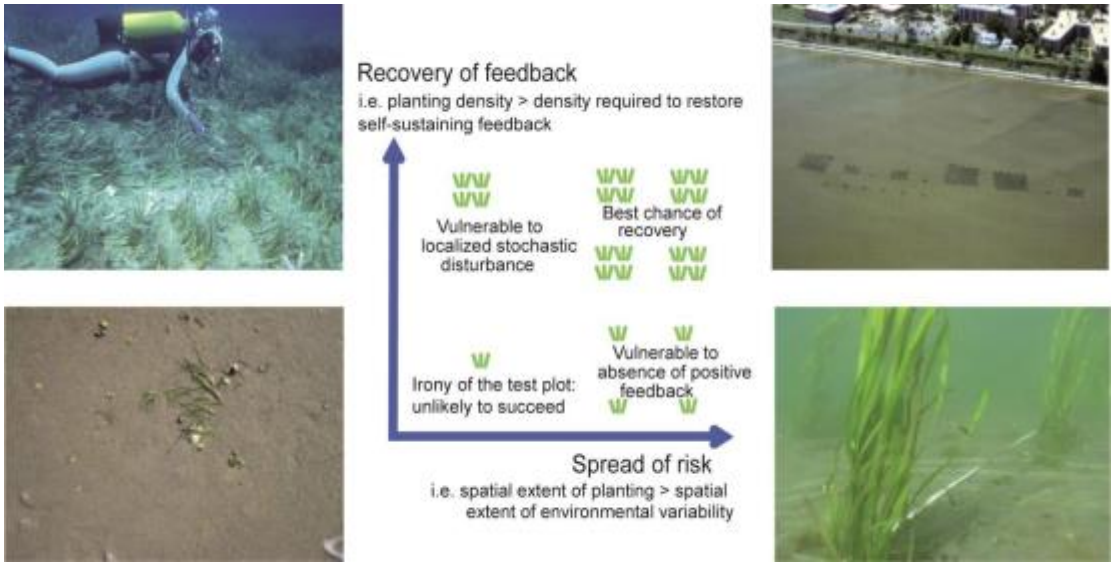


Figure 1. Framework depicting the synergy to investing in spatial extent and planting density, and the trade-off, given a high but limited number of plants, to invest relatively more in either spatial extent or in planting density. A large investment in high numbers may be needed for best restoration practice in dynamic systems to capture windows of opportunity generated by spatial heterogeneity (horizontal axis: spreading of risks, or spatial extent of planting, m^2) and to reach threshold required to initiate self-sustaining feedback (vertical axis: recovery of feedback, or planting density, m^2). Knowledge of the local environment is essential to choose the best planting strategy. (Picture courtesy clockwise: A. Meinesz, R.J. Orth, C. Durance, A. Bos).

Organizer(s):

Infantes E, van der Heide T, Moksnes P-O, Bouma TJ, & van Katwijk M.

WS4
Physical Stressors on Seagrass Wellbeing

Room: Plas 1Monday, October 17, 2016; 14:00 – 18:00

The workshop will examine and discuss the wellbeing of seagrass ecosystems in relation to the physical environment and stressors. Key themes for the workshop will include:

- Connectivity between ecosystems
- Global issues (GCC, including sea level rise, temperature; OA; coastline changes; biogeography)
- Disturbance and recovery in seagrass ecosystems (community structure, pattern)
- Technical aspects (remote sensing and GIS; instrumentation; monitoring)

The workshop will be run in four theme groups, reporting back to provide an overall summary. It is envisaged that there will be four major outcomes:

- A review and gap analysis
- Major outstanding questions and priorities for research
- Approaches at both local and global scales
- Required infrastructure and resources at both local and global scales

Organizer(s):
van Keulen M & Verduin J.

WS5
Exploring Options for Reducing the Impact of Anchoring and Mooring in Porthdinllaen, North Wales

Room: Plas 2Monday, October 17, 2016; 14:00 – 18:00

This workshop will draw together the knowledge, ideas and experiences from workshop participants around the issues of anchoring and mooring in seagrass, with a focus on seagrass friendly moorings in operation and mooring adaptations to reduce impact. The Porthdinllaen Seagrass Project will be investigating management options in 2017 and the information gathered at this workshop will feed directly into that work. A report will also be produced that summarises the findings of the workshop.

Organizer(s):
Palmer Hargrave, A

WS6
Seagrass Ecosystem Services – What's Next?

Room: Sgubor Monday, October 17, 2016; 14:00 – 18:00

How do we move forward with the information we have about seagrass ecosystem services? How can we use the information to improve the situation and appreciation for seagrass?

Anyone with an interest in seagrass ecosystem services and wanting to share, inspire and discuss how we can make seagrass more attractive, appreciated and acknowledged with help of seagrass ecosystem services are warmly welcome to attend!

Ways forward – open discussion 14:00 - 15:00

This workshop will focus on brainstorming how we (the seagrass research community) move forward with the information we have about seagrass ecosystem services. Can we together identify interesting ideas and actions and work together to develop new research to advance the research based on seagrass ecosystem services? Can we find clever ways of using ecosystem service knowledge to increase the appreciation of seagrass, that goes beyond "simply" putting an economic value on them?

The proposed outcome of the workshop will be a peer-reviewed paper which reviews how seagrass ecosystem services have already been utilised, and then presents the ideas from the workshop. We welcome participants that are able to provide working examples, share ideas and feel strongly about this area of study, to join this paper.

Group work 15:00 - 17:15

After the open discussion about "ways forward", we will continue in four outbreak groups. If there is an interest in any of the groups among the members they are welcome to prepare a post-ISBW action plan for a deliverable (e.g. a paper, education material, policy, blog post) for that specific "way forward".

The four groups are:

1) Seagrass ecosystem services and restoration - Marrying ES and seagrass restoration, both by using knowledge of ecosystem service delivery to plan and justify restoration, but also in using ecosystem service approaches to quantify restoration success. In this group we will construct a conceptual model of the factors influencing seagrass restoration decisions where the goal is to restore functional roles and the delivery of ecosystem services.

2) Seagrass ecosystem provision in relation to adjacent habitats - With new more extensive knowledge of seagrass ES, we will aim to compare seagrass in terms of ES to other coastal ecosystems, e.g. are other systems providing the same services as seagrass? Collate and review studies and see where we stand and where we need to fill knowledge gaps. This

workshop aims outline a publication, and all participants are welcome to be part of the publication and its writing process after the ISBW.

3) Communicating benefits of seagrass ecosystem services - Collect, collate and review experiences and identify opportunities to demonstrate benefits of key ecosystem services to the public. Some questions we can ask are: Is the intrinsic value of seagrass recognised by the general public through one or some of the ecosystem services it provides? Are we using seagrass ecosystem services to explain to the public the importance of conserving seagrass habitat? If so which ecosystem services are more or less often mentioned by managers to justify seagrass conservation? Does this vary from the local to global scale? Which media do we use to communicate seagrass conservation through ecosystem services? Which good case study examples are available worldwide? This part aims to hone these questions into testable hypotheses during the workshop and subsequently participants are welcome to bring together data to test these hypotheses as part of the publication and its writing process after the ISBW.

4) How to fill knowledge gaps of seagrass ecosystem services - Although the value of seagrass ecosystem services has been widely acknowledged these days, we still do not have large gaps in knowledge, especially in developing countries. In addition, types and values of multiple ecosystem services rely deeply on how local human communities get access and utilize coastal resources, which largely reflect economic and cultural conditions of each country/region. In this working group, we hope to discuss following topics such as (1) identification of regional gaps in ecosystem service valuation in seagrass beds, and how to fill these gaps, (2) regional variation in our perception of values of seagrass ecosystem services among different regions of the world, and (3) identifying used/unused ecosystem services in different coastal regions which should be considered for effective adaptive management of the seagrass ecosystems.

General discussion 17:15 – 18:00

Here we discuss the key issues and main findings from the break out groups.

All welcome!

Organizer(s):
Nordlund LM, Creed J, Jackson E, & Nakaoka M.

WS7
Timing and Triggers for Seagrass Flowering in Tropical to Sub-Tropical species

Room: Plas 1Wednesday, October 19, 2016; 14:00 – 18:00

The objectives of this workshop are to improve our collective understanding of the timing and triggers for flowering in tropical to sub-tropical species, and to discuss record-keeping protocols for flowering events.

Sexual reproduction is central to seagrass resilience, for example it increases genetic diversity, which is vital to resistance and recovery from disturbance and results in the formation of seed banks, which are required for recovery from disturbance. Cues for reproduction are reasonably well defined for some species; for example, they appear to be driven by environmental conditions in *Zostera marina* and by genetic and ecological factors (energy budgets/herbivory) in *Posidonia oceanica*.

Multi-specific tropical seagrass meadows are formed from diverse tropical species assemblages with varying life history traits. Flowering can occur throughout the year in some species (e.g. *Halophila ovalis*), while seasonal cues may be completely different (i.e. flowering at different times of year) among co-occurring species. Environmental conditions, such as stress can also affect the timing of flowering in tropical species. However, the timing and triggers of flowering are as yet undocumented for most tropical species.

Workshop activities will include:

1. Revision of recording protocols for reproductive structures in tropical seagrasses, including what to look for in species where structures are cryptic
2. Collation of informal (expert knowledge) information on timing of flowering, including an initial exploration of latitudinal and/or regional differences
3. Development of a plan for future collation of data on flowering, in particular of data from grey literature.

We anticipate that findings will be publishable as a peer reviewed article. Furthermore, we hope that the outcomes from such data collation will improve knowledge of environmental and ecological triggers for sexual reproduction, which can in turn help to identify whether local-scale management of seagrass meadows could be tailored towards reproduction.

Organizer(s):

Collier C, McKenzie L, Jervis J, & Waycott M.

WS8
Omics for All

Room: Chapel Wednesday, October 19, 2016; 14:00 – 18:00

"I am an ecophysiologist interested in learning how I might team up with someone doing seagrass omics". How might that work?"

"I'm a bucket ecologist who works in varied systems trying to understand the drivers of ecosystem diversity and productivity, how could I utilize your new found genome knowledge?"

"I am a manager and interested in restoration. How can genetics and genomics help mitigation and restoration efforts?"

In this workshop, we will provide some basic background on what the different divisions of ecological and evolutionary "omics" can address through 4-5 10-min presentations during the first hour followed by a general plenary discussion and short break. From there we will spend the next 2.5 hrs on in-depth discussions.

In prior consultation with various colleagues (most of whom will be present at the workshop) we have provisionally identified a number of broad topics of interest. The workshop participants will select a subset of these. Depending on the number of participants and interests, we may form smaller breakout groups.

The goals of the workshop are to recruit and inform newcomers, scan the research horizon, and establish potential partnerships for integrated/cross-disciplinary national and H2020 proposals. Step out of your comfort zone and explore.

Example topics:

- Combining omics and mitigation/restoration efforts. What affects population/community resilience and which indicators would be of practical use as early warning indicator sets?
- Modeling genetic diversity, meta-population structure and connectivity with environmental impact for structural/functional baselines and MPA designs.
- Seagrass-environmental interactions utilizing genome wide association studies (GWAS) over various geographic scales. G x P x E interactions
- Seagrass-microbiome* interactions. How does the microbiome affect seagrass health and how does that manifest in the seagrass ecosystem with respect to, e.g., productivity, growth and disease? *prokaryotes and eukaryotes.
- How does the seagrass plant immune system and general defense mechanism operate given that there are so many reductions in plant defense genes; how might the microbiome play into this?

- Rapid adaptation, plasticity and very rapid adaptation to, e.g., OA, temperature, salinity, light. Using genome wide variation and the methylome to evaluate selection on gene networks.
- Population and phylogenomics of seagrasses. Exploring shallow-time evolution, speciation and parallel adaptation within and among the three lineages.

Workshop Programme

14:00 Welcome, game plan, overview, 15 years of genetics, omics opportunities, issues, questions. Olsen J.

14:20 Microbiomes: Overview, assembly and function questions. Firl A.

14:30 Microbiomes: GWAS. Vann L.

14:40 Transcriptomes: Overview, highlights in seagrasses, coupling to genome. Procaccini G.

14:50 Methylomes: Overview, plasticity options vs. heritable short term adaptation. Jueterbock A.

15:00 Genetic diversity metrics and linkages to connectivity/ transplants/ resilience. Jahnke M.

BREAK

15:30 General Plenary + selection of topics

16:00 Focused topics discussion

17:45 Wrap up

Organizer(s):
Olsen J, Vann L, & Firl A.

WS9
Finding #oceanoptimism for seagrass

Room: Sgubor Wednesday, October 19, 2016; 14:00 – 18:00

The way we communicate about the environment is so negative and overwhelming that we are fueling a culture of hopelessness that threatens to seal the planet's fate. This is the premise upon which the social media trend of #oceanoptimism was born. This mantra has been taken up within the academic literature by many researchers trying to focus scientists minds on what aspects of ocean conservation are working. Within a seagrass context 'doom and gloom' sells. Even when explaining an optimistic story to a reporter it is often the negatives that reporters focus o to sell the story. Many of us are guilty of playing on this negativity. The aims of this workshop are to define the progress that the seagrass research and conservation communities are making to facilitate the future of seagrass meadows globally. We want to find where #seagrassoptimism is. We also need to know how we can use this information to push forward seagrass conservation and what steps are needed to improve this progress. Where are we making progress in terms of research, monitoring, restoration, legislation, protected areas, institutional recognition and media coverage?

For example, intertidal seagrass is now being widely monitored in the UK as part of the water framework directive (WFD) and used as an indicator of the quality of coastal environments. This is creating a wealth of information about the distribution, abundance and status of seagrass in the region and resulting in significant actions being made to manage destructive fishing on seagrass. This is a huge step forward and is a great example of #seagrassoptimism. It is also an example of where progress can be taken to the next level, as data is poorly communicated to stakeholders and not available to the public. Better communication could aid with greater understanding of these habitats by stakeholders.

Organizer(s):
Unsworth RFK & Duarte CM.

WS10
Seagrass Ecosystem Resilience and Global Change - A Systematic Review and Expert Opinion Survey

Room: Main Hall Thursday, October 20, 2016; 14:00 – 18:00

Understanding how global change will affect organisms, communities and ecosystems is the major challenge to ecology of the 21st century. As a consequence, 'resilience' has become a major buzzword in ecosystem and social-ecological science, management and policy making. Resilience of ecological systems (communities and their abiotic environment) encompass two measurable components; resistance (the ability of a system to persist during the disturbance) and recovery (the capacity to recover or 'bounce back' after the stress is relaxed). However, in many cases we still lack a synthetic understanding about the biological factors that affect or regulate the resistance and recovery of specific ecosystems to individual or multiple interacting stressors, which hampers our ability to operationalize resilience and halt the escalating loss of biodiversity and degradation of ecosystem services.

In seagrass ecology, studies on resistance to and recovery from stress and disturbance dates back to the first steps of the sub-discipline, but has over the last decades been fueled by the escalating loss of seagrasses. Yet, seagrass resilience research has (with notable exceptions) lagged behind that in other coastal ecosystems such as coral reefs. In particular, there has been few attempts to synthesize our understanding of the factors that regulate the resistance to and recovery from global stressors, such as ocean warming, acidification and salinity changes. As many seagrass ecosystems already suffer from regional stressors such as eutrophication or food web alterations, it is further vital to understand the effects of interactions between multiple stressors. One potential reason is that while seagrasses occur almost globally, we are a relatively small research community, and most of the research has been concentrated to a few species and biogeographic regions. Moreover, while resilience is a systems property dependent on interactions between multiple biotic and abiotic components, much of the seagrass research has focused more on the seagrass plants than the ecosystem or the seascapes they form and occur in. Given that many seagrass ecosystems still lack sufficient protection, and our understanding of their resilience is limited, they run an increasing risk of gradually or suddenly transforming into 'novel ecosystems' dominated by other organisms and processes. Thus, there is a clear need for a forward-looking, pragmatic synthesis of seagrass ecosystem resilience for the 21st century.

The aim of this workshop is to initiate the production of a synthetic review on the knowns and unknowns of global seagrass ecosystem resilience. The approach will be critical and pragmatic, aiming to synthesize (and scrutinize the certainty of) current understanding and proposing an agenda for seagrass resilience research in the coming decades.

First, we will first perform an all-inclusive, systematic review of research on seagrass resilience until today, i.e. the What, How, Where, and When of the field. We will contrast biogeographical regions, seagrass species and community types, and tackle the issues from complementary perspectives including genetics, biogeochemistry, plant ecology, community ecology, and seascape ecology. In cases where possible, this includes performing statistical

meta-analyses to assess the generality of factors that may increase seagrass ecosystem resistance to and recovery from specific stressors in different environments (e.g. biodiversity within and across species, functional groups or trophic levels).

Second, we will use an online survey to probe and synthesize the knowledge and opinions of seagrass experts around the world on current and near-future stressors and resilience in different seagrass ecosystems. Together, these two resulting data sets will allow us to evaluate and synthesize what we know, what is uncertain, and what are the main and most pertinent knowledge gaps to advance the field.

Based on draft documents, specific tasks at the workshop include
1) Discussing the general focus of the systematic review and its protocol,
2) Discussing and deciding about the details of the systematic review, e.g. proposed search phrases, databases, variables to be extracted etc.,
3) Discussing and improving the expert opinion survey protocol draft and nailing down the details on questions and sub-questions, email lists, etc.,
4) Dividing work tasks and inviting other experts whose involvement will benefit this work,
5) Decide on a work plan and set deadlines,
6) If possible, start the data collection.

The output will be one or several papers targeting the seagrass and broader research community, as well as managers and policy makers. The work hinges on the involvement of different experts and will be an inclusive, collaborative effort. Naturally, co-authorship will require substantial contributions to both data collection/processing and writing.

Organizer(s):
Boström C, Eklöf J, Krause-Jensen D, & Baden S.

WS11
SE Asian Seagrasses and Their Conservation – Setting Up a Network

Room: Chapel Thursday, October 20, 2016; 14:00 – 18:00

With unprecedented economic development and a rapidly increasing population the marine environment of SE Asia has never been under such high anthropogenic pressure. Although much effort is placed on understanding and conserving the coral reefs of the region, seagrass meadows remain largely over looked in conservation agendas. This is clearly illustrated by the dearth of data from the region in the 2007 global review of seagrass long-term change. A key problem in the region is a lack of communication and collaboration amongst researchers and scientists so that findings aren't shared. This short workshop plans to bring together seagrass scientists working across the region with the aim of developing a network for data sharing, collaboration and academic exchange.

Organizer(s):
Yaakub S, Jones B, & Unsworth RKF.

WS12
Doctor's Diagnosis: Affordable and Effective Methods to Assess Seagrass Health and Stressor Prevalence

Room: Sgubor Thursday, October 20, 2016; 14:00 – 18:00

Objectives: To discuss case studies where colleagues have identified and mitigated seagrass stressors using affordable and effective methods.

It is well known and documented that seagrass ecosystems worldwide are under duress from a range of natural and anthropogenic stressors. In many locations, seagrasses are in catastrophic decline with limited knowledge on the spatial and temporal implications the loss has on interconnected biotic and abiotic systems. Some seagrass restoration efforts have been successful but the loss of seagrass often leads to an environmental change that inhibits natural or human initiated recolonization.

In coastal areas, many natural resource management, conservation and protection organizations track seagrass area and distribution and report on the status of this critical resource over time. However, stakeholders often want to know what causes changes in seagrass and whether seagrass in a particular area is healthy. These inquiries challenge seagrass ecologists primarily due to the dynamic nature of the marine environment, the many confounding factors (drivers) that affect seagrass, and the timeframe for the funding and research.

So, this raises the question whether there are affordable and effective methods that others use to assess seagrass health or condition quickly and accurately? Do colleagues employ methods or tools to identify stressors that affect seagrass in the system where they work? This workshop is designed to have participants describe the system in which they work and provide a few case studies (examples) of methods applied that accurately identified seagrass condition, primary drivers (stressors) affecting seagrass, and strategies to abate the stressors and improve overall health of the system.

Organizer(s):
Gaeckle J & Bertelli C.

Contributed Talks

Blue Carbon

Room: Chapel Monday, October 17, 2016; 09:30 – 12:45
Session Chair: Dorte Krause-Jensen

NB: Presentation slots are 12 minutes + 3 minutes for questions. Talk numbers refer not to talk order, but to the position in the list of abstracts at the back of this book.

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09:30 153. The fate of seagrass export: a missing component of seagrass carbon sink capacity? Krause-Jensen D & Duarte CM.

09:45 9. The influence of short-term stress events on carbon storage and the resilience of temperate seagrass meadows in a changing environment. Soissens LM, Haanstra EP, Katwijk MM, et al.

10:00 6. Influence of sediment characteristics on carbon storage in four European *Zostera marina* areas. Dahl M, Deyanova D, Gütschow S, et al.

10:15 7. Blue carbon stocks in Baltic Sea eelgrass (*Zostera marina*) meadows. Röhr EM, Boström C, Canal- Vergés P, & Holmer M.

10:30 8. Demonstration of the eelgrass ecosystem service as a millenary blue carbon sink. Hori M, Hamaguchi M, & Miyajima T.

10:45 124. Habitat restoration and carbon sequestration: a promise for top predator recovery in coastal systems? Hessing-Lewis M, Hughes B, & Rechsteiner E.

COFFEE BREAK

11:30 11. Landscape patterns modulate carbon storage in seagrass sediments. Ricart AM, Pérez M, & Romero J.

11:45 12. Spatial and temporal variation in carbon storage in subtropical seagrass meadows. Samper-Villarreal J, Lovelock CE, Saunders MI, et al.

12:00 14. Turning carbon sinks to sources: Is bioturbation decreasing the persistence of seagrass carbon? Thomson ACG, Quintana CO, Valdemarsen T, et al.

12:15 96. Eutrophication indirectly reduced carbon sequestration in tropical seagrass bed. Jiang Z, Liu S, Zhang J, et al.

Ecosystem Services

Room: Sgubor Monday, October 17, 2016; 09:30 – 13:00
Session Chair: Nicholas Higgs

NB: Presentation slots are 12 minutes + 3 minutes for questions. Talk numbers refer not to talk order, but to the position in the list of abstracts at the back of this book.

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09:30 **29. Caribbean spiny lobster fishery is supported by chemosynthetic food pathways in seagrass habitats.** Higgs N, Attrill M, & Newton J.

09:45 **157. The global extent of seagrass fishery activity.**
Nordlund LM, Unsworth RKF, Gullström M, & Cullen-Unsworth LC.

10:00 **118. Mutualistic feedback supports high food web complexity in tropical intertidal seagrass meadows.**
van der Heide T, de Fouw J, van der Zee E, et al.

10:15 **17. Are seagrasses important in regulating surface elevation? Building a network of sediment elevation sites.**
Potouroglou M, Diele K, Krauss K, et al.

10:30 **19. Seagrass ecosystem services and their variability across genera and geographical regions.** Nordlund LM, Koch EW, Barbier EB, & Creed JC.

10:45 **20. Assessing the ecological and economic impacts of a drastic decline in tropical seagrass meadows on fish and prawn assemblages.**
York P, Coles R, Sankey T, et al.

COFFEE BREAK

11:30 **50. Using connectivity assessments for large scale seagrass conservation.** Jahnke M, Christensen A, Casagrand R, et al.

11:45 **79. Ecosystem services are lost as eelgrass declines.** Short FT.

12:00 **104. Epiphytic calcium carbonate production and sediment characteristics from a sub-tropical seagrass carbonate factory; Moreton Bay, Australia.**
McNeil M & Nothdurft L.

12:15 **156. Don't throw the baby out with the bathwater: Conservation concerns of seagrass fisheries.**
Jones BL, Unsworth RKF, Udagedara USC, & Cullen-Unsworth LC.

12:30 74. Recurrence of catastrophic seagrass mortality in Florida Bay (USA): Implications for resilience, natural recovery, and ecosystem services.
Carlson P, Yarbro L, Scolaro S, et al.

12:45 64. Global patterns of nitrogen fixation in seagrass ecosystems.
Garcias-Bonet N & Duarte CM.

Resilience

Room: Chapel Tuesday, October 18, 2016; 09:30 – 12:00
Session Chair: Rod Connolly

NB: Presentation slots are 12 minutes + 3 minutes for questions. Talk numbers refer not to talk order, but to the position in the list of abstracts at the back of this book.

-

09:30 106. Capacity of an intertidal seagrass species to tolerate changing environmental conditions: significance of light and tidal exposure.
Manassa RP, Smith TM, Beardall J, et al.

09:45 72. Biomechanical properties of two slow-growing tropical seagrass species: plasticity and relation to morphometry.
La Nafie YA, de los Santos CB, Brun FG, et al.

10:00 75. Relationships between water quality variables and benthic macrophytes communities in Florida Bay. Cole AM, Durako MJ, & Hall P.

10:15 77. A dangerous mix: Strain, dosage, and temperature increase virulence of seagrass wasting disease. Eisenlord ME, Groner ML, Burge C, et al.

10:30 78. Recurrence of *Thalassia testudinum* die-off in Florida Bay.
Hall MO, Furman BT, Merello M, & Durako MJ.

10:45 81. Testing the genetic basis of seagrass resilience.
Connolly RM, Maxwell PS, Macreadie PI, et al.

COFFEE BREAK

11:30 84. Seagrass sediments reveal millennial-scale dynamics and processes in coastal ecosystems. Serrano O, Lavery PS, López-Merino L, et al.

11:45 85. Unusual resilience of a pristine *Zostera noltii* meadows in Banc d'Arguin, Mauritania: strong resistance but slow recovery.
El-Hacen EM, Fivash G, Bouma TJ, & Olff H.

Faunal Ecology

Room: Sgubor Tuesday, October 18, 2016; 09:30 – 12:00
Session Chair: Richard Lilley

NB: Presentation slots are 12 minutes + 3 minutes for questions. Talk numbers refer not to talk order, but to the position in the list of abstracts at the back of this book.

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09:30 107. Revisiting pristine seagrass meadows: How dense aggregations of green turtles modify ecosystem functioning and resilience.
Alcoverro T, Arthur R, van Katwijk M, et al.

09:45 42. Using sea turtle satellite tracking data to identify remote seagrass habitat in the Indian Ocean. Esteban N, Mortimer JA, & Hays G.

10:00 36. Importance of marine landscape configuration on seagrass fish communities.
Gullström M, Staveley T, Perry D, & Lindborg R.

10:15 38. Do corals eat their veggies? First experimental evidence of corals feeding on seagrass matter. Lai S, Gillis LG, & Mueller C.

10:30 39. Habitat connectivity of Atlantic cod (*Gadus morhua*) in coastal shallow-water seascapes. Staveley T, Perry D, Cremle M, et al.

10:45 41. Day-night changes in functional groups and trophic level of fish community in a seagrass bed in the western North Pacific.
Shoji J & Kinoshita H.

COFFEE BREAK

11:30 33. The role of epifauna in the *Zostera* meadows of the Thau lagoon (Western Mediterranean). Rossi F, Pierrejean M, Rattaire M, et al.

11:45 44. Assessing differences in seasonal and spatial utilisation of tropical seagrass meadows by dugong (*Dugong dugon*) using novel low-level aerial photography and next generation photogrammetry.
Rasheed M, O'Grady D, Scott E, et al.

Genetics and Adaptation

Room: Main Hall Wednesday, October 19, 2016; 09:30 – 11:00
Session Chair: Craig Sherman

NB: Presentation slots are 12 minutes + 3 minutes for questions. Talk numbers refer not to talk order, but to the position in the list of abstracts at the back of this book.

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09:30 152. Applying transcriptomic approaches for detecting response to environmental changes in the Mediterranean seagrass *Posidonia oceanica.* Procaccini G, Dattolo E, Entrambasaguas L, et al.

09:45 154. Genetic structure and levels of genotypic diversity provide insights into the dispersal potential and relative importance of sexual and asexual propagules in two co-occurring seagrass species.
Sherman CDH, Smith TM, & York PH.

10:00 109. Inherit resilience in seagrass: Quantifying genetic and kin structure variation between *Zostera marina* life history strategies.
Willeboordse PL, Jarvis JC, Kamel S, & Eulie DO.

10:15 94. The effect of genetic diversity on ecosystem functioning in vegetated coastal ecosystems. Salo T & Gustafsson C.

10:30 55. Comparing the genetic diversity of *Halophila stipulacea* in its invasive and native range. Chiquillo KL, Campese L, Winters G, et al.

10:45 111. High pH water in eelgrass bed of Akkeshi-ko estuary, northern Japan: mitigation of ocean acidification by seagrass?
Nakaoka M, Ito M, & Ahn H.

Mixed Session

Room: Main Hall Wednesday, October 19, 2016; 11:30 – 13:00
Session Chair: Edward Hind-Ozan

NB: Presentation slots are 12 minutes + 3 minutes for questions. Talk numbers refer not to talk order, but to the position in the list of abstracts at the back of this book.

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11:30 123. Challenges for eelgrass restoration in Scandinavian waters.
Moksnes P-O, Eriander L, & Infantes E.

11:45 89. *Enhalus acoroides* (L.F.) Royle seagrass rhizomes: A potential proxy for coastal patterns in relation to climate change.
De Venecia MBB, Rollon RN, Siringan FP, & and David LT.

12:00 71. Seagrass-associated microbes: Protagonists or antagonists in the story about seagrass health?
Trevathan-Tackett SM, Sullivan BK, Gleason FH, & Macreadie PI.

12:15 160.Seagrass microbiome shifts under experimental eutrophication and algal blooms.
Engelen AH, Aires T, Muyzer G, & Serrão.

12:30 49. Regional seagrass monitoring as a tool for resource management in greater Puget Sound, WA (USA). Christiaen B, Gaeckle J, Ferrier L, et al.

12:45 125. Using a GIS-tool to predict potential eelgrass (*Zostera marina* L.) reestablishment areas in estuaries.
Flindt MR, Rasmussen EK, Valdemarsen T, & Canal-Verges P.

Resilience

Room: Chapel Thursday, October 20, 2016; 09:30 – 13:00
Session Chair: Len McKenzie

NB: Presentation slots are 12 minutes + 3 minutes for questions. Talk numbers refer not to talk order, but to the position in the list of abstracts at the back of this book.

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09:30 97. Do stable isotope ratios of seagrass reflect extreme weather events in an urbanised estuary? Clarke AJ, Gaston TF, Glasby T, et al.

09:45 103. Responses of *Zostera. japonica* to trace metals in the Yellow River estuary: Mechanism and simulation. Lin H, Sun T, & Zhou Y.

10:00 105. Tropical/subtropical seagrasses' resilience vs. pollutant effects including point source, sheet flow and oceanic source: Field coupled with lab tests on river turbidity, thermal, oil/dispersants, metals pollutants.
Thorhaug A.

10:15 110. Dredging-induced silt/clay-cover on seagrass leaves impedes the plants' performance and resistance towards H2S intrusion.
Brodersen KE, Hammer KJ, Rasheed M, et al.

10:30 113. Recovery Of *Cymodocea nodosa* from small-scale disturbances in a Mediterranean coastal bay. Sanmartí N, Ontoria Y, Ricart AM, et al.

10:45 134. Chronic light reduction impairs recovery from seasonal and physical disturbances in the climax seagrass species, *Thalassodendron ciliatum*.
Yaakub SM, Bouma T, Erftemeijer P, & Todd PA.

COFFEE BREAK

11:30 135. Do marine phytophthoras threaten seagrass beds? Implications of newly discovered pathogens for eelgrass restoration.
Govers LL, van der Zee EM, Man in 't Veld W, et al.

11:45 155. Shedding light on seagrass - the effects of light limitation on *Zostera marina*. Bertelli CM. Unsworth RKF.

12:00 86. Modelling the feedback between seagrass, sediment and light: The overlooked role of water residence time.
Adams MP, Ghisalberti M, Lowe RJ, et al.

12:15 88. To the limit - Recovery of intertidal seagrass beds reaches its optimum in the northern Wadden Sea (coastal North Sea). Dolch T, Buschbaum C, & Reise K.

12:30 91. The resilience of inshore seagrasses of the Great Barrier Reef: response to and recovery from extreme weather events.
McKenzie LJ, Collier C, Langlois L, et al.

12:45 95. Investigating meadows' injuries. When anchoring scars in seagrasses favor the development of chemical toxic compounds, what does it imply for conservation? Abadie A, Pergent G, Lejeune P, & Gobert S.

Seagrass Physiology

Room: Sgubor Thursday, October 20, 2016; 09:30 – 11:00
Session Chair: Lina Rasmusson

NB: Presentation slots are 12 minutes + 3 minutes for questions. Talk numbers refer not to talk order, but to the position in the list of abstracts at the back of this book.

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09:30 **69. Seagrass nutrient content: what about other elements?**
Arie Vonk JA, Christianen MJA, & Govers LL.

09:45 **59. Effects of salinity on the photodegradation of chromophoric dissolved organic matter (CDOM) released by seagrasses detritus.**
Wu Y, Jiang Z, Liu S, et al.

10:00 **62. Various factors influence the respiratory oxygen consumption in *Zostera marina*.**
Rasmusson LM, Gullström M, & Björk M.

10:15 **63. Understanding salinity tolerance mechanisms in *Halophila stipulacea*.**
Arland M, Barak S, & Winters G.

10:30 **65. Seagrass response to salinity and temperature: Effects on plant vitality and stiffness.** Meyer J, Infantes E, & Paul M.

10:45 **70. Do CO2 responses depend on temperature? A study of carbon metabolism in two tropical seagrass species.**
Ow YX, Uthicke S, Langlois L, et al.

Climate Change Adaptation and Faunal Ecology

Room: Sgubor Thursday, October 20, 2016; 11:30 – 13:00
Session Chair: Richard Unsworth

NB: Presentation slots are 12 minutes + 3 minutes for questions. Talk numbers refer not to talk order, but to the position in the list of abstracts at the back of this book.

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11:30 101. Primary production and thermal optima of three tropical seagrasses. Collier CJ, Ow YX, Langlois L, et al.

11:45 129. Seagrass seedlings in an acidified world: from photophysiology to herbivory. Hernán G, Ramajo L, Basso L, et al.

12:00 108. Consequences of shifting plant-herbivore interactions on seagrass ecosystem functions in a warmer world. Garthwin RG, Vergésa A, Poore AGB, & Wright J.

12:15 116. Contrasting outcomes of moderate warming for seagrass- and macroalgal-herbivore interactions in the Mediterranean. Pagès JF, Tomas F, & Alcoverro T.

12:30 90. Seed predation by the shore crab *Carcinus maenas*: a positive feedback preventing eelgrass recovery? Infantes E & Moksnes P-O.

12:45 117. Will climate change worsen eutrophication effects on seagrasses? Ontoria Y, Sanmartí N, Romero J, & Pérez M.

Restoration

Room: Main Hall Friday, October 21, 2016; 08:30 – 11:15
Session Chair: Emma Jackson

NB: Presentation slots are 12 minutes + 3 minutes for questions. Talk numbers refer not to talk order, but to the position in the list of abstracts at the back of this book.

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08:30 161. The Porthdinllaen Seagrass Project. Hargrave AP.

08:45 137. Increased survival of Enhalus seedlings restored with adult plants: a new technique in seagrass restoration.
Ambo-Rappe R, La Nafie YA, & Syafiuddin.

09:00 114. Dispersion of seagrass propagules and connectivity among meadows in the Great Barrier Reef world heritage area, Queensland, Australia.
Coles R, Grech A, Rasheed M, et al.

09:15 141. Seed and seedling transport: Hydrodynamics and substratum effects on three European seagrasses. Pereda-Briones L, Terrados J, Tomas F, et al.

COFFEE BREAK

10:00 121. Agent based modeling of the Faith of the Eelgrass Seed Bank in the Danish Estuary Odense Fjord. Kuusemäe K, Rasmussen EK, Pothoff M, et al.

10:15 120. Eelgrass (*Zostera marina*) recovery in Puget Sound, Washington, USA: restoration tools, successes and challenges.
Gaeckle J, Thom R, Beunau K, et al.

10:30 126. Development and test of eelgrass restoration methods in a Danish fjord. Lange T, Valdemarsen T, Aaskoven N, et al.

10:45 131. Seagrass ranching: Transplant grow out to recover seagrass clonal integration. Jackson EL, Wilson H, & Irving AD.

11:00 132. Seagrass restoration in New Zealand: assessing feasibility and engaging local communities via transplant trials.
Matheson F, Reed J, Griffiths R, et al.

List of Oral Abstracts

Abstract no. 6

Influence of sediment characteristics on carbon storage in four European Zostera marina areas

Martin Dahl[1*], Diana Deyanova[1], Silvia Gütschow[1], Maria E. Asplund[2], Liberatus D. Lyimo[1,3], Ventzislav Karamfilov[4], Rui Santos[5], Mats Björk[1], Martin Gullström[1].

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[4] Institute for Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences, 2, Gagarin Street, 1113 Sofia, Bulgaria
[5] ALGAE -Marine Ecology Research Group, CCMar - Center of Marine Sciences, Faro, Portugal

Seagrass meadows are highly efficient carbon sinks and important blue carbon habitats. Recent studies have, however, showed that there are large variations in sedimentary carbon content among species and habitats, which could have implications for management of these natural carbon sinks. The causes to the variability is not fully understood but may be linked to habitat characteristics and species-specific requirements. In this study, we assessed sedimentary carbon content in Zostera marina meadows and unvegetated sediment in four areas of Europe (the Gullmar Fjord on the Swedish west coast, Askö in the Baltic Sea, Sozopol in Black Sea and Ria Formosa in southern Portugal) by sampling sediment cores down to approximately 35 cm depth. The sediment was also analyzed for particle grain size, porosity and density. In addition, we measured seagrass plant and meadow variables as well as water depth. Sedimentary characteristics, water depth and seagrass-associated variables were analyzed in relation to sedimentary organic carbon using Partial Least Square (PLS) regression modelling. We found that there was a large variation among and within sites where the Gullmar Fjord was around 15 times higher in carbon content compared to the low carbon storage areas of Baltic- and Black Seas. The main factors related to high carbon content were the sediment characteristics where high proportion of fine grain size particles, high porosity and low density lead to higher sedimentary carbon concentrations. The overall carbon storage in our study was related to sediment characteristics but the analyses also showed that seagrass-associated variables, such as seagrass biomass and cover, were influential in some areas. We highlight that sediment characteristics are important for high carbon storage potential in Z. marina meadows, and should be taking into consideration when evaluating high priority areas for protection of efficient Z. marina carbon sinks.

Abstract no. 7

Blue carbon stocks in Baltic Sea eelgrass (Zostera marina) meadows

Maria Emilia Röhr[1,2*], Christoffer Boström[1], Paula Canal- Vergés[3], Marianne Holmer[2]

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[2]University of Southern Denmark, Department of Biology, Campusvej 55, 5230 Odense M, Denmark
[3]Danish Shellfish Centre, DTU Aqua, Technical University of Denmark, Øroddevej 80, 7900 Nykøbing Mors, Denmark

Although seagrasses cover only a minor fraction of the ocean seafloor, their carbon sink capacity account for nearly one-fifth of the oceanic carbon burial and thus play a critical structural and functional role in many coastal ecosystems. We sampled 10 eelgrass (Zostera marina) meadows in Finland and 10 in Denmark to explore the seagrass carbon stocks (Corg stock) and the carbon accumulation (Corg accumulation) in the Baltic Sea area. The study sites represent a gradient from sheltered to exposed locations in both regions to reflect expected minimum and maximum stocks and accumulation. The Corg stock integrated over the top 25 cm of the sediment averaged 627g C m^{-2} in Finland, while in Denmark the average Corg stock was over six times higher (4324 g C m^{-2}). A conservative estimate of the total carbon pool in the regions ranged between 8.6-46.2 t ha^{-1}. Our results suggest that the Finnish eelgrass meadows are minor carbon sinks compared to the Danish meadows, and that majority of the Corg produced in the Finnish meadows is exported. Similarly, the estimates for Corg accumulation in eelgrass meadows in Finland (< 0.002- 0.033 t C y^{-1}) were over two orders of magnitude lower compared to Denmark (0.376-3.636 Corg t y^{-1}). Our analysis further showed that > 40 % of the variation in the Corg stocks was explained by sediment characteristics (density, porosity and silt content). In addition, the DistLm analysis showed, that root: shoot- ratio of Z. marina explained > 12 % and contribution of Z. marina detritus to the sediment surface Corg pool >10 % of the variation in the Corg stocks, whereas annual eelgrass production explained additional 2.3 %. The mean monetary value for the present carbon storage and sequestration capacity of eelgrass meadows at Finland and Denmark, were 346 and 1862 € ha^{-1}, respectively. We conclude that in order to produce reliable estimates on the magnitude of eelgrass Corg stocks, Corg accumulation and the monetary value of these services, more Blue Carbon studies investigating the role of sediment biogeochemistry, seascape structure, plant species architecture and hydrodynamic regime for seagrass carbon storage capacity are in urgent need.

Abstract no. 8

Demonstration of the eelgrass ecosystem service as a millenary blue carbon sink

Masakazu Hori (Fisheries Research and Education Agency, Japan), Masami Hamaguchi (Fisheries Research and Education Agency, Japan) and Toshihiro Miyajima (University of Tokyo, Japan)

Seagrass meadows have been identified one of three important coastal habitats can significanatly store organic carbon in the sediments. It has been also suggested the carbon stored in the sediment can remain stored over millenary time scales, especially in the seagrass meadows forming thick mats of below-ground structure, such as Posidonia species.

Here, we demonstrated the presence of millenary blue carbon derived from Zostera marina, even in temperate seagrass beds without massive below-ground structure. Sediment long cores (maximum 2.0 m in depth) were collected by PVC pipe with casing in both seagrass beds with Zostera vegetation and tidal flats without any vegetation around. The obtained sediment cores were cut into 5 cm slices, and the sliced sediments were analyzed for total carbon and nitrogen contents, stable isotopic compositions, and DNA markers. The results of delta 13 C signatures of sediment indicated that a considerable fraction of organic matter accumulated in the seagrass-bed sediments was derived from autochthonous sources. Moreover, the DNA markers we developed clearly identified the presence of Z. marina even at 2 m depth of sediment. Additional analysis of radiocarbon dating of the sediment exhibited a range of 4160-4580 years before present, suggesting that Z. marina beds also function definitely as a millennium blue carbon sink.

Abstract no. 9

The influence of short-term stress events on carbon storage and the resilience of temperate seagrass meadows in a changing environment

Soissons Laura M[1*], Haanstra EP[1], van Katwijk MM[2], Brun FG[3], Peralta G[3], Cardoso PG[4], Grilo TF[5], Ondiviela B[6], Recio M[6], Valle M[7,8], Garmendia J-M[7], Ganthy F[9], Auby I[9], Godet L[10], Fournier J[11], Desroy N[12], Kadel P[13], Asmus R[13], Herman PMJ[1,2], Bouma TJ[1]

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[4] IMAR – Institute of Marine Research, Department of Life Sciences, University of Coimbra, 3004-517 Coimbra, Portugal
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[6] Environmental Hydraulics Institute "IH Cantabria", Universidad de Cantabria, C/Isabel Torres No 15, Parque Científico y Tecnológico de Cantabria, 39011 Santander, Spain
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Seagrass meadows form highly valuable ecosystems and habitats in the marine environments. They are however threatened and declining worldwide at an alarming rate, raising the need to better understand their resilience in a globally changing environment. Throughout the year and related to their climatic setting, seagrass meadows are exposed to different levels of stresses: (i) relative predictable long-term stress events, such as low temperatures and low light levels during winter; (ii) and the much more unpredictable short-term stress events from eutrophication or small-scale disturbances. Carbohydrate reserves in seagrass rhizomes are stored over the summer period and have been defined as good indicators for chances for winter survival. Using Zostera noltei meadows as a model, we firstly assessed how rhizomal carbohydrate reserves relates to long-term seasonal stress events, using a climatic latitudinal gradient in Western Europe to vary winter intensity. Subsequently we tested through a manipulative field experiment at a single latitude, whether small-scale disturbance under eutrophication may affect carbohydrate reserves, and thereby affect the seagrass capacity to withstand long-term seasonal stress events. We observed a positive relationship between rhizomal carbohydrate reserves at the beginning of the growing season and winter intensity (i.e., past winter temperatures along the latitudinal gradient). At the end of the season, we also observed a linear increase of carbohydrate reserves along the latitudinal gradient. These two relationships demonstrated the importance of carbon storage in northern areas, submitted to colder winters. Our small-scale field experiment revealed that the amount of carbohydrate reserves may be strongly reduced by the combination of both stress and disturbance. This implies that the long-term winter survival in Northern latitudes is highly sensitive to unpredictable short-term stress events from eutrophication or small-scale disturbances. Our results have strong implication in a context of climate change and increasing threats to seagrass ecosystems, particularly in the most sensitive – not evergreen – Northern populations.

Abstract no. 11

Landscape patterns modulate carbon storage in seagrass sediments

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Due to the imminence of climate change there is growing interest in seagrass systems as natural carbon sinks. Recent studies have provided reasonable estimates of the carbon stocks of seagrass ecosystems. However, the factors that affect its variability remain poorly understood. Here we assess how landscape-level attributes (patch size and matrix composition) influence the carbon storage in seagrass sediments. We quantified organic carbon (C_{org}) content and other geochemical properties ($\delta^{13}C$, particle size) in the surface sediments of continuous meadows, patchy meadows interspersed with rocky-algal reefs and patchy meadows in sedimentary bottoms. We also sampled the potential sources of carbon and applied Bayesian mixing models to determine their relative contribution. The results obtained indicate that continuous meadows accumulate larger amounts of C_{org} than patchy

meadows, whether embedded in a rock or sand matrix. The C_{org} from continuous meadows was also more ^{13}C enriched, which suggests that a high proportion of carbon comes from plant material (autochthonous sources), whereas patchy meadows (especially in a sand matrix) showed a higher contribution from allochthonous sources (mainly seston). These findings indicate that continuous meadows store more C_{org} in the sediment than patchy meadows, and this is probably due to the higher contribution from seagrass leaves, which are much more refractory than seston. In general, landscape configuration, and especially patchiness, would appear to reduce the carbon storage capacity of seagrasses. Since the current decline of seagrass is leading to habitat fragmentation, our results constitute an additional argument for the promotion of effective measures to preserve the integrity of these natural carbon sinks.

Abstract no. 12

Spatial and temporal variation in carbon storage in subtropical seagrass meadows

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Seagrass meadows are one of three habitats that serve as marine carbon sinks, preserving up to thousands of years of carbon stored in their sediments. However, seagrass meadows are highly threatened and are continuing to decline worldwide. Seagrass management and conservation initiatives require adequate understanding of the spatial and temporal variability of carbon storage in these ecosystems, which is currently limited. This study aimed to identify how varying environmental and biological conditions influence spatial and temporal variability of carbon storage in subtropical seagrass meadows. Seagrass biomass and sediment cores were collected between the years 2012 and 2013 at multiple locations across a water quality gradient within Moreton Bay, Australia. The number of cores collected were 298 biomass cores, 298 shallow sediment cores, and 20 deeper sediment cores of up to 2 m sediment depth. Sediment carbon content and seagrass structural complexity were determined for each location. Environmental variables were determined from field data (water quality) and modelled data (wave height). Spatial variability of carbon content was found among sites and linked to variations in seagrass canopy complexity,

water turbidity, depth and wave energy. Sediment isotopic composition varied among locations, indicating variations in the contribution of carbon sources. Seasonal variability was limited and overshadowed by spatial variability. Millennial variation was observed, by dating the deeper sediment cores using ^{210}PB and ^{14}C. Carbon content, vertical accretion, isotopic composition, and carbon accumulation rates varied through the sediment column in Moreton Bay and were higher following European settlement. This study provides comprehensive results on spatial and temporal variability of seagrass sediments in Moreton Bay, which provides useful information for the development and implementation of blue carbon conservation and management initiatives.

Abstract no. 14

Turning carbon sinks to sources: Is bioturbation decreasing the persistence of seagrass carbon?

Alexandra C. G. Thomson*[1], Cintia O. Quintana[2], Thomas Valdemarsen[2], Peter I. Macreadie[1], Peter J. Ralph[1], Erik Kristensen[2] .

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Seagrass meadows are one of the most proficient carbon (C) sequestration ecosystems globally. Their ability for long-term storage of C is largely due to the constant supply and burial of seagrass-derived, slowly degrading organic matter rich in structural polymers. The C sequestration and stocks in seagrass ecosystems are generally treated as static without consideration of disturbances that may affect the persistence of C. Only dramatic events (i.e. a storm or dredging) are usually assessed, while natural and persistent disturbances (i.e. bioturbation) are ignored.
We performed a mesocosm experiment comparing the degradation of detritus from a highly labile macroalgae (Fucus vesiculosus), with a more recalcitrant seagrass (Zostera marina), in sediment with and without bioturbation by the polychaete Arenicola marina. Additionally, we investigated if there was any priming effect when F. vesiculosus and Z. marina detritus were degrading simultaneously.
After 4 weeks, 30% of Z. marina and 27% of F. vesiculosus detritus in non-bioturbated treatments was degraded. Bioturbation by A. marina dramatically changed this pattern. Degradation of seagrass C was hampered due to rapid burial of detritus into deep and anoxic sediment (18% was degraded). Conversely, degradation of macroalgae C was increased due to more efficient microbial degradation in bioturbated sediment (67% was degraded). In treatments with mixed organic addition, 23% of Z. marina, and 43% of F. vesiculosus detritus was degraded in non-bioturbated treatments, and addition of A. marina increased the degradation by an additional 20%.
We conclude that degradation of seagrass and macroalgae detritus and hence stability of blue C stocks is strongly dependent on the degree of sediment reworking and the level of sediment oxygenation through A. marina bioirrigation. This altered rate of detrital

degradation and consequential CO_2 release has implications for the loss global seagrass C stock through time.

Abstract no. 17

Are seagrasses important in regulating surface elevation? Building a network of sediment elevation sites.

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Coastal vegetation has the ability to maintain its position through the accumulation of both organic and inorganic material. This ability depends on the complex interplay of vegetation, hydrodynamics and sediment supply. Achieving a greater understanding of how seagrasses control surface elevation becomes increasingly important under scenarios of accelerated sea level rise. Seagrasses can promote sediment accretion through trapping of suspended sediments from the water column, accumulation of allochthonous and autochthonous organic material, and the production of below-ground root-rhizome material. Surface elevation tables (SET) have been widely employed in mangroves and salt marshes around the world to study patterns of sediment elevation/accretion but have been underutilised in seagrasses. For this study, we adapted and applied this powerful technique to seagrass meadows at a range of settings and locations. In addition, we corroborated this data with wider scale mapping of microtopographic relief, using Terrestrial Laser Scanning (TLS), which is capable of mapping surfaces with high precision.

Abstract no. 19

Seagrass ecosystem services and their variability across genera and geographical regions

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Seagrass ecosystems play a multi-functional role in human well-being, e.g. food through fisheries, control of erosion and protection against floods. Quantifying these services reveals their contributions to human well-being and helps justify seagrass conservation. There has been no comprehensive assessment as to whether seagrass ecosystem services are perceived to vary over the globe or amongst genera. Our study compiles the most complete list of ecosystem services provided by seagrasses, including bioregional- and genus-specific information from expert opinion and published studies. Several seagrass ecosystem services vary considerably in their (known) provision across genera and over the globe; seagrasses clearly are not all equal with regard to the ecosystem services they provide and as seagrass genera are not evenly distributed over all bioregions a services present sometimes depends on the genera present. Larger size seagrass genera (e.g. Posidonia, Enhalus) are perceived to provide more substantial and a wider variety of ecosystem services than smaller species (e.g. Halophila, Lepilaena). Nevertheless smaller species provide important services. Our findings have the following implications for the management and economic valuation of seagrasses: 1) Large gaps exist in our knowledge of the ecosystem services provided by seagrass ecosystems globally. 2) Better understanding of which ecosystem services are associated with specific seagrass genera and bioregions is important for improved coastal management and conservation. 3) The transfer of estimates of economic value of services from one seagrass ecosystem to another system, genera and bioregion must be used with caution, as the lack of such ecological or economic correspondence can lead to highly unreliable valuation estimates.

Abstract no. 20

Assessing the ecological and economic impacts of a drastic decline in tropical seagrass meadows on fish and prawn assemblages.

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Seagrass meadows provide valuable ecosystem services including increased biodiversity and enhanced fisheries production through the provision of nursery habitat, however, global coverage of seagrass ecosystems is declining rapidly. Recently the impact of a tropical cyclone led to the almost complete disappearance of seagrass in a well-studied inlet in northern Australia with little recovery over a four year period. This created a valuable opportunity to combine historical data with renewed sampling where seagrass meadows previously existed to determine the ecological change in juvenile fish and prawn assemblages and evaluate the cost of seagrass loss to fisheries production. We replicated the previous sampling methods to target juvenile fish and prawns for comparison with

historical data collected from the early 1990s and 2000s when seagrasses were widespread. Fish abundance and species richness were significantly reduced following seagrass declines and the assemblage composition also differed. Abundances of the major commercial prawn species declined markedly since the loss of seagrass with a potential to have a major economic impact to a fishery that was estimated to be worth of over $1 million per year in 1993. This study highlights both the ecological and economic consequences of seagrass loss in tropical estuaries. Results will allow informed cost-benefit analyses to be made when deciding on the conservation value of seagrass habitats and the implemention of compensatory restoration projects to offset seagrass loss from natural and anthropogenic disturbance.

Abstract no. 29

Caribbean Spiny Lobster Fishery is Supported by Chemosynthetic Food Pathways in Seagrass Habitats

Nicholas Higgs & Martin Attrill (Marine Institute, Plymouth University)
Jason Newton (NERC Life Sciences Mass Spectrometry Facility, SUERC)

The Caribbean spiny lobster (Panulirus argus) is a generalist predator that forages in tropical seagrass habitats, but most of our knowledge of its diet comes from gut content studies. We used bulk stable isotope analysis (carbon, nitrogen and sulphur) to examine the diet of this commercially important species from the most productive fishery in the Caribbean region. Stable isotope mixing models indicate that a significant portion of spiny lobster diet is obtained from chemosynthetic primary production in the form of lucinid clams that host symbiotic chemoautotropic bacteria. These clams are closely associated with seagrass ecosystems and provide an abundant food source that lobsters have learned to exploit effectively. This nutritional pathway was previously unrecognized in the spiny lobster's diet and highlights the important role of seagrass ecosystems in supporting productive fisheries.

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Abstract no. 33

The role of epifauna in the Zostera meadows of the Thau lagoon (Western Mediterranean)

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In seagrass meadows, mobile epifaunal invertebrates can be important for controlling epiphyte biomass growing on seagrass leaves and for supporting large biomasses of predator fish, including those of commercial value. Information on epifaunal distribution

and functions can be important for understanding and predicting seagrass survival and establishing seagrass conservation measures. Zostera meadows covers more than 30% of the surface of the Thau lagoon, one of the biggest Mediterranean lagoon, which supports large part of the local economy through fishing and aquaculture. Yet, biodiversity and functions of these meadows is largely unexplored and seagrasses are completely ignored by managers and citizens. Since 2014, we have conducted experimental work to understand the functional role of epifaunal invertebrates and their relationship to seagrass structure, production and survival. This paper summarizes some of the major conclusions of this research and illustrates a way to transfer this knowledge to citizens, through a travelling exhibition.

Abstract no. 36

Importance of marine landscape configuration on seagrass fish communities

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Understanding how variation in marine landscape configuration is related to ecological patterns and processes is of emerging significance in applied ecology, and facilitates coastal resource management and conservation planning. Especially challenging for management and marine spatial planning is to identify habitat linkages across the seascape mosaic and to assess the strength of connectivity over relevant scales, for example when selecting marine protected areas. Although widely applied in the terrestrial environmental science, a multi-scale landscape ecology approach to study the relationship between measures of spatial heterogeneity and ecological processes within the marine realm is still underdeveloped. With focus on temperate shallow-water coastal seascapes across the Swedish west coast, we used a hierarchical landscape ecology approach to examine the relative strength of seascape configuration and a range of scale-dependent environmental predictors (at habitat- and within-patch scale levels) on seagrass fish community patterns. To provide more confident generalisations, we compared our results from temperate environments with findings from analogous surveys conducted in tropical and subtropical regions along the East African coast. We found that configuration of marine shallow-water landscapes can play a major role in structuring seagrass fish communities at all latitudes (with relative strength linked to actual response variables explored), while environmental predictors (e.g. seagrass structural complexity) at finer scales also influence community patterns of fish. Our research clearly demonstrates the importance of considering heterogeneity in shallow-water landscape configuration when assessing species-environment relationships and seascape connectivity, and highlights the need of a multi-scale seascape approach to properly conserve seagrass fish communities.

Abstract no. 38

Do corals eat their veggies?: First experimental evidence of corals feeding on seagrass matter

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We present the first experimental evidence of a coral (Oulastrea crispata) ingesting and assimilating seagrass material. Tropical seagrass meadows export a substantial portion of their productivity and can provide an important source of nutrients to neighbouring systems such as coral reefs, however, little is known about the mechanisms of this link. To investigate whether seagrass-nutrient uptake via coral heterotrophy is possible, we conducted a feeding experiment with seagrass particulate and dissolved organic matter. Using gut extractions and stable isotope analyses, we determined that O. crispata ingested ^{15}N-enriched seagrass particles and assimilated the nitrogen into its tissue at a rate of 0.75 μg N cm^{-2} h^{-1}. Corals took up nitrogen from dissolved matter at a comparable rate of 0.98 μg N cm^{-2} h^{-1}. While other ecological connections between seagrass meadows and reef ecosystems are well known, our results suggest a previously ignored direct nutritional connection between seagrasses and corals.

Abstract no. 39

Habitat connectivity of Atlantic cod (Gadus morhua) in coastal shallow-water seascapes

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Tracking the movement of individual organisms is one of the most informative ways to assess connectivity between species and their environments. Using acoustic telemetry as a tool for studying ecological connectivity with relation to seascape configuration has become a more common approach to understanding coastal systems. In this study, acoustic telemetry methods were used to track 48 Atlantic cod Gadus morhua throughout two shallow-water coastal seascapes in the Gullmar Fjord, western Sweden. Atlantic cod were used as they are a commercially important species known to inhabit these areas and are one of the major predatory fish that use seagrass meadows both as nursery and feeding sites. An array of acoustic receivers (25 in total, each with a detection range of approx. 250

m radius) was distributed throughout the seascapes to capture and determine fish's diel movements with real-time spatial movement data. Thus demonstrating habitat visitation, from benthic habitat maps, and species-specific pathways. Preliminary data and analyses suggest that Atlantic cod were utilising these shallow-water coastal areas with some fish expressing signs of high site-fidelity, particularly around seagrass meadows. Some individuals showed strong diel patterns moving between areas within and outside (i.e. deeper waters) the receiver detection range. This information offers insights into detailed spatial and temporal movements of an important mobile organism in the seagrass shallow-water seascape, which contributes to a further understanding of species-habitat connectivity, and trophic linkages in temperate coastal waters.

Abstract no. 41

Day-night changes in functional groups and trophic level of fish community in seagrass bed in the western North Pacific

Jun SHOJI and Hikari KINOSHITA, Hiroshima University, Japan

Seagrass (Zostera marina) bed has been considered to serve as predation refuge for juvenile and small-sized fishes. However, recent surveys in Seto Inland Sea, temperate of Japan, have indicated that predation risk of juvenile rockfish (Sebastes spp.) increased during nighttime due to nocturnal visit of piscivorous fishes. In the present study, seasonal and day-night changes in fish community structures and predation rate on juvenile and small-sized fishes were examined in the seagrass beds in temperate and sub-boreal waters in the western North Pacific. The number of piscivorous fish species collected by a large seine, and their abundance and biomass during nighttime was significantly higher than those in daytime in all seasons. Occurrence of piscivorous fishes during nighttime was confirmed by a video camera with infrared light. Analysis of stomach contents of piscivorous fishes showed predation rate during nighttime significantly higher than those during daytime. The piscivorous fishes visiting the seagrass bed during nighttime consist of important fisheries resources. Therefore, the function of seagrass beds as fish habitats should be evaluated considering two possible pathways in which seagrass beds contribute to fishery production: daytime predation refuge for small fishes while as nighttime foraging ground for large piscivorous fishes.

Abstract no. 42

Using sea turtle satellite tracking data to identify remote seagrass habitat in the Indian Ocean

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Chagos Archipelago in the central Indian Ocean hosts the world's largest contiguous marine reserve, and some of the most remote and pristine tropical marine ecosystems anywhere. During 2012-2016, 18 post-nesting green turtles (Chelonia mydas) were satellite tracked from Diego Garcia atoll and travelled to foraging grounds ranging in distance from 75 to 4,000 km of their Diego Garcia nesting habitat. Four of the green turtles settled within the Chagos Marine Reserve and provided the first evidence of foraging habitat for adult green turtles in the Chagos Archipelago.

Ground truthing surveys were recently conducted at two of the foraging sites on the Great Chagos Bank (GCB) that were identified by this satellite tracking study. They reported extensive meadows of Thalassodendron ciliatum, at depths ranging from 23-30 m along the shallowest parts of the GCB. The Great Chagos Bank is the world's largest living coral atoll; and seagrass habitat had not been previously reported there.

Abstract no. 44

Assessing differences in seasonal and spatial utilisation of tropical seagrass meadows by dugong (Dugong dugon) using novel low-level aerial photography and next generation photogrammetry

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In many tropical locations seagrasses have a key role in supporting mega-herbivores including the dugong (Dugong dugon). These large herbivorous animals are almost entirely reliant on seagrasses as their food source. Listed as 'vulnerable to extinction' by the International Union for the Conservation of Nature (IUCN), the largest dugong population on the planet occurs in tropical northern Australia and the Torres Strait. For the majority of areas within this range little is known on how the use of different seagrass areas and meadow types by dugong varies temporally and spatially.

The feeding trails left behind when dugong excavate for seagrass offer some of the best physical evidence of feeding and habitat use and are common in preferred foraging habitats in the intertidal regions of the Great Barrier Reef. We developed a novel method for quantifying dugong feeding trails over large spatial scales using low-level aerial photography from helicopter and drone platforms, combined with next generation photogrammetry (structure from motion) techniques and software. This enabled the production of orthomosaics of meadows with less than 5cm pixel resolution suitable for identifying dugong feeding scars or trails and developing algorithms to reliably extract feeding activity metrics over large spatial scales.

The technique was applied in quarterly assessments of feeding activity and seagrass change and generated new insights into how dugongs utilise seagrass habitats over time and space as well as the relationships between herbivory and seagrass recovery. We discuss the implications of these results and how they can be combined with tagging and other studies to aid in management and understanding of critical seagrass areas that support dugong feeding activity.

Abstract no. 49

Regional seagrass monitoring as a tool for resource management in greater Puget Sound, WA (USA)

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Lisa Ferrier, Washington Department of Natural Resources
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Eelgrass (Zostera marina) provides a wide range of ecosystem services, but is vulnerable to environmental stressors. As such, it is an important indicator of the health of Puget Sound, WA (USA). The Washington State Department of Natural Resources monitors status and trends in eelgrass area and depth distribution throughout greater Puget Sound to support environmental decision making. Monitoring started in 2000 and is still ongoing. Over 400 sites have been sampled as part of this program. Long-term monitoring of seagrasses in a geomorphological complex region such as Puget Sound poses a unique set of difficulties. Competing monitoring goals have different requirements on the sample design, and balancing large-scale monitoring with research that addresses local management questions can be challenging. Our program monitors eelgrass at multiple spatial scales, provides annual sound-wide overviews, conducts higher density sampling within sub-regions of the Sound, and performs detailed assessments for specific sites. In addition, we link our long-term monitoring data to local management efforts by establishing partnerships and working collaboratively on local projects. These partnerships result in improved datasets that have immediate resource management application. They exemplify how collaborations can increase the power of data collected over multiple spatial scales and conserve financial resources, resulting in a long-term management benefit.

Abstract no. 50

Using connectivity assessments for large scale seagrass conservation

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Developing adequate strategies to manage, conserve and restore marine ecosystems biodiversity and services is becoming a key target of environmental policies. Connectivity assessments are crucial to large-scale conservation planning, in particular for establishing and monitoring connected networks of marine protected areas (MPAs). Seagrasses are important ecosystem engineers in the coastal environment and designing MPAs to ensure connectivity of such ecologically-important habitat providing species is crucial given the major declines of seagrasses worldwide and their increasing fragmentation, which has important cascading effects on the associated ecosystem. Here, we focus on two seagrass species (*Posidonia oceanica* and *Zostera noltei*), which are affected by smaller sized habitats and increased isolation in two pilot project areas in the Black Sea and in the Adriatic. We aim to determine the extent to which the assessed populations (collected in established and suggested MPAs) are connected using oceanographic modelling (Langrangian particles) and genetic analyses (neutral microsatellite markers) to assess both potential and realised connectivity. Conserving populations in MPAs that are at a distance that still allows gene-flow – given the environmental conditions of the area – is probably the best way to maintain levels of connectivity that can avoid inbreeding and allow the spread of advantageous alleles in the future and will allow the network of MPAs to work well in protecting biodiversity in and over its' boundaries. The combined use of the two approaches to assess connectivity can moreover allow detecting areas with lower evolutionary potential, source and sink populations and directionality of dispersal and gene flow.

Abstract no. 55

Comparing the genetic diversity of Halophila stipulacea in its invasive and native range

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Seagrasses are important primary producers in many marine ecosystems, and support a wide diversity of marine life. Despite intrinsic benefits, an invasive seagrass, such as Halophila stipulacea can have negative impacts on an ecosystem, by displacing native seagrasses, and changing the community composition of the reef. The invasive seagrass, Halophila stipulacea, is endemic to the Red Sea, Persian Gulf and Indian Ocean. Presumably the opening of the Suez Canal facilitated the range expansion of H. stipulacea to the

Mediterranean Sea and has recently documented in the Caribbean Sea, all putatively via boat traffic. It is hypothesized that various introductions can be independent, admixture, or serial introductions. Using a 2bRAD sequencing technique, we obtained 250 polymorphic sites (via SNPs), and we found that the invasive population appears to be much less genetically diverse than the native population, possibly due to a genetic founder effect associated with a small population size during the introduction and establishment phase of the introduction.

Abstract no. 59

Effects of salinity on the photodegradation of chromophoric dissolved organic matter(CDOM) released by seagrasses detritus

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Seagrasses detritus have proved to be the main source of CDOM in seagrass beds. And CDOM released from seagrasses detritus was greatly influenced by salinity gradients. According to the salinity variations in Xincun Bay, Hainan, China, four salinity gradients(0, 11, 22, 33 ppt) were set to investigate the effects of sanity on chromophoric dissolved organic matter(CDOM) released by seagrasses(Thalassia hemprichii and Enhalus acoroides) detritus. The results showed that CDOM were rapidly degradated under ultraviolet-B in four salinity gradients, and significant difference were found between the highest salinity gradient(33) and the other three salinity gradients. And CDOM released by E. acoroides was degradated faster than T. hemprichii significantly. But little difference was found in the photodegradation process of the organic components among the four salinity gradients, such as Protein-like and Humic-like substances. On the other hand, dissolved organic nitrogen(DON) in CDOM was intensely photodegraded. About 26.44% of DON released by E. acoroides was photodegradated to dissolved inorganic nitrogen(DIN) when salinity was 0 ppt, 94.32% of the converted DON was rapidly photo-mineralized to ammonium and 65.1% of nitrite was converted to nitrate. When salinity was 33 ppt, the concentration of ammonium released by T. hemprichii only increased 22.89%which was significantly lower compared to the salinity level of 0, 11, 22 ppt. The photo-oxidation process from nitrite to nitrate was also inhibited under 33 ppt. Therefore, salinity plays an important role in the photodegradation process of CDOM released by seagrass detritus, and alters the conversion process from DON to DIN. And this photodegradation process could accelerate the circulation of refractory organic matters and make them bioavailable to seagrasses and the surrounding environment in seagrass beds.

Abstract no. 62

Various factors influence the respiratory oxygen consumption in Zostera marina

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In temperate areas, eelgrass (Zostera marina) may have great impact on coastal carbon- and oxygen fluxes through their high photosynthetic capacity and respiration. While photosynthesis is well studied in eelgrass, respiration has not been given as much attention, especially not on the individual plant level. Many estimations of daily photosynthetic productivity have assumed that respiratory rates obtained in darkness are constant over the day, something we have found misleading. Here, a comprehensive assessment of factors influencing the respiratory rates of Z. marina is presented. The results indicated that light might suppress respiration rates, at least in the lower light ranges. Moreover, dark respiration rates were found to fluctuate greatly on a diel basis, with peaks at late evening and during night. Furthermore, respiration was found to be different depending on the age of the tissue, where younger shoots had a higher respiratory demand than older. In contrast, older tissues of the leaves (i.e. apex and mid parts) had higher respiration than the younger basal parts. Finally, respiratory Q10 values were found to be lower, yet more stable, than photosynthetic Q10 values, indicating that temperature has a major influence on the balance of seagrass gas exchange. All together these findings clearly show that respiration is highly variable and different factors needs to be taken into consideration when estimating respiration quotes for eelgrass.

Abstract no. 63

Understanding salinity tolerance mechanisms in Halophila stipulacea

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Halophila stipulacea is a tropical seagrass native to the Indian Ocean and Red Sea, but it has been spreading in the Mediterranean, and recently the Caribbean Sea. Its success as an invasive species has been partially attributed to tolerance to variations in salinity. Thus, elucidating the mechanisms involved in salt tolerance in this species will contribute to the modeling of its future invasive distribution. H. stipulacea is also closely related phylogenetically to Vallisneria americana, a fresh water plant. Comparing salt tolerances in H. stipulacea with that of its fresh water relative will contribute to understanding the evolution of seagrasses from their freshwater ancestors.

For this, H. stipulacea plants were exposed to control (40), hypo (15, 20, 25) and hyper (60, 65 PSU) salinities for 3 weeks followed by a 4-week recovery phase. Similarly, V. americana plants were exposed control (0), and hyper (5, 10, 15 PSU) salinities. Plants were followed over time for changes in leaf counts and surface area, C/N ratios, biomass, dark-adapted quantum yield of photosystem II and chlorophyll content. In comparison with both the control (40 PSU) and hyper salinity treatments (60, 65 PSU), H. stipulacea plants exposed to hypo-salinities, lost more leaves and decreased in leaf area and chlorophyll content. The C/N ratios of the below-ground tissues of the H. stipulacea plants after hypo- and hyper-salinity stress were lower than control plants suggesting certain adaptive mechanisms employed by the plant.
In comparison with control (0 PSU), V. americana plants exposed to 10 PSU, suffered reductions in leaf blade elongation, leaf number, biomass and quantum yield and were not able to survive at all at 15 PSU.
In both species, the ongoing work is to link these physiological responses with transcriptomics and metabolomics to investigate the differences in the molecular mechanisms involved in salinity stress tolerance.

Abstract no. 64

Global Patterns of Nitrogen Fixation in Seagrass Ecosystems

Neus Garcias-Bonet and Carlos M. Duarte

Seagrass ecosystems are important carbon sinks, due to their high productivity. Despite the fact that seagrass ecosystems are restricted to shallow coastal areas, they are responsible for the 15% of the total organic carbon buried in the ocean. Therefore, seagrass meadows have an important role in climate change mitigation by sequestering large amounts of CO_2 and retaining the incorporated carbon. However, seagrass growth is often nutrient limited. Atmospheric nitrogen fixation has been identified as an important source of new nutrients to fulfil their nutrient requirements. In this study, we constructed a database containing all the published data regarding nitrogen fixation rates in seagrasses, in order to detect global patterns and to identify factors controlling this process. We identified a strong temperature-dependence. Appling Thermal Response Analysis, we estimated a global optimum temperature around 25ºC, with slightly variations for each seagrass species. Moreover, we calculated the activation energy of the rise and fall components of the temperature responses. These results suggest that under predicted global warming scenarios, nitrogen fixation rates will be affected. In cold regions, nitrogen fixation might be enhanced, while nitrogen fixation in tropical and subtropical regions might collapse. This could have severe implications in seagrass productivity and carbon storage capacity and therefore in climate change mitigation.

Abstract no. 65

Seagrass response to salinity and temperature: Effects on plant vitality and stiffness.

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Seagrass can be exposed to temperature and salinity fluctuations, especially in estuaries and coastal regions with changing fresh water runoff from the hinterland. These fluctuations are likely to increase if runoff is enhanced due to an increase in severe weather events. While species plasticity allows adaptation to a range of water temperatures and salinities on species level, rapid changes in these parameters may affect plant mechanical properties such as stiffness and buoyancy. These parameters play an important role in a plant's response to hydrodynamic forcing. If stiffness and buoyancy are affected negatively, the capacity of seagrass to resist hydrodynamic forcing (e.g. storm conditions) will be reduced. Only a very limited number of direct measurements of biomechanical parameters are presently available and while a wide range of natural variability has been acknowledged, effects of external factors (e.g. water temperature, salinity) on these properties has not yet been investigated. Here, we present data on the response of Zostera marina to changes in water temperature and salinity varying from 0-32 PSU and temperatures from 17-26 °C. Eelgrass from various locations and depths along the Swedish West coast were exposed to different salinities and temperatures and tested at regular intervals in laboratory experiments. Measurements included photosynthetic activity (PAM, as a proxy for vitality) and flexural stiffness using a cantilever test (as proxy for resistance to hydrodynamic forcing). Additionally, we quantified to what extend the observed negative effects are reversible if incident conditions are re-established. The results were compared with data on Fucus sp. collected under identical conditions, to evaluate the response of different species growing under comparable abiotic conditions. The results will provide an improved understanding of ecosystem functioning and failure and allow the link of abiotic factors to the resistance of seagrass to hydrodynamic forcing.

Abstract no. 69

Seagrass nutrient content: what about other elements?

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Seagrass element ratios closely reflect dominant environmental conditions in their meadows and potential adaptations of seagrasses to deal with changes in their environment. Seagrass elemental composition has been intensively studied for macronutrients (nitrogen and phosphorus) in relation to disturbances such as eutrophication, and also for metals in relation to accumulation of pollutants from

anthropogenic sources. However, almost no information is currently available on other major elements in seagrasses that are known to play an important role in functioning of vascular plants and how elemental ratios beyond carbon:nitrogen:phosphorus reflect adaptations of seagrasses to various environmental conditions. In this presentation we will provide a first overview on the elemental composition for ten seagrass species including potassium, calcium, magnesium, manganese, sulphur, sodium and silicon with their ratios to carbon, nitrogen and phosphorus. Besides presenting differences between species and sediment origins, we discuss the role of these elements in relation salinity stress and grazing. Tissue composition was analysed for over 300 seagrass samples using inductively coupled plasma emission spectrometry, collected over a broad geographical range (Caribbean, Europe, West-Africa, Indonesia and Australia). The distribution of measured concentrations was left skewed for most elements. Although variability within species was high, clear differences between species were observed for many of the studied elements. Seagrasses growing on carbonate sediments had in general low silicon contents. Nitrogen:element ratios and carbon:element ratios were mostly inversely related to the respective element composition. In contrast, only few phosphorus:element ratios showed a clear inverse relationship. Given the known importance of these elements amongst others in relation to salinity stress, disease resistance and grazing in plants, more insight into the role of these elements in the physiology of seagrasses and the functioning of meadows can be essential to better understand resilience of these important ecosystems to a changing environment.

Abstract no. 70

Do CO_2 responses depend on temperature? A study of carbon metabolism in two tropical seagrass species.

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Increased dissolution of atmospheric carbon dioxide (CO_2) into seawater leads to ocean acidification and higher partial pressure of CO_2 (pCO_2) in seawater. Seagrasses, thought to be carbon limited at present day seawater dissolved inorganic carbon concentrations (pCO_2

~ 400 to 500 µatm), can benefit from the rise in CO_2 availability. Seasonal variation in temperature influences seagrass metabolism and may affect how they utilise the extra CO_2; however, the combined effects of temperature and increased CO_2 availability on seagrass productivity are unknown. This study examined the effects of pCO_2 enrichment and temperature on carbon metabolism in two tropical seagrass species (Cymodocea serrulata and Halodule uninervis). Seagrasses were exposed to three temperatures (20°C, 25°C and 30°C, spanning seasonal variation) and three target pCO_2 levels (present day 353 – 485 µatm; high 915 – 1102 µatm; extreme 1658 – 2297 µatm) for seven weeks. Net productivity, biomass allocation and carbohydrate contents were quantified to determine carbon assimilation and utilization under different treatments. For both species, temperature independently increased net productivity, respiration and above-ground biomass. With raised net productivity at warmer treatments, C. serrulata exported more carbohydrates to its rhizomes, while H. uninervis invested in increasing shoot density. Carbon dioxide enrichment effected increased above- to below-ground biomass ratio in C. serrulata, and higher net productivity in H. uninervis, with the effects greatest at 30ºC. Overall results demonstrate that temperature exerts a stronger control over carbon metabolism than CO_2 enrichment in tropical seagrasses. Species varied in the allocation of fixed carbon in response to temperature and CO_2, highlighting the importance in accounting for species differences when predicting meadow-scale productivity responses in a changing environment.

Abstract no. 71

Seagrass-associated microbes: Protagonists or antagonists in the story about seagrass health?

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As seagrass scientists, we well know that seagrass health and resilience depends on a fine balance among physical, chemical and biological variables. Currently, one of nascent research topics in this field aims to understand the relationship among seagrasses, microorganisms and the environment. The collection of microorganisms associated with seagrasses, e.g., their microbiome, may include taxa that serve both beneficial (nitrogen cycling) and detrimental (hydrogen sulphide production, wasting disease) roles. Here, we present two studies aimed at further understanding seagrass-microbe relationships. First, we analysed the leaf microbiomes of Zostera populations from known pristine and nutrient/runoff-impacted sites along the temperate Victoria, Australia coast. By using metagenomics to identify the microbial communities and their functions, we aim to get a small snapshot of the seagrass' epi- and endophytic microbes and to explore the possible influences of environmental conditions on the seagrass microbiome. Second, we conducted the first survey along the southeastern Australian coast for the protist Labyrinthula.

Labyrinthula, which is known to be both a saprobe and opportunistic pathogen, was isolated from 6 seagrass species, 5 of which are endemic to Australia. We will report on the first pathogenicity study performed on Labyrinthula in the Southern Hemisphere and will discuss our findings in terms of host specificity and local and global biogeography. The outcome of this work will be a timely addition to the growing story concerning the roles microbes play in seagrass health.

Abstract no. 72

Biomechanical properties of two slow-growing tropical seagrass species: plasticity and relation to morphometry

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Seagrasses are acknowledged to have large morphological plasticity in relation to environmental conditions but little is known about their mechanical plasticity. We investigated how mechanical properties of two slow-growing seagrass species i) vary between species, plant parts and amongst locations, and ii) how this variation is related to plant morphometry. We sampled two climax seagrass species Enhalus acoroides and Thalassia hemprichii from four Indonesian islands covering a gradient of anthropogenic activities (relatively pristine versus anthropogenic impacted areas) and wave exposure (sheltered versus exposed). Enhalus acoroides had a higher FMAX value (absolute force needed to break a material) than T. hemprichii, indicating that E. acoroides leaves were less easy to break than T. hemprichii leaves. It resulted not only from having a larger dimension (higher cross sectional area = thickness x width), but also from bearing stronger tissues (higher FTS, specific force to tear, i.e., the maximum force needed to break a material per its cross sectional area). Sheaths were more extensible than leaves, which was probably due to the softer meristematic tissues that form the sheaths that still bear elastic cell walls. Amongst locations, E. acoroides acclimated to local conditions by modifying both morphological and biomechanical properties, while T. hemprichii were less responsive to location. However, in E. acoroides we did not found a clear correlation between variation in biomechanical properties and morphometry with the anthropogenic influence or wave exposure. Overall, both species showed morphological and biomechanical acclimation capacities within the studied environmental range, although E. acoroides showed a higher plasticity than T. hemprichii.

Abstract no.74

Recurrence of Catastrophic Seagrass Mortality in Florida Bay (USA): Implications for Resilience, Natural Recovery, and Ecosystem Services.

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Vicki Absten, Florida International University, and Daniel Carlson, Florida State University

Catastrophic mortality of dense Thalassia testudinum beds in Florida Bay occurred in several episodes from 1987 to 1991, resulting in the complete loss of thousands of hectares of seagrass. At that time, acutely toxic levels of dissolved sulfide in sediments were determined to be the proximal cause of seagrass mortality, but the mechanisms responsible for sulfide accumulation in sediments were not conclusively demonstrated. With the recurrence of seagrass mortality in Florida Bay in summer 2015, we show that several processes create the conditions that lead to sulfide toxicity and catastrophic mortality of Thalassia. Regional drought and elevated water temperature lead to hypersalinity, particularly in northern Florida Bay. In addition, dense seagrass communities experience hypoxic and anoxic conditions in the water column at night. Death of seagrasses exposes roots, rhizomes and lateral meristems of neighboring Thalassia shoots to acutely toxic levels of sulfide, causing secondary mortality. Dead belowground tissues provide labile carbon sources to sulfate-reducing bacteria enhancing sulfide production and creating a positive feedback loop of increasing sulfide toxicity leading to more seagrass loss. We estimate that up to 2.8 million kg of seagrass carbon have been remobilized in the current event by at least 50% mortality of Thalassia over 9400 ha of Florida Bay. Climate analyses show that, in the short term, higher water temperatures might result in recurring seagrass mortality events. However, over time scales of decades, seagrasses in Florida Bay have shown remarkable potential for recovery. In the still-longer term, sea level rise will increase tidal exchange and flushing in Florida Bay reducing the likelihood of seagrass mortality. Nevertheless, the potential for seagrass mortality, especially in transitional or unstable environments, should be considered in calculating the carbon sequestration capacity of seagrass beds.

Abstract no. 75

Relationships between water quality variables and benthic macrophytes communities in Florida Bay

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Seagrass beds form the dominant ecosystem within Florida Bay. Freshwater inflow into Florida Bay has declined by 60% due to alterations in water usage in the Everglades and south Florida, leading to increased salinity and changes in benthic macrophyte communities. The Comprehensive Everglades Restoration Program is a large-scale restoration plan to return water flow back to historical levels and decrease salinities in Florida Bay. We explored two data sets, attempting to find variations in water quality variables, which could be linked to changes in benthic macrophyte occurrence and abundance. Water quality data were collected monthly-to-bimonthly from 2005 to 2013 at fixed water quality monitoring

stations as part of an ecosystem-wide monitoring network. Macrophyte data were collected during spring and fall from 2006 to 2013 at 15 permanent transects in Florida Bay co-located at the fixed water quality stations. This method of collecting both types of data from the same locations allowed for more sensitive analyses to determine possible interactions between water quality and benthic macrophytes. Logistic regression analysis indicated that increased salinity was positively associated with marine species such as Thalassia testudinum and negatively associated with Halodule wrightii. Turbidity, total organic carbon, and salinity seemed to have a greater effect on macrophyte communities in the months preceding spring, while total phosphorus and dissolved oxygen seemed to have a greater effect in the months preceding fall. pH exhibited the most significant interactions with macrophytes for both seasons, and it was positively correlated with seagrass abundance but negatively correlated with several algal groups. The interaction between pH and seagrasses indicated that they may be acting as ecosystem engineers in Florida Bay by affecting water quality through their photosynthetic activity. Revealing these types of interactions should help inform water quality policy for this region.

Abstract no. 77

A dangerous mix: Strain, dosage, and temperature increase virulence of seagrass wasting disease

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Seagrass wasting disease, caused by the opportunistic marine pathogen Labyrinthula zosterae, has the potential to devastate important seagrass habitats worldwide, yet little is known about the host-pathogen interaction or how the disease will be impacted by climate change. Understanding how these factors alter disease is an important first step towards mitigating negative impacts. In this study we investigate the effect of L. zosterae strain, pathogen dosage, and temperature on virulence, the degree of host damage caused by a pathogen. Field surveys show increased prevalence and severity of wasting disease during the summer, however, this does not explain variation between sites. We hypothesize a combination of differential L. zosterae strain virulence and response to temperature is driving this variation. We tested L. zosterae virulence in Zostera marina by inoculating plant tissue with strains collected from a range of eelgrass populations in the inland water of the northeast Pacific. The 11 strains tested displayed qualitatively different virulence, with infection rates ranging from 0 to 100%. Pathogen virulence increased proportional to dosage. Growth rates at a range of temperatures were tested for a subset of these strains. Results suggest the temperature increases growth rates, but the degree differs between

strains. We conducted a controlled temperature experiment in which Z. marina shoots were allowed to acclimate to low (11°C), high (18°C) and fluctuating (between 11°C and 18°C) water temperatures and then half these individuals were exposed to a virulent L. zosterae strain. Disease occurred more rapidly and with higher severity at high temperatures. To further understand the host-pathogen interaction, we will examine the transcriptional response to infection in both the host and pathogen in this experiment. Our results show that pathogen virulence is impacted by strain, dosage, and environment; suggesting L. zosterae has the potential to cause exponentially increasing damage where these factors co-occur.

Abstract no. 78

Recurrence of Thalassia testudinum die-off in Florida Bay

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Widespread mortality of Thalassia testudinum was first documented in Florida Bay during the summer of 1987. This, thought to be, unprecedented event spanned 3 years, resulted in over 9,000 ha of seagrass mortality and nearly a decade of cascading ecological disturbances. Initial putative causes for seagrass die-off ranged from climatic anomalies and watershed changes to wasting disease and eutrophication. Subsequent experimental research suggested the main contributory factors for the die-off were a combination of high T. testudinum biomass, high water temperatures and prolonged hypersalinity, leading to oxygen imbalance in the plants, sulfide intrusion and plant death. The Fisheries Habitat Assessment Program (FHAP) has tracked the system's slow recovery, since 1995. Recent FHAP data indicated that even the most affected locations had returned to pre-die-off densities of T. testudinum, raising concerns that the system was again at risk. During the summer of 2015, following several months of high water temperatures and drought, researchers reported a recurrence of seagrass die-off in north-central Florida Bay. An interagency effort is currently underway to document the duration, extent, impacts and possible factors responsible for this current die-off. Initial observations indicate that there is high spatial coincidence between current seagrass mortality and the 1987-90 event, with approximately 8,777 ha of severe die-off in 2015. In addition, environmental data indicate that hypersalinity, stratification of the water column, bottom-water anoxia and sulfide toxicity may again be proximate factors in initiating this recent seagrass die-off. Observations from the 1987 and 2015 die-offs indicate that this combination of environmental conditions may exceed the resilience of Florida Bay seagrass beds when succession has reached a critical threshold of dense T. testudinum.

Abstract no. 79

Ecosystem Services Are Lost As Eelgrass Declines

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Seagrasses provide many ecosystem services, among them filtration, binding of sediments and nutrient uptake from the water column. Human population increases and associated development in the Great Bay watershed in New Hampshire, USA have raised inputs of both point and non-point source nitrogen over the past 30 years. Three decades of monitoring show a severe decline of eelgrass largely caused by increased anthropogenic nitrogen loading. Eelgrass throughout the estuary is now 21% of the maximum system biomass seen in 1996, with loss of overall eelgrass density and many of the subtidal beds. As eelgrass declined, its sediment retention capacity diminished and more sediments became resuspended, exacerbating light reduction to the plants and accelerating eelgrass loss. The eelgrass beds in Great Bay are now patchy with low shoot density, and mostly result from annual production of seeds. Excessive nuisance macroalgae thrives in the high-nutrient, low-light conditions which prevent the reestablishment of eelgrass. The persisting low-density eelgrass meadows survive on the broad intertidal flats of this shallow, dynamic estuary because they receive unimpeded light exposure at low tide. The loss of eelgrass bed integrity has severely reduced the plants' filtration capacity for both sediments and nutrients, exacerbating the decline of eelgrass and reducing estuarine health. The eelgrass flats no longer retain fine-grained sediments which are now easily resuspended by wind and tidal currents, making the entire estuary more turbid. Suspended sediments are causing continued losses of eelgrass, but it was the elevated nitrogen loading that initiated eelgrass decline and system-wide break down. At this point, lowered eelgrass biomass is removing less nitrogen from the water column, further promoting the growth macroalgae which is smothering the remaining eelgrass plants.

Abstract no. 81

Testing the genetic basis of seagrass resilience

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The response of seagrass systems to a severe disturbance provided an opportunity to quantify the degree of resilience in different meadows, and subsequently to test whether resilience had a genetic basis. After an extreme flood event in Moreton Bay, Queensland, Australia, we measured a suite of variables in twelve seagrass meadows selected to

maximise variation in exposure to the disturbance. We used a combination of physiological, morphological and environmental variables, and rates of key feedback processes, to estimate the capacity of each meadow to resist, and recover from, the disturbance (i.e., to show resilience). There are solid theoretical reasons for expecting that resilience has a genetic basis, and in particular that more resilient meadows have greater genotypic diversity. However, because the resilient meadows occur in areas historically exposed to disturbance, the alternative is also possible, that selection will have resulted in a narrower, less diverse subset of genotypes than in other meadows. Analysis of DNA microsatellites found no single, all-encompassing relationship between resilience and genotypic diversity. But marked variation in genotypic diversity among meadows was explained by a significantly lower diversity in meadows with characteristics known to confer resilience; e.g., high biomass and high chlorophyll concentrations. There clearly is phenotypic expression of genetic variation in these meadows. And there is a strong indication that historical selection for genotypes conferring protection against disturbance has reduced diversity in meadows contemporarily showing greater resilience.

Abstract No. 84

Seagrass sediments reveal millennial-scale dynamics and processes in coastal ecosystems

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Seagrass meadows are marine habitats with high ecological importance. In the case of the genus Posidonia, the study of sedimentary sequences underneath their meadows (mats) has enabled to unravel Mid- to Late-Holocene coastal environmental change, including the impact of both human-induced and natural processes on marine biogeochemical cycles, as well as the identification of baseline conditions. Compared with other coastal environmental archives, seagrass soils are reliable palaeo-archives for a number of reasons: 1) they provide a coherent chrono-stratigraphy due to the ability of seagrass meadows to retain sediments; 2) they have a relatively high temporal resolution (around 5 to 20 yr cm^{-1}) spanning up to 5000 years; 3) the anoxic environment favours the preservation of organic remains (i.e. biotic proxies) and allows the application of palaeo-environmental reconstruction techniques, and 4) their location in coastal areas enables the reconstruction of both marine and terrestrial environments and their interactions. To date, the study of Posidonia sediment archives has provided records of ecosystem dynamics and processes over the last millennia in the Mediterranean Sea and the Indian Ocean. These pioneer works

include the identification of baseline conditions and the time-course of ecological change (cycles, trends, resilience and thresholds) under environmental stress in seagrass-dominated ecosystems, and the reconstruction of centennial-scale fluxes of chemical elements in coastal environments, among others. The research so far demonstrates the power of seagrass sedimentary archives to reconstruct the trajectories of anthropogenic pressures on coastal ecosystems and the associated regime shifts; which can be used to improve the capacity of scientists and environmental managers to understand, predict and better manage ecological change in these ecosystems.

Abstract no. 85

Unusual resilience of a pristine Zostera noltii meadows in Banc d'Arguin, Mauritania: strong resistance but slow recovery

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Seagrass stability is crucial for coastal biodiversity as well as many ecosystem services (e.g. carbon sequestration, wave attenuation and sediment stability). Small and medium scale changes between seagrass and bare states can be easily overlooked in extensive seagrass meadows. In this study we explored the capacity of extended Mauritanian Zostera noltii meadows to resist disturbance and rejuvenate after die-offs events. First using long-term Landsat images, we documented enormous changes in Z. noltii meadows in Banc d'Arguin and a very slow recovery at a land-scale scale. To further gain insight into their resilience on the ground, we conducted a field experiment and a lab experiment to investigate the possibility for a subset of possible stressors to be involved in the catalysis of widespread mortality events under natural conditions, and the natural regenerative capacity of these seagrasses to combat the formation of gaps. We found that seagrass meadows on Banc d'Arguin have a remarkable capacity to resist harsh environmental stress, but have hard time to reassimilate gaps. Mauritanian Z. noltii is able to persist for at least 1 month in salinities as high as 70 psu, and is able to regrow into areas with porewater sulphide concentrations as high as 837µM L^{-1} in the near absence of facilitative benthic fauna. Yet and after 1.5 year the recovery is still less than 50% in all plots. We found that the greatest limiting agent in the rejuvenation of seagrass meadow gaps in this system is the frequency of inundation, despite the presence of highly toxic substrate. Our findings seem to contrast previous work on Zostera noltii in the tropic where the species is known for quick recovery after small and medium disturbances. Surprisingly also the recovery rates were higher in plot with high sulphide concentrations than low concentration ones.

Abstract no. 86

Modelling the feedback between seagrass, sediment and light: The overlooked role of water residence time

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Several reinforcing feedbacks may hinder restoration of seagrass. However, the strength of these feedbacks varies strongly with local characteristics of both the seagrass and external environmental factors.

In this talk, a deterministic mathematical model demonstrates how the local hydrodynamics affects the occurrence of alternative states induced by a positive feedback between seagrass presence and sediment resuspension. The model is solved under steady state conditions, and its parameters are obtained from reported literature values. Because hydrodynamic conditions vary widely in the estuarine and coastal areas that seagrass can colonise, we modelled the two extremes of hydrodynamic environments: (1) seagrass meadows subject to unidirectional flow with negligible wave action present, which represents the minimum residence time of water in the meadow, and (2) seagrass meadows present in a wave-dominated environment with low net horizontal spatial water movement, which represents the maximum water residence time in the meadow.

We show that water residence time is a critical factor to determine whether the positive feedback between seagrass presence and sediment resuspension has the potential to induce alternative states of seagrass presence and absence. For environmental management, our results demonstrate that high water residence time in an area where seagrass can grow is a prerequisite for the feedback between seagrass and water clarity to significantly impact on whether seagrass is present or absent.

Abstract no. 88

To the limit - Recovery of intertidal seagrass beds reaches its optimum in the northern Wadden Sea (coastal North Sea)

Tobias Dolch, Christian Buschbaum, Karsten Reise

On a worldwide scale, most seagrass beds undergo a decline. This was also observed in the Wadden Sea, especially in the 1970s – 1990s. However, a long-term aerial survey revealed that seagrass beds in the northern Wadden Sea have recovered for the last 20 years. This is primarily ascribed to a reduction of nutrient discharges from large rivers commencing in the

1980s. Today, seagrass beds cover more than 15 % of the tidal flat area, which is even more than their extent 80 years ago. The recovery happened primarily from 1995 to 2010 when seagrasses have increased almost steadily 4-fold in bed area. However, for the last 5 years we are observing that the bed area seems to have reached a steady state. The results of a seagrass habitat model revealed that suitable habitats are by now almost completely occupied. This leads to the conclusion that this abatement of increase is not due to detrimental water quality but that seagrass has reached its optimum extent as it has tapped its ecological potential in the northern Wadden Sea. However, it has to be kept in mind that this study refers to the present ecological potential after centuries of embankment. It can further be assumed that this is not a steady state as with rising sea level and associated increasing hydrodynamics, which are detrimental for seagrass, a reduction of suitable habitats can be expected. Besides, the recent strong recovery only applies to beds the northern Wadden Sea whereas seagrass in the central Wadden Sea shows only slight signs of recovery due to their close proximity to large estuaries.

Abstract no. 89

Enhalus acoroides (L.F.) Royle Seagrass Rhizomes: A Potential Proxy for Coastal Sedimentation Patterns in Relation to Climate Change

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Given the growing frequency of extreme weather events, and increasing rain intensities associated with typhoons, it is relevant to address sedimentation of muddy coastal habitats through time and the consequent responses of coastal ecosystems. As there are no long-term records of coastal sedimentation and a dearth of information on sedimentation in shallow coastal areas, this study aims to develop a proxy for sedimentation using the large, long-lived tropical Enhalus acoroides seagrass rhizomes for studying coastal sedimentation and erosion in relation to climate change patterns. This will be achieved through i) describing the sediment dynamics of a muddy coast through time, based on the rhizome geometry of E. acoroides; and 2) correlate derived sediment dynamics with long-term records of environmental parameters.

E. acoroides rhizome samples of at least 5-years of age were collected from Lucena, Quezon. Age-estimation techniques were applied to the seagrass rhizome internodal series and their annual growth cycles determined. The geometry of each rhizome sample was plotted to obtain a general pattern of the the rhizome contour in time. Rhizomes were examined for the presence of common signatures that may be indicative of historical perturbation i.e. storms. Remotely sensed long-term environmental data were downloaded from open sources and correlated with the time series on interannual rhizome internodal growth and

the general rhizome contour pattern. General rhizome orientation indicative of erosion was usually associated with El Niño; rhizome orientation associated with high sedimentation associated with La Niña periods; and horizontally oriented rhizomes indicative of relative sediment equilibrium during none event periods. Net sedimentation and erosion rates through time were likewise estimated from the rhizome geometry. The common E. acoroides can serve as good proxies for studying the past history of sediment dynamics in muddy coasts as they are affected by the varying precipitation patterns influenced by ENSO-related climate change.

Abstract no. 90

Seed predation by the shore crab Carcinus maenas: a positive feedback preventing eelgrass recovery?

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There is an increasing interest to restore the ecosystem services that eelgrass provides, which has been declining worldwide due to anthropogenic causes. Most attempts to restore eelgrass using seeds are challenged by very high seed losses and the reasons for these losses are not all clear. We assess the impact of predation on seed loss and eelgrass establishment, and explore methods to decrease seed loss during restoration in the Swedish northwest coast. In a laboratory study we identified three previously undescribed seed predators, the shore crab Carcinus maenas, the hermit crab Pagurus bernhardus and the sea urchin Strongylocentrotus droebachiensis, of which shore crabs consumed 2-3 times more seeds than the other two species. The importance of shore crabs as seed predators was supported in field cage experiments where one enclosed crab caused 73% loss of seeds over a 7-day period on average (~ 21 seeds 24 h^{-1}). Seedling establishment was significantly higher (18%) in cages that excluded predators over an 8-month period than in uncaged plots and cages that allowed predators but prevented seed-transport (0.5%), suggesting that seed predation constitute the major source of seed loss in the study area. Burying the seeds 2 cm below the sediment surface prevented seed predation in the laboratory and decreased predation in the field, constituting a way to decrease seed loss during restoration. Shore crabs may act as a key feedback mechanism that prevent the return of eelgrass both by direct consumption of eelgrass seeds and as a predator of algal mesograzers, allowing algal mats to overgrow eelgrass beds. This shore crab feedback mechanism could become self-generating by promoting the growth of its own nursery habitat (algal mats) and by decreasing the nursery habitat of its dominant predator (cod). This double feedback-loop is supported by a strong increase of shore crab abundance in the last decades and may partly explain the regime shift in vegetation observed along the Swedish west coast.

Abstract no. 91

The resilience of inshore seagrasses of the Great Barrier Reef: response to and recovery from extreme weather events

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Inshore seagrasses of Australia's Great Barrier Reef are recognised as nationally significant because they provide food for endangered and threatened species as well as important provisioning and regulating services. However, these seagrasses are characterised by high disturbance regimes where the influence of cyclones and large flood events are acutely experienced. In March 2006 and February 2011, severe Tropical Cyclones Larry and Yasi, respectively, crossed the tropical north Queensland coast. Inshore seagrass meadows monitored along the tropical north Queensland coast over a decade as part of the long-term Seagrass-Watch and Reef Rescue Marine Monitoring Programs provided an opportunity to study the state of seagrass prior to and rate of recovery following these recurrence events. Seagrass abundance, community structure, landscape and reproductive status was assessed before and after the disturbance events. The findings indicated that the level of resistance and rate of recovery were highly influenced by habitat, the state of the meadow prior, the level of physical disturbance, and the availability of seed reserves. Meadows of greater abundance and composition of opportunistic and/or persistent species demonstrated higher resistance during the disturbance and those with greater seed banks demonstrated higher recoverability. Meadows where both resistance and recoverability were high, experienced a short (1-2 yr) state change and were more resilient to intermediate disturbance recurrence. Meadows with low resistance (low abundance, patchy landscape, dominated by colonising species) and low recovery capacity (absence of a seed reserve and reliance on vegetative reproduction before meadow loss) experienced a protracted state change, which following disturbance recurrence resulted in a recalcitrant trajectory (conditions no longer suitable for seagrass growth). We will discuss the adaptability of different seagrass habitats to different disturbance regimes, and discuss the current status of seagrass across the GBR to provide insight into the resilience of inshore seagrasses regarding future climate change predictions.

Abstract no. 94

The effect of genetic diversity on ecosystem functioning in vegetated coastal ecosystems

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In species-poor communities, genetic diversity potentially plays an important role for ecosystem functioning, though this is still largely unexplored in marine and estuarine ecosystems. We studied how genetic diversity (sensu genotypic diversity and/or allelic richness) affects ecosystem functioning in marine habitat-forming plant communities. Firstly, we conducted a 15-month field experiment in the highly seasonal Baltic Sea and established mono- and polycultures of different genotypes and genotype combinations of Zostera marina. Secondly, we reviewed existing literature and performed a meta-analysis of 16 studies including this study. We found no evidence of positive genetic diversity effects on shoot production in the field experiment, but diversity did enhance community stability over time. The literature review revealed that a majority of the included studies observed positive effects of genetic diversity on ecosystem functions such as primary production and nutrient uptake. The results from the meta-analysis support the hypothesis that genetic diversity effects on productivity are stronger during or after periods of stress. These diversity effects were also more positive in the field compared to mesocosm studies. Our results indicate that genetic diversity has positive effects on ecosystem functioning, particularly during increased environmental stress. Thus, local genetic diversity should be preserved especially in species-poor ecosystems, where it potentially provides insurance against environmental change.

Abstract no. 95

Investigating meadows' injuries. When anchoring scars in seagrasses favor the development of chemical toxic compounds, what does it imply for conservation?

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The Neptune grass Posidonia oceanica forms extensive meadows from the surface to 40 m depth in the Mediterranean Sea, and constitutes a seascape matrix in which natural and anthropogenic patches are generated. Among patch types induced by human activities, those created by mechanical damages (e.g. trawling, anchoring) are known to quickly generate within seagrass meadows artificial unvegetated area. In P. oceanica beds it results in bare mat zones with decaying roots and rhizomes of the plant with a different biogeochemistry of the substrate. According to these aspects, several questionings naturally emerge. Does these new conditions are suitable for the plant recolonization of the artificial

patches? If yes, should chemical features be considered when assessing meadows state of conservation for coastal management purpose?
To answer these interrogations, we investigated the effect of these chemical changes in a place of intensive anchoring in Corsica (France) by combining boat counting, GIS analyses, meadow structure parameters and the study of chemical features of the substrate. Our results show a clear influence of the hydrogen sulphur (H2S, a toxic compound for the plant) that remains high (up to 46 µM) even after the warmest period within bare mat patches stemming from anchoring. Through our analysis, it also appears that structural parameters alone are not always suitable to highlight the impact of large ships, our results revealing anchoring impacts at 15 and 20 m depth otherwise undetected. This statement should lead to the development of new tools aiming to assess the state conservation of seagrass meadows under mechanical pressures by taking into account the substrate's chemical quality. Eventually, it will bring a revaluation of the management of coastal area highly frequented by leisure ships.

Abstract no. 96

Eutrophication indirectly reduced carbon sequestration in tropical seagrass bed

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Seagrass beds, a global substantial "Blue Carbon" sinks, are experiencing worldwide decline mainly induced by eutrophication. There has been very little evaluation about the influence of eutrophication on sediment organic carbon (SOC) sequestration capacity in seagrass bed. We surveyed a tropical seagrass bed in South China Sea along fish farming-induced gradients of nutrient to assess the variability in the SOC and its composition in 30 cm sediment core. In summary, statistically lower sediment organic carbon (SOC) was observed in the sediment layer 6-21 cm close to fish farming, which indicated lesser input of organic carbon from smaller seagrass belowground tissue. Greater easily oxidisable organic carbon (EOC) was found in all layers of sediment core approaching fish farming. Microbial biomass carbon (MBC) showed higher concentration in the upper partial sediment core around root system far from fish farming, while MBC near fish farming kept stable along the depth. Nutrient enrichment markedly induced larger ratio of EOC/SOC and MBC/SOC in layer 3-18cm and 15-27 cm, respectively. The estimated organic carbon stock of the top 30 cm sediment in seagrass bed was 6.80 MgC/hectare. Therefore, eutrophication indirectly reduces the carbon sequestration capacity in seagrass bed by enhancing labile organic carbon, and the composition of SOC pools should be considered when studying the seagrass SOC sequestration capacity. And measures should be taken to reduce the release of nutrient into seagrass bed for enhancing carbon sink. Furthermore, more investigation on SOC pools

in seagrass bed along the China coast should be carried out, to get better understanding the ecological function of seagrass bed as "Blue Carbon" sinks.

Abstract no. 97

Do stable isotope ratios of seagrass reflect extreme weather events in an urbanised estuary?

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Seagrasses, together with their epiphytic algae counterparts, offer a range of services to the estuarine environment. However, the increasing pressure placed on estuaries due to urbanisation and population expansion has resulted in the decline of seagrass meadow coverage in many coastal estuaries. During extreme weather events, catchment derived nutrients can cause nutrient enrichment in estuaries, resulting in algal blooms, water quality reduction and loss of seagrass cover. Stable isotope analysis is an effective tool for identifying nutrient sources and energy flows in estuarine ecosystems, and can also be used to indicate trophic position in foodweb dynamics.
This study used stable isotope analysis to determine the spatial and temporal variability of nutrient sources in an urbanised estuary on the NSW coastline. Samples of Zostera capricornii and epiphytic algae were collected from 22 sites in Lake Macquarie between January and April 2015 following consistent rainfall that culminated in an extreme weather event, resulting in large amounts of stormwater and wastewater effluent being discharged into Lake Macquarie. Evidence obtained from these samples indicated a wide range of δ15N and δ13C values within the lake, suggesting multiple nutrient sources. Spatial modelling revealed untreated sewage δ15N values in epiphytic algae and seagrass and treated wastewater reuse entering the system. These results indicate that Lake Macquarie is a highly dynamic system and the effective management of wastewater and effluent inputs to the lake ecosystem is essential to maintain a productive and healthy ecosystem.

Abstract no. 101

Primary production and thermal optima of three tropical seagrasses

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Temperature is a strong driver of metabolic rates and so increasing temperatures will play a significant role in determining future responses of seagrass to climate change. In this study we aim to measure 1. seagrass productivity, 2. thermal optima, and 3. seasonal and latitudinal variation in thermal optima of three tropical to subtropical seagrass species (Cymodocea serrulata, Halodule uninervis and Zostera muelleri). We measured photosynthesis and respiration rates of leaves and the root/rhizome complex using oxygen sensitive optodes in closed incubation chambers at temperatures ranging from 15ºC to 43ºC. The temperature-dependence of photosynthesis and respiration was fitted to empirical models to obtain maximum metabolic rates, thermal optima, and maximum temperature (when the metabolic rate drops to 0). The two species that are more widely distributed throughout the tropical Indo-Pacific, C. serrulata and H. uninervis, both had thermal optima (T_{opt}) for net photosynthesis of 33.7 – 35.5ºC with little variation between summer and winter and between sites that are more than 1500km apart. Z. muelleri, which is more commonly distributed throughout sub-tropical and temperate regions had a much lower thermal optima of 30.4ºC. When plant-scale net productivity was calculated from leaf productivity and rhizome respiration rates, net productivity was reduced by up to 65% (compared to net productivity of leaves only) and the thermal optima for maximum productivity was reduced by 0 – 1.5°C, except in Z. muelleri in which it was reduced by >10°C. The ratio of below-ground to above-ground biomass determined the change in predicted plant-scale net productivity and thermal optima. Net productivity calculated for samples with low below-ground biomass yielded a calculated maximum net productivity of 1.9 – 3.8 mg C g DW^{-1} h^{-1} (depending on species and sampling time) and net productivity estimates for the highest below- to above biomass ratio was reduced to 1.1 – 2.3 mg C g DW^{-1} h^{-1}. The findings from this study will be discussed in the context of complimentary studies on measuring and predicting seagrass productivity in changing environmental conditions.

Abstract no. 103

Responses of Zostera. japonica to Trace Metals in the Yellow River Estuary: Mechanism and Simulation

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Seagrass habitats are facing a serious threat and a global degradation now, and large-scale decline of Z. japonica has been reported worldwide, especially in Asia. As the first barrier against the sea, seagrass ecosystems are susceptible to contamination from various anthropogenic activities. Aquatic ecosystems are more sensitive to trace metal pollutants

than terrestrial ecosystems, and both natural and anthropogenic sources of metals can contaminate seagrass meadows. Up to now, knowledge on mechanism and simulation of trace metal affecting Z. japonica is by far limited. Thus, our study aimed at: (i) identifying the most high risk trace metals in the Yellow river estuary and to test Z. japonica metal uptake ability; (ii) how anti-oxidative feedback from biological mechanisms affects the transcriptome analysis and detailed changes in co-expressed genes and antioxidative defense system biomarkers under metal stress; (iii) modeling Z. japonica growth under effects of trace metals in Yellow river estuary by a dynamic model for predicting influences of trace metals on the growth of Z. japonica photosynthesis, respiration, and sloughing dynamics etc. In conclusion, Z. japonica showed high metal accumulation potential, and there are no differences in the effects of low concentration exposures to the three trace metals tested, but at higher concentrations of Cu Z. japonica can combat toxic effects by the involvement of both primary (through chelation) and secondary (through antioxidant) pathways. A total of 900 differentially expressed genes (DEGs) were identified, of which 19 co-expressed genes directly related to metals stress. Futhermore, the developed model is a viable method to determine the relationship between Z. japonica growth and distributions of trace metals under effects of human activities in Yellow River estuary.

Abstract no. 104

Epiphytic calcium carbonate production and sediment characteristics from a sub-tropical seagrass carbonate factory; Moreton Bay, Australia

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Seagrass beds are recognised as playing an important role in global carbonate ($CaCO_3$) sediment production and carbon sequestration, by facilitating the settling and stabilisation of fine sediments. In addition, leaf blades provide a substrate for epiphytic calcifying organisms; primarily crustose coralline red algae, small benthic foraminifera, encrusting bryozoans, and serpulid worms, which contribute skeletal carbonate to the sediment substrate after death. The role of seagrass meadows as 'carbonate factories' is well established in tropical reef-related lagoons and cool-temperate settings, where epiphytic carbonate production results in the development of carbonate mud-rich facies. However, there is limited understanding of the dynamics and extent of seagrass meadows as carbonate factories in sub-tropical siliciclastic (quartz sand dominated) environments.

We determined an annual rate of epiphytic calcium carbonate production and seagrass associated sediment characteristics (grain size, mineral composition) at five sites across Moreton Bay, Queensland Australia, a sub-tropical seagrass environment. The rate of carbonate production from calcareous epiphytes was 130.5 ±7.4 g $CaCO_3$ m^{-2} $year^{-1}$, comparable to that recorded from tropical (180 g $CaCO_3$ m^{-2} $year^{-1}$) and temperate (210 g $CaCO_3$ m^{-2} $year^{-1}$) settings. The total amount of calcium carbonate produced from Moreton Bay's ~18,000 hectares of seagrass meadows is ~23,358 tonnes $CaCO_3$ $year^{-1}$, sequestering

10,278 tonnes carbon year^{-1}. Thus demonstrating that epiphytic inorganic carbonate is an important vector for carbon sequestration in seagrass systems. We found no relationship between the amount of attached epiphytic carbonate and the amount of carbonate (calcite and aragonite) in the sediment substrate. This suggests that contrary to their tropical carbonate counterparts, epiphytic sediment in siliciclastic dominated systems are exported out of the system due to re-suspension and erosion, transportation via detrital wrack, or removed via dissolution.

Abstract no. 105

Tropical/Subtropical Seagrasses' Resilience vs. Pollutant Effects including point source, sheet flow and oceanic source: Field coupled with lab tests on: River turbidity, thermal, oil/dispersants, metals pollutants.

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Seagrass field plus laboratory studies of pollutants' effects on Atlantic tropical/subtropical seagrasses, have been carried out over time generally in absence of information to assist in creating accurate policies/regulations. These data and recommendations have been incorporated into the policies in minimally 38 + nations for seagrass resilience. **Sheet flow pollutants**, exemplified by Puerto Rican river flow through agricultural, forested, and urban extents is defined. Creating models of six rivers' resultant "normal" plumes and "extreme " storm plumes each, we measured seagrass health, biomass, sediment, and macro-algae at river mouth, within "normal" plumes, within "extreme wind & precipitation events" plume and controls beyond plumes' impacts, mapping remotely. Significant differences among "normal plumes" vs. "control areas" occurred. The 6 riverine outputs effected seagrass areas was 23 km^2, (number of Puerto Rican rivers is 178. Intense animal interaction occurred among foundation habitats leading us to establishing a series of preserved "resilience corridors". **Point-source pollutants**: upper seagrass temperature tolerances were defined by 7year-field studies at 32 stations plus seagrass upper tolerance comparisons of four thermal effluents from energy plants defining seagrass tolerances. This was coupled with laboratory studies from central Caribbean to Gulf of Mexico, and formulated per species as precise upper long-term limits (3-4 d). Reviews, then policies, were created with resource managers, and disseminated within GESAMP and CEP-UNEP, FAO, DOE and nations. **Oceanic pollutant source**s: oil toxicities plus dispersed-oil using dozens of dispersant types were studied on 3 types of petroleum on seagrass , resulting in finding "low toxicity dispersants" which would aid shoreline clean-up and wildlife rescue as well as minimizing mangrove kills, while minimizing seagrass effects. **Sediment residuals**: Our studies of heavy metals uptake within seagrass with precautions for accumulation will also be discussed. Included are the recommendations for resource managers and stakeholders during each pollutant type for sustaining seagrass.

Abstract no. 106

Capacity of an intertidal seagrass species to tolerate changing environmental conditions: significance of light and tidal exposure

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Seagrass meadows are high-value ecosystems, which perform a number of important ecological roles in coastal areas. However, with multiple stressors threatening these aquatic plants, their current decline rate is likely to increase. As such, understanding their ability to acclimate to a range of environments may be key to their survival. With light availability being one critical factor for health, the objective of this study was to assess the ability of the intertidal species, Zostera muelleri, to compensate for variations in light in its natural environment. The impacts of light during inundation (high tide) and exposure (low tide) were examined along a vertical gradient from the high to low intertidal at two sites with differing light histories. Photoacclimation was evaluated through morphological and physiological characteristics over two tidal cycles. Results were consistent with seagrasses having optimized their photosynthetic capacity, with physiological acclimations being site specific. Longer-term morphological changes were also noted, suggesting a dissimilar light history between sites for an extensive period. Interestingly, at the site with the greatest light range, but the lowest light penetration at depth, a significant reduction in photosynthetic activity during exposure was observed. This suggests that Z. muelleri is capable of tolerating light stress through photoacclimation, allowing for the more efficient harvesting of light at low levels. Overall, this study demonstrates that Z. muelleri has the ability to adjust both physiologically and morphologically to changing environmental conditions, a key aspect to survival and persistence in temperate intertidal areas.

Abstract no. 107

Revisiting pristine seagrass meadows: How dense aggregations of green turtles modify ecosystem functioning and resilience

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Pristine seagrass meadow are often viewed as systems dominated by long-lived seagrass species that are highly structured, and deliver a suite of critical ecosystem services to humans. In contrast to pristine terrestrial ecosystems, views of pristine seagrass ecosystems often lack megaherbivores and top predators. Possibly as this view of pristine seagrass systems was established after its mega herbivores became ecologically extinct. This view might not match pristine seagrass landscapes in the state before human overharvesting. In this presentation we revisit the concept of 'pristine seagrass ecosystems', presenting 4 examples of areas around the world where green turtles (perhaps the most important mega-herbivores of seagrass meadows in the past), have seen significant population increases thanks to conservation initiatives and the decline of their dominant predators. We describe how high densities of green turtles may influence seagrass ecosystem composition, structure and function. We illustrate their dramatic impact on seagrass landscapes and their extraordinary plasticity to seagrass change by combining our empirical data from the Indo-Pacific; Lakshadweep Archipelago, Mayotte Island and Derawan Archipelago, and the Caribbean; Akumal and Puerto Morelos. We show that, green turtles can be critical ecosystem engineers that, under increasing densities, adapt their forage selectivity, feeding behaviour and movement, which can lead to a complex mosaic of meadow composition and function as the ecosystem copes with increasing green turtle herbivory. In extreme cases, this can even lead to meadow extinction with turtles migrating to other feeding grounds. The decline of seagrass meadow function due to excessive turtle-grazing can have unintended flow-on consequences for local coastal communities that depend on the goods and services that well-developed meadows provide, generating significant conflict. We emphasize the need for policy and management approaches that consider the interactions of protected species with their seagrass habitat.

Abstract no. 108

Consequences of shifting plant-herbivore interactions on seagrass ecosystem functions in a warmer world

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The indirect effects of climate change, such as changes to species interactions, are emerging as a significant threat to ecological communities. Ocean warming is causing tropical herbivorous fish to shift their distributions polewards, and this is leading to overgrazing of algal forests in some regions, causing dramatic community phase shifts. While the consequences of this 'tropicalisation' on temperate seagrass meadows are currently unknown, an increase in grazing due to range-shifting herbivores has the potential to reduce standing crops of seagrasses and impact on the important ecosystem functions they

provide. To test the effects of increased herbivory on the temperate seagrass Posidonia australis, we set up a simulated herbivory experiment along its entire latitudinal range on the east coast of Australia (~11° latitude). Control plots were left un-manipulated and treatment plots were subjected to two levels of cropping (10% or 80% of the leaves cropped), with the aim of simulating extensive grazing events such as those resulting from a rabbitfish juvenile recruitment pulse. We then measured the impacts of increased herbivory on primary production, circulation of organic matter within the meadow, seagrass chemical traits and its role as habitat for fish. Using a latitudinal gradient provides us with a 'space-for-time' substitution for the potential impacts of tropicalisation on seagrass ecosystem functions. This data will address how climate-driven changes to trophic interactions may alter the production and functioning of temperate seagrass ecosystems, which is particularly important considering the accelerating loss of seagrass meadows worldwide.

Abstract no. 109

Inherit resilience in seagrass: Quantifying genetic and kin structure variation between Zostera marina life history strategies

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To understand the impacts of life history strategy on population level variations in Zostera marina resilience to disturbance, the genetic and kin structures of two meadows expressing different life history strategies were measured. In an ecological context, genetic structure refers to the patterning of species genetic diversity across multiple local populations within a single metapopulation. This structure can have significant effects on interactions between conspecific individuals as well as population level resilience to disturbance. Throughout their distribution in the northern hemisphere, Z. marina populations express life history strategies which range from perennial to annual forms. Despite their clonal nature, perennial populations of Z. marina show significant genetic structure within populations and across multiple spatial scales. Increased sexual reproduction in mixed-annual and annual populations compared to perennial meadows may result in greater variation in genetic and kin structures, potentially providing a greater resilience to disturbance. However, the genetic and kin structures of populations which express the less commonly observed annual life history strategies are unknown. Spatially explicit measurements of genetic and kin structures in one perennial and one mixed-annual meadow were collected near the southern limit of the species distribution along the western Atlantic Ocean. To link genetic results to resilience capacity, the spatial structure of recovery mechanisms from both small (m) and large scale (10 – 100s m) disturbances were also quantified via shoot and rhizome growth rates and seed bank viability, respectively. Understanding the effects of life history on both the genetic and kin structures within Z. marina populations and their impacts on meadow resilience to disturbances is crucial to increase the effectiveness of seagrass conservation.

Abstract no. 110

Dredging-induced silt/clay-cover on seagrass leaves impedes the plants' performance and resistance towards H_2S intrusion

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Coastal development, such as dredging operations, can have pronounced negative effects on the fitness of neighbouring seagrass meadows, owing to reduced light conditions in the water-column as a result of sediment re-suspension and plant burial (e.g. Erftemeijer & Lewis, 2006; York et al. 2015). Sediment re-suspension may also lead to thin leaf silt/clay-covers, especially if the leaves are covered by filamentous epiphytes, further reducing the plants' performance through impeded gas exchange with the surrounding water-column. Under controlled conditions in the laboratory, we used O_2 microelectrodes to determine O_2 fluxes (i.e. rates of apparent net photosynthesis and respiration) and the thickness of the diffusive boundary layer (DBL) around leaves of Zostera muelleri with or without µm-thick leaf silt/clay-covers. We combined such detailed measurements with in situ measurements of the internal, meristematic O_2 and H_2S concentrations of Z. muelleri experimentally exposed to pulses of silt/clay re-suspension over diurnal cycles. Net photosynthesis rates were up to 5-fold higher in control leaves as compared to leaves with silt/clay-cover. An ~2.5-fold thicker DBL around leaves with silt/clay-cover markedly impeded O_2 flux into the leaves during darkness and thus adversely affected internal aeration. Internal meristematic O_2 concentration (i.e. the O_2 concentration at the basal leaf meristem) of Z. muelleri experimentally exposed to silt/clay re-suspension in situ were lower than in the control plants, with relatively long time periods of complete meristematic anoxia during night-time. Such internal anoxic conditions of Z. muelleri when exposed to silt/clay re-suspension in situ resulted in H_2S intrusion into the meristematic tissue even at relatively high over-night water-column O_2 concentrations. Silt/clay-cover on leaves of Z. muelleri thus negatively affects plant performance, leading to reduced internal aeration, thereby rendering seagrasses more prone to over-night phytotoxic H_2S intrusion.

Abstract no. 111

High pH water in eelgrass bed of Akkeshi-ko estuary, northern Japan: mitigation of ocean acidification by seagrass?

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Impact of ocean acidification is more intense at colder current regions due to higher capacity of seawater to dissolve CO_2. In addition, pH of coastal water in nearshore estuaries sometimes fluctuates drastically due to freshwater input from rivers. However, our knowledge on the impact of ocean acidification is not sufficient in such environments. Eelgrass bed in estuaries of temperate and cold-temperate regions is known to have high primary productivity, and can potentially buffer the progress of ocean acidification by absorbing CO_2 by photosynthesis. We investigated the mitigation capacity of ocean acidification by eelgrass bed by monitoring temporal changes in pH at Akkeshi-ko estuary, northeastern Japan. Continuous monitoring of pH over 24 hours conducted in the eelgrass bed between May and September showed that pH was very high (> 8.3) most of the time and sometimes reached more than 8.6. Most interestingly, it did not show typical daily fluctuation pattern; i.e., low pCO_2 (high pH) in daytime due to photosynthesis and high pCO_2 (low pH) in nighttime due to respiration. Instead, pH remained high even in the nighttime. The finding suggests that the estuary water is mostly in CO_2 deficiency due to strong photosynthetic activities of eelgrass bed in summer months. The finding may indicate high buffering ability of seagrass beds against ongoing acidification. The low pCO_2 and high pH caused by the eelgrass bed may benefit calcifiers in the estuary such as the Pacific oyster and the little neck clam which are commercially important species.

Abstract no. 113

Recovery of Cymodocea nodosa from small-scale disturbances in a Mediterranean coastal bay

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The capacity of species to efficiently recover after disturbances is a key component of ecosystem resilience and may depend on several aspects including species features and disturbance characteristics. Seagrass meadows are key, yet threatened, habitats that are affected by both large and small-scale disturbances.
In the present study we evaluated the capacity of Cymodocea nodosa to recover from small-scale physical disturbances in a Mediterranean shallow coastal bay. Several experiments were done to assess recovery depending on: i) the intensity of the disturbance, by removing 50% of shoots, 100% of shoots and all above and belowground biomass (low, high and very high treatments respectively); ii) the area disturbed, by removing all biomass from 0.4, 0.25 and 1 m^{-2} and iii) the timing of the disturbance, by removing all biomass at the beginning of the growing season (June) and during the dormancy period (October).
Recovery from low and high intensity disturbances was relatively fast as shoot density took 3 weeks to recover. No differences were found between low and high treatments. Also, no differences between these treatments were found in the number of apical shoots and in the length of new rhizomes, indicating that recovery was mainly by regrowth of existing shoots. Recovery from very high disturbances appeared to be much slower, as shoot density and

canopy height did not recover after 10 months. Apparently no differences in recovery patterns were found regarding the extent of the areas affected and the timing of the disturbance within 10 months.
We conclude that Cymodocea nodosa appears to be highly resilient to small-scale disturbances when they affect only aboveground tissues. However, when disturbances affect both above and belowground tissues, the recovery capacity is substantially lower. Overall, these findings may help managers to properly conserve seagrass meadows by considering the intensity of potential disturbances.

Abstract no. 114

Dispersion of seagrass propagules and connectivity among meadows in The Great Barrier Reef World Heritage Area, Queensland, Australia.

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Severe tropical storms and floods in north- eastern Australia between 2007 and 2012 damaged or destroyed seagrass meadows along hundreds of kilometres of coastline. The subsequent deaths of turtles and dugong have led to the very status of our iconic Great Barrier Reef World Heritage Area being questioned. We examined how meadow loss at this scale may re-establish from the dispersion of propagules floating in the water. We conducted a study based around Townsville and Abbot Point in North Queensland using a 2 dimensional numeric model developed for studying water movement. We released virtual propagules in the model between August and November 2011 with actual wind and current data. Model results suggest connectivity between offshore meadows and inshore meadows is likely to be low, limiting their ability to provide a reservoir of propagules. Time of year, location of release and the location of the propagule (surface or sub-surface) influenced movement. Over an 8 week model duration most propagules remained between 30 and 60 kilometres of their release point but distances up to 950 kilometres were possible. Most movement was to the north –west. A network analysis identified meadows that are a source of propagules; that act as stepping stones in the network and where meadows were not well connected to other meadows. We report on the value of this exercise for its management implications.

Abstract no. 116

Contrasting outcomes of moderate warming for seagrass- and macroalgal-herbivore interactions in the Mediterranean

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Most terrestrial and aquatic species respond to warming temperatures by adjusting their physiology, distribution, and/or phenology. While these direct effects of climate change on individual species are now well-documented, fewer studies have addressed the effect of warming on species interactions. However, research increasingly shows that changes in species interactions can be crucial in determining community responses to climate change, especially in systems with strong top down control. In the Mediterranean, the sea urchin Paracentrotus lividus is a key species capable of controlling macroalgal forests and the annual primary production of the seagrass Posidonia oceanica. Warming temperatures might influence the strength of this top-down control by (i) affecting the herbivores' consumption rates, which might be size-dependent; (ii) their movement patterns, which determine their landscape level effects; (iii) or the rates of plant primary production.

In this study we aimed at assessing how a warming Mediterranean might affect the plant-herbivore interactions between the sea urchin P. lividus, the seagrass P. oceanica and macroalgae (Cystoseira mediterranea). To this aim we tested in the laboratory if warming affected (i) sea urchin herbivory rates, (ii) the rates of primary production and (iii) sea urchin movement patterns.

Our results show that sea urchin herbivory rates did not change between 15ºC and 25ºC, but beyond this point, sea urchins stopped consuming the seagrass. In contrast, they increased their consumption of macroalgae until an abrupt cease at 29ºC. Moreover, there was an evident interaction between warming and sea urchin size. Sea urchins did not change their movement patterns as a results of warming. Conversely, P. oceanica primary production decreased at higher temperatures.

These results suggest contrasting effects of moderate levels of warming in Mediterranean coastal communities. While the strength of top down control on the seagrass P. oceanica will be reduced, we expect to find a tighter control of macroalgal communities by sea urchins. This suggests that seagrass communities in the Mediterranean might be more resilient to a warming sea than the community of macroalgae.

Abstract no. 117

Will climate change worsen eutrophication effects on seagrasses?

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Coastal ecosystems are among the most productive, yet highly threatened, systems in the world. They face an increasing number of multiple stressors whose combined effects could lead to multiple consequences. For instance, predicted temperature increases or heat waves occurrence could worsen eutrophication effects if they act synergistically. Seagrass meadows, which are suffering a worldwide decline, are expected to be highly vulnerable to the combined effects of both eutrophication and climate change. Although we have a general understanding of the effects of increasing temperatures and eutrophication on seagrass meadows, we know little about their interactive consequences. In the present study, we evaluated the synergism of both temperature and percentage of organic matter in the sediment on Cymodocea nodosa using a factorial mesocosms experiment where plants were exposed to three temperatures (20, 30 and 35ºC) and to two levels of organic matter content (0,7% and 15%). We measured the maximum quantum yield (Fv/Fm), leaf necrosis, shoot and rhizome growth rate, shoot demographic balance, redox potential and organic matter content in the sediment at the end of the experiment.
Our results showed that Cymodocea nodosa was highly thermal tolerant with an optimum for growth at 30ºC. The effects of both very high temperature (35ºC) and high organic matter content separately had negative effects on plant performance as shown by leaf necrosis increase, shoot and rhizome growth rates and shoot demographic balance decrease. Moreover, the combination of both factors resulted in an enhanced decrease of plant performance indicating a synergistic effect that was attributed to the effect of temperature on sediment bacterial activity and sulfide production, as shown by redox potential values. We can conclude that climate change can enhance the negative effects of eutrophication on seagrasses so effective manage of local stressors are crucial to prevent further deterioration of these important coastal ecosystems.

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stract no. 118

Mutualistic feedback supports high food web complexity in tropical intertidal seagrass meadows

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In many coastal ecosystems, species such as corals, salt-marsh plants, mangroves and seagrasses provide a keystone habitat for thousands of species by modifying their environment. As these foundation species often engage in mutualistic interactions, associated communities may not only depend on the foundation species, but indirectly also on the mutualistic partner. We studied how habitat modification by seagrass affects food web structure in a West African intertidal ecosystem, and how environmental disruption of a facultative mutualistic feedback between seagrass and sulfide-consuming lucinid bivalves may affect ecosystem stability. Results from a detailed field study reveal that seagrass, through habitat modification rather than its role as a food source, strongly increases food web complexity by enhancing species richness and the number of tropic interactions per species. Next, simulations of an empirically parameterized computer model demonstrate how the mutualistic seagrass-lucinid feedback stabilizes intrinsically unstable seagrass meadows in our study area by alleviating sulfide toxicity caused by organic matter build-up within the beds. However, a minor increase in seagrass mortality (as a proxy for environmental stress) triggers mutualism breakdown, resulting in sudden ecosystem collapse. These findings were supported by empirical results. Local climate and remote sensing analyses revealed rapid, patch-wise seagrass degradation following a summer with intense low-tide drought stress. Field measurements comparing degrading patches with patches that remained healthy demonstrated that bivalves declined dramatically in degrading patches with associated high sediment sulfide concentrations, indicating that breakdown of the seagrass-lucinid mutualism amplified the observed collapse. Our combined theoretical and empirical results illustrate the importance of the mutualistic seagrass-lucinid feedback for food web structure and overall ecosystem stability, but also show that relatively small environmental changes may trigger dramatic ecosystem shifts.

Abstract no. 120

Eelgrass (Zostera marina) recovery in Puget Sound, Washington, USA: restoration tools, successes and challenges

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In an effort to recover ecosystem health in Puget Sound, Washington, USA, the Washington State Department of Natural Resources is responsible for the implementation of a management plan to restore 20% more eelgrass (Zostera marina) by 2020. Based on an estimated 22,000 ha of eelgrass in region, the recovery target is equivalent to 4,400 ha; an area slightly larger than the size of the largest eelgrass meadow on the west coast of the contiguous US. Eelgrass restoration will provide a multitude of benefits, ranging from

habitat for species to ameliorating climate change. One aspect of the eelgrass recovery strategy is to identify and prioritize suitable sites for strategic transplants that will expedite recruitment and restore natural processes. We developed an eelgrass transplant suitability model for Puget Sound to identify potential restoration sites using key variables essential for seagrass production and long-term resilience to a changing environment. To verify model output, 30 sites were test transplanted with eelgrass and monitored for transplant success between 2012 and 2015. Eelgrass test transplant results varied, and to date five sites with the highest success were selected for large-scale transplanting. Long-term monitoring is scheduled with an emphasis on the success of specific donor stocks, the recovery of donor sites, and the effects seagrass restoration has on water chemistry. The restoration process endured challenges that ranged from permitting issues to anthropogenic and environmental stressors. However, issue specific solutions and adaptive management allowed the restoration process to progress towards achieving objectives within the region.

Abstract no. 121

Agent Based Modelling of the Faith of the Eelgrass Seed Bank in the Danish Estuary Odense Fjord.

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In a field campaign the eelgrass seed bank was studied to verify if lacking seeds could explain the missing recovery of eelgrass in the Danish estuary Odense Fjord. Here no seeds were found in the vicinity of the beds in the autumn.
Further experiments were conducted to determine seed behavior in the water column (settling rate of seeds and flowering shoots, critical current speed for seed movement, floating of flowering shoots and seed dropping over time).
An agent based model (ABM) was developed and used to predict seed movement in the estuaries. Eelgrass seeds were dispersed by seeds dropping from flowering shoots attached to the beds or detached rafting flowering shoots dropping seeds on the journey. The seed movement model was parameterized based on experimental studies of seed behavior in the water. The model simulates seed settling, seeds rolling on seabed and resuspending, dampening of movement due to obstructions, floating flowering shoots releasing seeds, wind drift etc. The seed dispersal model makes it possible to predict the fate of seed banks in estuaries. The first simulation results indicate that a substantial part of the newly produced seeds are lost as wash up where the germination is lost due to desiccation. Another great loss is dispersal of seeds to deeper areas not supported by sufficient light. The maps with potential seedbanks coupled with maps with potential areas suitable for eelgrass transplantations can greatly increase the success of bed recovery.

Abstract no. 123

Challenges for eelgrass restoration in Scandinavian waters

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Along the Swedish west coast, almost 60% of the eelgrass meadows have been lost since the 1980's as a result of nutrient pollution and overfishing. Despite improved environmental conditions in the last decades, no recovery has occurred, and interest to restore lost eelgrass habitats are growing. However, methods are lacking for restoration of eelgrass beds at high latitude environments where the short growing season, ice formation and glacial sediments create special challenges for restoration. Here we summarize 4 years of studies evaluating different methods for eelgrass restoration in Scandinavian waters using seeds and adult shoots. Monitoring of potential restoration sites revealed decreased water quality in areas that have lost large eelgrass beds, likely as a result of increased sediment resuspension. This local increase in turbidity together with physical disturbance and shading from drifting algal mats appear to prevent natural recovery and make eelgrass restoration very difficult in many areas. Field studies showed very high growth rate of planted seedlings and shoots in areas with good light condition during the short summer, also in glacial sediments with high organic content (>10%), but high mortality during winter for plants in environments with low light. Restoration using seeds are challenged by very high losses of seeds during winter dormancy, where seed-predation, transport by currents and bioturbation by lugworms caused >99% loss in shallow areas. Storing seeds over winter and planting them in the spring did not reduce losses. However, seed burial increased seedling establishment up to 5x, and may be necessary if seeds should be used for restoration in this region. The most promising and cost-effective method today for eelgrass restoration along the Swedish west coast, with the least impact on donor beds was hand-planting of single eelgrass shoots without anchoring using diving.

Abstract no. 124

Habitat restoration and carbon sequestration: a promise for top predator recovery in coastal systems?

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A growing body of ecological literature demonstrates that recovery of top predators can cause whole scale changes in ecosystems, beyond trophic effects. For seagrass systems, these include changes in ecosystem services with tractable economic and social values, including carbon storage, provision of faunal habitat and coastal protection from storms. On the west coast of North America, sea otter recovery in California has been shown to restore

seagrass habitats via a trophic cascade. In contrast, the magnitude of trophic effects associated with sea otter recovery on the Central Coast of British Columbia is weaker: a result of lower sea otter density, occupation of greater habitat complexity and a more diverse assemblage of prey species. These context dependencies offer a comparative framework to review the potential ecosystem incentives offered by top predator recovery, as well as the trade-offs in ecosystem services reflected by differing human values. In this review we: 1) illustrate factors contributing to differences in ecosystem-level outcomes based on a comparison of sea otter recovery in seagrass habitats in California and British Columbia, 2) review our findings in light of the broader ecological literature on top-down influences on ecosystem effects, 3) consider a spectrum of seagrass ecosystem services, include carbon storage, associated with top predator recovery and, 4) discuss the trade-offs in seagrass ecosystem services based on management goals and human values for habitat conservation, restoration, climate mitigation and top predator recovery. Using the sea otter-seagrass example, we illustrate the potential, and caveats, for top predator recovery to influence ecosystem services in coastal systems.

Abstract no. 125

Using a GIS-tool to predict potential eelgrass (Zostera marine L.) reestablishment areas in estuaries

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The lacking recovery of eelgrass (Zostera marina) has been observed in many coastal areas throughout the world. Through a strategic field project we managed to identify the stressors and their thresholds on the recovery process. Among these were 1) Physical stress from wave and current action 2) low sediment anchoring capacity facilitate uprooting of eelgrass seedlings; 3) benthic light intensity 4) ballistic stress from drifting macroalgae are damaging seedlings, 5) too frequent resuspension impoverishing the benthic light climate and dispersing seeds to deeper areas not sufficiently supported with light, 6) lugworms burial of seeds, and uprooting or burial of seedlings. Based on the field and associated lab studies and literature values we present a GIS-tool that from data on a suite of stressors are able to predict potential areas for recovery of eelgrass by transplantation actions and seed broadcast. Input data may be monitoring data, scientific project data or model simulation results. Here we have used model results to calibrate the model against while the validation is performed on both field data and model data. The input data were reclassified into 5 ranges, according to how much it impacted the eelgrass recovery process: 1) Optimal recovery, 2) Good recovery, 3) Threshold for recovery, 4) Poor recovery and 5) Very poor recovery. Afterward a weighed overlay function was performed, ending up with an accumulated value for stress impact on the eelgrass recovery process in all location in the

Danish estuary, Odense Fjord. The GIS-tool was able to classify individual and multi-stress situations at specific locations. It also managed to predict potential recovery area at the present loading and after a 30% reduction of the external nitrogen loading of the system.

Abstract no. 126

Development and test of eelgrass restoration methods in a Danish fjord

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Seagrasses are functionally essential species with high ecosystem importance. Worldwide seagrasses are declining due to anthropogenic impacts such as eutrophication, trawling fisheries and offshore constructions. Numerous seagrass restoration programmes have been initiated but these have rarely been successful. Various factors influence the success rate of restorations attempts. One of them is the choice of restoration method which was investigated in this study. To identify the best suited eelgrass restoration approach in Odense Fjord six transplanting methods and six seed-planting methods were tested. The selected transplantation method were based on planting frames with eelgrass shoots attached and undisturbed eelgrass cores. Both the transplantation and seed-planting approach had infauna-excluding membranes, physically protective enclosures and a combination of both. The seed planting also involved sand-capping on muddy sediments. The restoration methods was tested on three sites in the fjord. The sites had generally low to moderate physical exposure. Seed-based restoration sites and transplantation sites was established in the fall 2014 and in early summer 2015, respectively. All seed-based restoration attempts was lost over the winter to physical exposure and sand mobility. Two transplantation sites was lost after 5 months while the remaining site showed high growth rates in treatments with protective enclosures. In the end of the growth season shoots with physically protective enclosures had 6 times higher shoot numbers compared to unprotected shoots. Infauna-excluding membranes did not have any clear positive effects on the transplants. Planting frames proved more successful than undisturbed eelgrass cores. The results indicate the importance of physical protection in unvegetated sandy on shallow waters where the current and wave energy not is dampened by wave buffering vegetation or other buffering structures.

Abstract no. 129

Seagrass seedlings in an acidified world: from photophysiology to herbivory

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While increased oceanic CO_2 concentrations threatens most of marine life, photosynthetic organisms, such as seagrasses, are predicted to perform better under the future acidified environment. However, understanding the effects of elevated pCO_2 in newly produced plants is essential for evaluating the consequences of ocean acidification on seagrass populations. Seedling recruitment guarantees the potential for adaptation to a changing environment and herbivore pressure exerted on seedlings can have critical effects on plant populations. In this study we determined the effects of a three-month experimental exposure to current and future predicted CO_2 concentrations on the physiology, morphology and defense strategies against herbivory in the earliest life stage of the seagrass Posidonia oceanica. Photosynthetic parameters (electron transport rate and compensation irradiance) changed after 60 days of exposure yet these differences disappeared at the end of the experiment. The photosynthetic resources were allocated to storage of sucrose in roots and seeds, which increased their carbon content under high CO_2, with seeds also exhibiting higher biomass than in control conditions. Some resistance traits related to herbivory of leaves (total phenolic compounds, thickness and fiber content) were not affected by higher CO_2 concentrations, however, N content decreased and sucrose was higher in this treatment. Feeding preference experiments with sea urchins indicated a clear preference for seedlings grown under high pCO_2 conditions. According to our results, while seagrass seedlings might show a higher photosynthetic performance under a future high CO_2 ocean scenario, and therefore would have more resources to tolerate some stressors, these positive effects of increased CO_2 availability may be counteracted by an increase on herbivore pressure.

Abstract no. 131

Seagrass ranching: Transplant grow out to recover seagrass clonal integration

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Tropical Australian seagrass meadows have long been identified as highly dynamic, with a dominance of transitory meadows of opportunistic and colonising seagrass species. More persistent meadows dominate locations where physical disturbance is minimal. Species with

more persistent life history traits rely primarily on vegetative clonal growth and are slower to recover from anthropogenic disturbance, resulting in a net decline. Novel approaches in relation to seagrass restoration techniques are needed for these regions. Transplanting cores by hand remains a popular method in seagrass restoration, particularly in areas where seed herbivory is high and where mechanical methods are impractical. As a clonal organism seagrasses are able to transport essential resources for survival between connected ramets, sustaining the growth of shoots in sub-optimal conditions. However, coring results in severance of rhizomes and physiological integration within seagrass clones, compromising natural resistance to poor conditions and resulting in poor transplant survival and extension. In addition, common practice with seagrass transplantation advises the immediate or quick transplant of donor cores to the new site. Here we examine how clonal integration manifests across different species local to the subtropical Port Curtis Bay (Queensland, Australia) and the influence of rhizome severance on three intertidal tropical species of seagrass Zostera muelleri, Halophila ovalis and Halodule uninervis. The potential of "growing out" cores prior to planting to improve survival in a subtropical bay with a high frequency of anthropogenic disturbance is assessed.

Abstract no. 132

Seagrass restoration in New Zealand: assessing feasibility and engaging local communities via transplant trials

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Richard Griffiths, Northland Regional Council
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Mary Diniss, Guardians of Pauatahanui Inlet

In New Zealand there is anecdotal evidence of seagrass loss in a number of estuaries with highly modified catchments but very few studies have documented these losses, examined probable cause/s and assessed restoration potential. Here we outline two such case-studies which have led to small-scale transplant trials involving local communities with promising results.

In Whangarei Harbour, almost all seagrass (1400 ha, Zostera muelleri) disappeared from c. 1970s. Losses were linked to point source discharges and dredging activities. However, changes to these practices has seen improvement in harbour conditions and recent regeneration of seagrass to c. 75% of historical extent. Regeneration coincided with an initial very successful transplant trial involving the local community which identified sods and sprigs, relocated as 0.25 m^2 plots, as highly effective transplant methods for this species. The donor site recovered within 9 months. A second trial has subsequently shown that even small groupings of small sods (5 x 0.1 m diameter in 0.25 m^2 plot) will work and this approach has successfully re-established seagrass at another site of former habitation where natural regeneration has not yet occurred.

Our second case-study in Te Awarua-o-Porirua Harbour documented a 40% loss of seagrass beds since the 1980s. Losses were linked to siltation and NO_3^- pollution but light climate data suggested present-day conditions sufficient for plant growth. To directly test growth potential two transplant trials have been established and monitored by an enthusiastic community group. The first (autumn) trial, setup hampered by storms, has had mixed results, with only a few plants remaining after 11 months. The donor site has recovered. A second (spring) trial, using fewer sods kept better intact in transit, has seen most plants persist in good condition after 4 months.

This presentation will provide latest results and summarise the lessons learnt from these case-studies.

Abstract no. 134

Chronic light reduction impairs recovery from seasonal and physical disturbances in the climax seagrass species, Thalassodendron ciliatum

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Disturbances play an important role in the maintenance of seagrass meadows. While recovery from induced and seasonal disturbance in climax and pioneer species have been compared, little is known about how plants that have been subjected to chronic stress react to induced and seasonal disturbances. This study describes the recovery of an understudied seagrass, Thalassodendron ciliatum, from shading and physical disturbances. Plots of T. ciliatum were subjected to a pre-conditioning treatment of 70% light reduction and subsequently a physical disturbance. Results show that speciemens subjected to light reduction and physical disturbance were the slowest to recover whereas those that were not subjected to light reduction recovered to pre-experiment densities within 3 months of being returned to ambient conditions. This study demonstrates how light reduction can have persistant effects on seagrass recovery even after a return to ambient light conditions.

Abstract no. 135

Do marine Phytophthoras threaten seagrass beds? Implications of newly discovered pathogens for eelgrass restoration.

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Willem Man in 't Veld, Johan P. Meffert, Patricia van Rijswick, National Plant Protection Organisation the Netherlands
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Phytophthoras are potent pathogens that can be devastating to terrestrial plants, causing billions of dollars of damage yearly to agricultural crops and harming fragile ecosystems worldwide. Surprisingly, nothing is known about the distribution and pathogenicity of their marine relatives, although many marine plant species are habitat-forming foundation species vital to ecosystem functioning in coastal zones. We are the first to report on widespread infection of Phytophthora and Halophytophthora species on a common seagrass species, Zostera marina (eelgrass), across the northern Atlantic and Mediterranean. In addition, we tested the effects of Halophytophthora sp. Zostera and Phytophthora gemini on Z. marina seed germination in a full-factorial laboratory experiment under various environmental conditions. Results suggest that (Halo)Phytophthora species are widespread, as we found these oomycetes in eelgrass beds in seven countries across the North Atlantic and Mediterranean. Infection by Halophytophthora sp. Zostera, P. gemini, or both, strongly affected sexual reproduction by reducing seed germination by 6 times. Our findings may have far-reaching consequences, because these pathogens likely negatively affect ecosystem functioning, as well as current restoration and conservation efforts of rapidly declining eelgrass beds across the northern hemisphere.

Abstract no. 137

Increased survival of Enhalus seedlings restored with adult plants: a new technique in seagrass restoration.

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The extent of seagrass area and their associated ecosystem functions and services have been declining due to many factors. Seagrass restoration is important to prevent such declines and their consequences. Seagrass restoration studies have been done over the past three decades with various techniques with varying degrees of success. A study on seagrass restoration method was conducted as a field experiment to see how planting density affect the survival of seagrass Enhalus acoroides seedlings in Badi Island, Makassar, Indonesia. The main purpose of the experiment study reported here was to show the benefit of combining two methods of seagrass restoration (vegetative and generative) in enhancing the survival of seagrass agents for restoration. Enhalus seeds were taken from donor bed in nearby island, Barrang Lompo, and germinated to become seedlings to be used in this experiment. Seedlings were planted in three different densities (high, medium, and low) with each treatment accompanied by adult transplants of E. acoroides that also represented two different densities. Fifty adult transplants were added to represent high

density, ten adult transplants to represent medium density and no addition of adult transplant to seedlings with low density. Results showed that seedlings with high density of adult transplant had a lower survival rate as probably due to the shading effect of the adult transplant to the seedlings that may decrease the amount of light reaching the seedlings. Results showed that seedlings with high density of adult transplant had the highest survival rate compared to medium density- and with no adult transplant. This might show the protection ability of adult plant to the seedlings both from predation and from environmental parameters, especially substrate movement and waves.

Abstract no. 141

Seed and seedling transport: Hydrodynamics and substratum effects on three European seagrasses

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Waves and currents influence not only the spatial distribution of seagrass meadows but also the transport, establishment and survivorship of seagrass propagules and hence the success of seagrass recruitment from sexual reproduction. However, the hydrodynamics of dispersal of seagrass propagules in interaction with different substrata remains to be elucidated. Using a hydraulic flume we quantified how unidirectional flow velocities affect seed and seedling transport of three seagrass species (Posidonia oceanica, Cymodocea nodosa and Zostera marina) over substrata of different complexity. We assessed the characteristics of the substratum (complexity of bottom surface, flow reduction and turbulent kinetic energy) and the propagule properties (morphology, density and sinking velocity) to elucidate the establishment potential of propagules and to identify safe-recruitment microhabitats. We used substrata of different complexities (sand, rock, and a customized P. oceanica matte of different shoot densities) and different early life seagrass stages (seeds and seedlings of 3, 8, and 25 weeks of age). Threshold velocities indicate that Z. marina (10 cm s-1) seeds start to move over a flat sandy bottom earlier than P. oceanica (18 cm s-1) and C. nodosa (19 cm s-1) seeds. Propagule trapping increased with bottom complexity, which was related to the flow reduction that each substratum generated. Trapping was larger in high density matte than in rocks or sand. Over sand, flow reduction was minimal and no early life stages were trapped. In contrast, over rocks and high density matte flow was reduced more than 50%. Furthermore, notable differences between early life stages were observed, being seeds the first trapped, followed by seedlings of increasing ages. As propagules develop, their increase in surface area and decrease in density likely contribute to the above mentioned trapping patterns. Together these results provide important insights into the drivers of seagrass recruitment, which could be applicable for restoration purposes.

Abstract no. 152

Applying transcriptomic approaches for detecting response to environmental changes in the Mediterranean seagrass Posidonia oceanica.

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Developing adequate strategies to manage, conserve and restore marine ecosystems biodiversity and services is becoming a key target of environmental policies. Molecular transcriptomic approaches can allow understanding the potential meadow resistance and resilience to environmental stressors, and to select a series of early warning indicators, through gene expression approaches. I will present a synthesis of studies looking at the response to changes in light and temperature in the Mediterranean endemic seagrass species Posidonia oceanica, maintained in controlled conditions. Both omics and target genes approaches have been combined with the study of plant phenotypic changes revealing that the plasticity of the responses at the molecular level is tightly linked with the degree of plasticity at the physiological one. Moreover, light and heat induced phenotypic changes have been related to changes in expression of target genes and/or to the involvement of specific metabolic pathways helping to identify the molecular basis of abiotic stress responses in the species. Overall results suggest that P. oceanica plants collected along the bathymetric range of the species, are able to activate molecular responses to adjust their metabolism to endure environmental changes. Nevertheless, the intensity of the response and acclimation capacity varies between shallow and deep plants and thus, according to the environmental conditions to which plants are adapted, which have important consequences in plant resilience and resistance as well as for the management and conservation of the meadows. The use of transcriptomic approaches have been useful in the identification of early warning signal that the system is in distress, long before conditions become irreversible and possibly un-restorable. Moreover it can help in designing restoration strategies, allowing a correct selection of genotypes for transplantation.

Abstract no. 153

The fate of seagrass export: a missing component of seagrass carbon sink capacity?

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Seagrasses export a large fraction of their primary production, both in particulate and dissolved organic form, but the fate of this export production remains unaccounted for. Here we review available evidence on the fate of seagrass carbon export to conclude that this represents a significant contribution to carbon sequestration, both in sediments outside seagrass meadows and in the deep sea. This implies that the contribution of seagrass meadows to carbon sequestration has been underestimated by only including carbon burial within seagrass sediments.

Abstract no. 154

Genetic structure and levels of genotypic diversity provide insights into the dispersal potential and relative importance of sexual and asexual propagules in two co-occurring seagrass species.

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Seagrasses display a range of life history strategies that have important ecological and evolutionary consequences. Most species have the capacity to produce both sexual and asexual propagules that have varying dispersal potentials. The relative importance of these different modes of reproduction and patterns of connectivity between meadows should be reflected in the genetic structure and levels of genotypic diversity within and between meadows. However, for most seagrass species, information on the genetic structure and fine-scale patterns of genetic variation in natural populations is lacking. In this study we use a hierarchical sampling design to determine levels of genetic and genotypic diversity for two co-occurring Australian seagrass species, Zostera muelleri and Z. nigricaulis. Both species show significant genetic structuring at surprisingly small spatial scales, while patterns of genotypic diversity vary widely between meadows for both species. Taken together, our results indicate that both sexual and asexual reproduction are important in maintaining meadows of Z. muelleri and Z. nigricaulis, however, local ecological and hydrodynamic factors play an important role in determining patterns of connectivity and recruitment of sexual and asexual propagules.

Abstract no. 155

Shedding light on seagrass - the effects of light limitation on Zostera marina

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Seagrasses provide a wealth of ecological and physical benefits to the global environment. The most significant threats to seagrass are believed to be those that decrease water quality causing light limitation. In temperate regions, Zostera marina is one of the most widespread seagrass species found growing in sheltered bays and estuaries, often in conflict with coastal developments and where degradation of coastal water quality continues. At present, minimum light requirements of seagrasses are often expressed as percentage surface irradiance (% SI) at the maximum depth limits. However, SI levels vary both spatially and temporally with some indication of photo-acclimation in seagrasses to local light regimes which are also influenced by turbidity. A range of robust bioindicators of light stress in seagrasses have previously been identified from a meta-analysis of experiments covering 11 genera and 18 species of seagrass. This study aims to estimate minimum light thresholds and to test the morphological, physiological and photo-physiological bioindicator responses specific to Z. marina when light stress is applied within controlled laboratory conditions. All plants placed under shade treatments of 20.12 µmol photons $m^{-2}s^{-1}$ and lower displayed significant reductions in maximum leaf length and leaf width after three weeks whereas growth rate and photosynthetic properties (alpha and ETRmax) were drastically affected within the first week. It can be therefore be suggested that minimum light requirement are higher than 20.12 µmol photons $m^{-2}s^{-1}$ and 12.9% SI, and possibly considerably higher. The outcomes of this study give good insight into the minimum light requirement threshold and responses of certain bioindicators and the timeframes involved specific to Z. marina. The results from this study provide useful information in the context of monitoring and restoration techniques for eelgrass meadows and their light environment for the future.

Abstract no. 156

Don't throw the baby out with the bathwater: Conservation concerns of seagrass fisheries

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Small-scale fisheries account for over 50% of wild-caught seafood globally, utilize over 99% of the worlds fishers, and are frequently promoted as a more sustainable option over large-scale fisheries. Yet there exists limited quantitative understanding of the potential negative impact of such fisheries, specifically seagrass fisheries on non-target non-charismatic bycatch. Such information is of wide importance to fisheries and conservation management. Here, we provide a unique assessment of the bycatch of different fishing gears types (fyke, trawl, set trammel & drift trammel nets) used in a seagrass fishery and place this in the context of local resource use patterns. We reveal strong evidence of the potentially severe ecological impacts of small-scale seagrass fisheries. Fishers targeting shrimp (fyke, trawl and

drift trammel nets) had the highest overall impact on non-target species, with bycatch rates higher than the majority of industrial fisheries (44%, 44% and 67% by weight respectively). Fishers targeting finfish (set trammel nets) had the lowest bycatch rates. Our results indicate that levels of bycatch depend more on target and gear type than size of vessel, calling into question the broad assumption that small-scale fisheries are "inherently more sustainable" than large-scale industrial fisheries. Our findings raise questions about fisheries exploitation in the context of food supply and security in a country where poverty and severe acute malnutrition are prevalent. These findings highlight the need for increased research, management, and conservation efforts to focus on bycatch associated to small-scale fisheries

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Abstract no. 157

The global extent of seagrass fishery activity

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Seagrass meadows are commonly cited as supporting fisheries productivity through their role as nursery grounds, but their role in supporting direct fisheries exploitation as fishing grounds remains poorly understood. In this talk we provide a global assessment of the extent, importance and nature of fisheries exploitation of seagrass meadows. We use a series of local and regional seagrass experts to elicit knowledge about seagrass fishing practice in their area. Our study finds that seagrass-based fisheries are globally important and present virtually wherever seagrass exists. These fisheries support subsistence, commercial and recreational activity. Throughout the world a wide range of fishing methods and gear are used to exploit seagrass fish and invertebrate communities. The gears used reflect the spatial distribution patterns of seagrass meadows and their depth ranges from intertidal (accessible by foot) to relatively deep water (where commercial trawls can operate). In summary, seagrass fisheries appear to target any fish or invertebrate that can be eaten, sold or used as bait. In the coastal communities of developing countries, the importance of the nearshore seagrass fishery for livelihoods and wellbeing is clear. In developed countries, the seagrass fishery is often more recreational and/or more highly species specific. The results of this study highlight the global scale of the exploitative nature of seagrass fisheries and emphasise the need for targeted seagrass fisheries management.

Abstract no. 160

Seagrass microbiome shifts under experimental eutrophication and algal blooms

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Seagrasss beds are under a general worldwide decline. Most declines are attributed to anthropogenic disturbances, such as eutrophication, climate change and physical damage, land cultivation and coastal development. In addition, stressed seagrass systems have to cope with (invading) bloom-forming seaweeds that threaten to displace the seagrasses and change the ecosystem fundamentally. This threat has increased enormously over the last few decades and is today considered amongst the most serious ecological problems threatening the biodiversity and habitat-structures on local to global scales.
It is becoming increasingly clear that the microbiomes of marine and terrestrial organisms add genetic diversity and functions that play important roles in host development and ecology. Although the characterization of such communities associated to seagrasses 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 to terrestrial plants, little is know about microbiomes associated with marine macrophytes. By elucidating bacterial community structure, composition and function associated with seagrasses across experimental levels of eutrophication and algal biomass, we show that microbiomes of sediment and seagrass roots react differently to eutrophication and algal load suggesting a strong influence of the seagrass on the associated microbiome. Seagrass root associated microbiomes only shifted slightly under eutrophicated conditions, but the addition of algal biomass caused large, alga identity dependent, changes in microbiome structure and composition. These alga caused shifts differed strongly when combined with eutrophication. These shifts are especially related to sulfur cycling which has strong consequences for seagrasses.

Abstract no. 161

The Porthdinllaen Seagrass Project

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Porthdinllaen is a part of a marine conservation area called Pen Llŷn a'r Sarnau Special Area of Conservation (SAC). This area has been chosen as a SAC because of the marine habitats and wildlife that it supports, including reefs, estuaries, grey seals and bottlenose dolphins.

Seagrass is an important component of the SAC and is one of the reasons this area is so special. The seagrass bed in Porthdinllaen is one of the largest and the densest in North Wales with recent surveys estimating it to cover an area the size of 46 football pitches. The seagrass in Porthdinllaen is part of the intertidal mudflats and sandflats feature of the SAC. This feature is in unfavourable condition, mainly due to the effect of anchoring and mooring on the seagrass in Porthdinllaen.

The aim of this project is to develop and implement management options that will improve the condition of the seagrass whilst allowing the existing use of the bay to continue. The aim is to develop and implement these management options in full partnership with stakeholders.

Stakeholder engagement and involvement is essential if the management options that will be put in place by this project are to succeed. Over the last few years the project has been collecting data to get better understanding of the seagrass and the ecosystem services it provides as well as investigating a variety of management options for the area. This has been done in collaboration with local stakeholders and sea users.

List of Poster Abstracts

Carbon storage in living vegetation of disturbed seagrass meadows in Andaman coast of Thailand

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In the coastal ecosystems seagrass meadows have second highest rate of the carbon storage. The carbon is stored in living and non-living biomass and in the deposited sediment. Carbon stock in the living biomass varies among the meadows based on the type, whether it is uniform or mixed. The aim of this research was to estimate carbon storage in the living biomass of the uniform and mixed type of disturbed seagrass meadows in the sheltered and exposed bays along the Andaman coast of Thailand. The results of the biomass suggest same patterns of above and below ground parts between low and high density meadows in two seasons within same meadow type. Biomass of meadows had the same patterns in the exposed and sheltered bay as well as the same densities. Carbon stored in the plants had an opposite trend from biomass and displayed various patterns among above and below ground parts of same densities within different type meadows. Even in the meadow type of the same density stored carbon varied between seasons. The results showed that mixed and uniform meadows have the same patterns of the biomass between seasons, but different trends of carbon storage between seasons within same densities. The maps created from the total carbon pool of the living biomass offer a stepping stone for the further carbon storage studies of this region.

Investigating the potential of *Cymodocea nodosa* (Ucria) Ascherson as coastal carbon sink coupling marine habitats' cartographies and in situ non-destructive sampling

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Seagrass meadows are major carbon sinks, trapping about 10% of the total CO2 sequestrated in the oceans. In the Mediterranean, a major focus has been made on the climax species *Posidonia oceanica* (L.) Delile, while other species remained little studied. In the framework of the STARECAPMED project, we thus chose to study *Cymodocea nodosa* (Ucria) Ascherson, a pioneer species with a rapid turnover and an expected high stocking capacity. Furthermore, the area covered by that species has been largely underestimated. In

order to fill these two knowledge gaps, we first mapped all seagrass habitats within a Mediterranean bay (Calvi, Corsica, France) using side scan images, aerial photographs and ground truths. This cartography was followed by seasonal in situ density measurements and non-destructive shoot sampling (leaf cutting). Samplings were performed at different depths (5 to 23m depth) in 6 contrasted stations (small patchy meadows to continuous beds) in order to cover all the existing facies of the bay. Elementary contents (carbon, nitrogen and stable isotope ratios) were measured in laboratory. This first work shows that C. nodosa meadows in Calvi Bay cover an area of 0.498 km^2. Carbon stocks of the leaves reached 0.76 tons in winter and 5.61 tons in summer. Their nitrogen contents of the leaves showed a marked seasonality with a maximum value of 0.020 $mgN.m^{-2}$ in July and a minimum value of 0.005 $mgN.m^{-2}$ in March. Some modifications in the trophic conditions of the water column at several stations were put in an obvious through the N stable isotopes values, mostly during the summer period. The actual underestimation of the area covered by that species in Calvi Bay has been properly mapped thanks to side scan sonar techniques revealing, together with elementary content analysis, its importance in the carbon balance of coastal areas.

Understanding links between seagrass species traits and carbon storage in sediments

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To determine the global carbon sink potential of seagrass ecosystems, we must improve our understanding of the factors contributing to variations in carbon storage. The aim of this work was to link seagrass community composition to differences in sediment carbon storage. At 19 *a priori* selected sites within highly diverse seagrass meadows surrounding Zanzibar, Tanzania, species cover was estimated along with three community traits shown to influence carbon sink capacity (amount of above and belowground biomass, seagrass tissue %N, and shoot density). Five distinct species assemblages were identified and there were notable differences in seagrass traits among communities. The community dominated by *Thalassodendron ciliatum* (TC) had significantly higher above- and belowground biomass, while the community composed of small-bodied seagrass species had higher shoot density, and the community dominated by *Thalassia hemprichii* (TH) had the highest leaf nitrogen content. Although these trait differences have been shown to lead to differences in carbon storage in other seagrass systems, carbon inventories from the top meter of sediment at our sites were low and not significantly different among communities, ranging from10 to 43 Mg C_{org} ha^{-1}. Ultimately, the low-depositional environment of the sampled meadows outweighed the seagrass-mediated biological controls over sediment carbon storage.

Changes of sediment organic carbon cycling in response to long-term nutrient enrichment in tropical seagrass bed of South China Sea

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To identify the effect of nutrient enrichment on the sediment organic carbon (SOC) cycling in tropical seagrass bed, we collected the surface seawater, sediment and primary producers from three stations with different distance to the fish farming area in Xincun Bay, South Chian Sea. The results showed that nutrient decreased as the distance increase to the fish farming area. And SOC and hydrolases in sediment vegetated by the seagrass *Enhalus acoroides* were significantly higher in near the fish farming area than the pristine area, but not the oxidoreductases. The SOC $\delta^{13}C$ ratio was 11.58±1.96 in the high nutrient region, while it was -14.45±0.37 and 15.18±0.73 in the relative low nutrient area. This indicated that the relative contribution of seagrass to SOC increased with increasing nutrient. The bacteria $\delta^{13}C$ ratios (-15.27±0.99) in *E. acoroides* sediments collected from pristine were similar to the algae (macroalgae, epiphyte and benthic microalgae) and SOC, suggesting that algae was of major importance as a bacterial carbon source. There was a shift in bacterial carbon sources in anthropogenic impacted *E. acoroides* meadows (-11.82±0.59 and -11.92±0.65) towards seagrass. The enhanced seagrass litter or the labile organic carbon exudation from seagrass roots mainly accounted for the alteration of the SOC sources, and thus changed the bacteria carbon source. Therefore, nutrient enrichment could change the sediment organic carbon cycling. In addition, the increasing of seagrass litter and labile organic carbon exudation might influence the seagrass beds "blue carbon" function.

Clear as mud: The influence of simulated green turtle grazing, runoff, and sting rays on seagrass ecology in Bocas del Toro, Panamá

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Green turtle (*Chelonia mydas)* abundance in the Caribbean is estimated to only be 0.33% of what it was in pre-Colombian times (McClenachan et al. 2006). The severe reduction of this formerly abundant herbivore has likely dramatically altered the ecology of the seagrass beds where *C. mydas* feeds, but the conclusions of past studies of the effect of sea turtle grazing in the Caribbean have varied by location.

We conducted our experiment in Bahía Almirante, in Bocas del Toro, Panamá. This experimental site receives notably more rainfall than the site of any other published grazing experiment in the Caribbean. To simulate grazing, we clipped turtlegrass (*Thalassia testudinum*) with scissors in a way that imitated grazing by *C. mydas.* Highly grazed plots

were clipped every two weeks, lightly grazed plots were clipped every four weeks, and ungrazed plots were never clipped. Seagrass growth rates, production, and morphology were assessed in each plot opportunistically, as was shoot density. Plots were also photographed monthly to quantify ecological succession.

Grazing had the effect of generally reducing seagrass production per unit area as well as leaf width and leaf area. Shoot density steadily declined in highly grazed plots, but was elevated in lightly grazed plots when compared to ungrazed ones. While *T. testudinum* shoot density was reduced in highly grazed plots no other species of seagrass or rhizophytic algae was able to colonize the resulting empty space. This may be related to the fact that Bocas del Toro receives over 3m of rain each year leading to large amounts of runoff into Bahía Almirante, which leads to higher levels of nutrients and reduced water clarity compared to other sites where similar experiments have been conducted. The most surprising finding was that stingrays displayed a preference for digging holes into grazed as opposed to ungrazed plots.

Decapods in seagrass ecosystems: Does landscape matters?

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Landscape patterns play an important role in ecological processes in the coastal ecosystem mosaic. Seagrass meadows are known to provide food resources and shelter to many species, thus maintaining coastal biodiversity, especially invertebrates such as decapods. Decapods are abundant in seagrass meadows but scarcely studied from the landscape perspective. The distribution and abundance of benthic species, besides stochastic factors during larval planktonic stages, can be the result of the interaction between landscape patterns and local habitat features. Here we assessed the influence of seagrass landscape configuration (continuous meadows, patchy meadows in a sand matrix and patchy meadows in a rock matrix) and habitat features (i.e. detritus biomass, shoot density, organic matter content in sediment and height of unburied rhizomes) in the decapod assemblage of *Posidonia oceanica* seagrass meadows. A total of 1608 decapods belonging to 47 species were found. Species richness, total abundance and Shannon-Wheaver diversity were site specific, and not related to landscape configuration. Habitat features (shoot density, fine detritus and organic content in the sediment) had a significant effect on decapod assemblage structure. Moreover, the whole composition of decapod assemblage was significantly influenced by landscape configuration. We concluded that the abundance and richness of the decapod assemblage were mainly determined by stochastic processes and habitat features, while landscape configuration influence became important when looking at the specific composition of decapod assemblage. This study contributes to the emerging evidence of the role of landscape in modulating the distribution and abundance of coastal organisms, and its contribution to biodiversity patterns.

Diversity, dynamics and trophic ecology of animal communities associated to *Posidonia oceanica* (L.) Delile macrophytodetrital accumulation: synthesis of a ten year study

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In the Mediterranean, Neptune grass *Posidonia oceanica*, produces a huge quantity of detrital biomass. These macrophytodetritus may accumulate in shallow waters, forming litter accumulations colonised by abundant, yet understudied, animal communities. These accumulations are especially foraged by juvenile and adult fishes. Here, we aim to synthesize results obtained over the last ten years regarding diversity, dynamics and trophic ecology of associated meio- and macrofauna. Accumulations are found throughout the year but important seasonal and short-term variability in composition, quantity and physico-chemical parameters inside the accumulation is observed. Accumulations are dominated by respiration (litter degradation), however, primary production occurs at exposed surfaces (epiphytic production). Meio- and macrofauna have distinct traits in comparison to adjacent habitats (seagrass meadows or epilithic algae communities). A physico-chemical gradient occurs inside accumulations which partially defines assemblage composition and distribution. Meiofauna, in particular harpacticoid copepods, is diverse, abundant and composed of species from seagrass meadows, water column and sediment. In contrast, macrofaunal assemblages are simplified compared to the ones occurring in the seagrass meadows and are dominated by amphipods. Litter accumulations display a lower macrofaunal diversity than do seagrass meadows, but a higher abundance and animal biomass. Meio- and macrofauna show a high trophic diversity, dominated by ingestion and assimilation of epiphytes (macroalgae and, probably, detrivorous microbiota). Moreover, direct or indirect assimilation of carbon originating from seagrass detritus is demonstrated for many species. Although diverse trophic niches were observed, the assemblage showed a simplified trophic web structure compared to the seagrass meadows. Detritivorous organisms dominate this assemblage and are more abundant in the litter than in the living meadows. Consequently, according to its abundance and the fact it consumes directly and indirectly seagrass material, fauna associated to litter accumulation may play a significant role in the degradation and transfer to higher trophic level of detrital seagrass carbon.

Feeding behaviour of the sea urchin *Tripneustes gratilla* in relation to a seagrass overgrazing event in Zanzibar Archipelago, Tanzania

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The sea urchin Tripnesutes gratilla is known as a cosmopolitan seagrass grazer, and its feeding behaviour has been extensively studied, but rarely in direct relation to large overgrazing events. In this study we describe an overgrazing event in Thallasodendrum ciliatum meadows around Prison Island, Zanzibar, Tanzania, that occurred between 2014 and 2015, in relation to T. gratilla feeding behaviour. Seagrass in the grazed meadows were surveyed for percentage cover, shoot density, above and below biomass, as well as C:N:P ratios and total phenolic compounds of the different species. T. gratilla population structure was determined by measuring abundance and density in different meadows together with its size frequency. The feeding behaviour of T. gratilla was portrayed by the analysis of the gut content, feeding rates, and seagrass biomass used to cover themselves, presumably for camouflage. According to the gut content and feeding rates, T. gratilla had a feeding preference for T. ciliatum and a preference for camouflaging with T. ciliatum leaves and inhabiting these meadows. Preference of T. ciliatum over other seagrass species is related partly to the nutritive quality and quantity of total phenolic compounds of this species. T. ciliatum meadows show some
recovery, suggesting that even though these events are destructive for the seagrass meadows shoots, their belowground biomass can support the recovery through their energy reserves; demonstrating the resilience of seagrass meadows to withstand severe changes in their environment.

The ecological quality status of the Marchica lagoon (Morocco, Mediterranean Sea): Use of *Cymodocea nodosa* meadows and its associated macrofauna

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Due to their location between the continent and the sea and their shallow depths, the Marchica lagoon perform important ecological and socio-economic functions. Though the lagoon is under pressure of a complex mixture of human-mediated stressors (urbanization, pollution, overfishing, tourism, etc.). This study is a first contribution to the assessment of the ecological quality status (ES) of the lagoon using *Cymodocea nodosa* (Ucria) Ascherson meadows and associated benthic macro-invertebrates. Samples were collected using a Van Veen grab. In total, 28 stations were sampled during February 2015. The *C.nodosa* meadows were characterized by considering shoot density, biometry and biomass of leaves, rhizomes and roots. First results revealed significant differences in biomass and morphometric parameters between stations. The *C. nodosa* at the station B bay seems to be well

developed, showing the highest values of shoot density (326 shoots.m-2), total biomass (98,9 g DW.m-2) and aboveground biomass (26,6 g DW.m-2). The results obtained were compared to other regions in the Mediterranean to assess the quality and the health of the eelgrass meadows of Marchica lagoon. Benthic macrofauna consistently registered responses to environment variation. A total of 90 taxa of macrobenthic invertebrates were recorded belonging to six zoological groups. Results show that the spatial distribution of the abundance and richness of benthic communities is not uniform along the study area; it seems to be influenced by several environmental and anthropogenic factors, and hydrodynamics also appears to play an important role in the distribution of species. The assessment of the ecological quality status, was evaluated using several biotic index (Shannon-Wiener H', AMBI, M-AMBI, BENTIX, BOPA, BITS). The results showed partial agreement between single index-derived ES and underlined the dependency of these biotic indices on the habitat characteristics, on the one hand, and the necessity to define specific reference conditions to the Marchica lagoon.

Linking offshore variables to seagrass fish communities in temperate coastal seascapes

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Species assemblages and the role of abiotic factors in shaping ecosystems is remarkably complex, with a myriad of influential factors from fine-scale single habitat variables to ocean-wide biogeochemical cycling. While a number of studies have been done to understand nearshore habitat connectivity in shallow-water fish, little is known about the importance of offshore variables in shaping fish community patterns. The current study aimed to understand how offshore environments influence temperate seagrass fish communities. Distance to open ocean and deep water, latitude, and wave exposure were tested for influence on fish assemblages (at species or family level and by means of habitat preference guilds) using multiple linear regression analysis. These predictor variables were selected because of their association with changing climate and nearshore-offshore linkages. The results showed that proximity to deep water was the most influential variable with significance for fish density from the Gadidae, Labridae and Syngnathidae families as well as for fish density from the Juvenile Migrant (JM) habitat preference guild. Additionally, proximity to the open ocean influenced JM and Labridae, while latitude was significantly related to densities of the Gasterosteidae family. Establishing such associations between surrounding ecosystems and how species use certain habitats is essential for developing a clear picture of how coastal seascapes function. The understanding of seascape connectivity and the influence of factors that may exhibit changes in the future is critical for resource management.

Simplified food web of tropical seagrass bed, toward an improved understanding of the role of benthic energy pathway --- A case study in Xincun Bay, South China

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Seagrass beds provide food and habitat for numerous fish and invertebrate species. In order to elucidate the trophic structures and energy pathways in tropical mixed-species seagrass bed, $\delta^{13}C$ and $\delta^{15}N$ of major potential food sources and consumers were analysed to identify the transfer route of energy into the food web in Xincun Bay, southern China. Mean $\delta^{13}C$ values of the organic matter sources and consumers ranged from -16.9‰ to -6.8‰ and -15.7‰ to -6.4‰, respectively, suggesting considerable differences in ultimate sources of carbon. Values of $\delta^{15}N$ ranged from 3.1‰ (the seagrass *Cymodocea rotundata* drift) to12.7‰ (*Stolephorus insularis*), indicating a food web with 3.6 trophic levels. Based on the evidence of trophic links suggested by $\delta^{13}C$ and $\delta^{15}N$ results, we construct a general food web model for the tropic seagrass meadow, the trophic pathways between the potential carbon sources and consumers can be obviously divided into a pelagic and a benthic one, with the former pathway based on POM and the latter on a mixed pool of seagrass material, epiphytes and SOM. And the benthic pathway was the foremost energy pathway in the seagrass food web. Integrated with the trophic role and food web analyses, this study suggests that seagrasses are the main energy sources of the food web, indicating the great importance of seagrass protection in the tropic area.

Epigenetic variation in seagrass clones

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Evolutionary theory predicts that low genetic variation reduces a population's ability to cope with environmental variability and to adapt to changing environments. However, the ecological and evolutionary success of >1000 years old clones of the seagrass *Zostera marina* challenges the direct relationship between genetic diversity and adaptation. We aim at testing the hypothesis that the key to this paradox may be an hitherto overlooked layer of evolutionary relevant variation: epigenetic variation
Epigenetic variations are molecular-level changes, such as DNA methylation, that alter gene expression, but not the underlying DNA sequence. *Z. marina* is a key structural species for

coastal ecosystems and an ideal model system to study the evolutionary and ecological value of epigenetic variation, as its partially clonal reproduction allows experimental designs eliminating the confounding effect of genetic variation
Our main objective is to describe the spatial pattern of epigenetic variation in a ~1000 years old seagrass meadow of low genetic variation from the Åland islands. In 2015, we sampled 100 shoots along a transect of >250m. Each shoot (ramet) is assigned to its clonal origin (genet) based on its multi-locus genotype at SNP loci. We screen within-clone variation of cytosine methylation in three DNA sequence motifs (CpG, CHG and CHH) using Next Generation Sequencing of 10,000 bisulfite-converted Restriction site associated DNA (RAD) fragments that represent 2.5% of the ~200 Mb genome. This work will be the first step to uncover whether epigenetic variation may compensate for the absence of genetic variation in seagrass clones, a fundamental question in the budding field of ecological epigenetics.

The causes and consequences of genetic diversity in Ruppia-populations: a case study in the Camargue

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Ruppia is a cosmopolitan genus of submerged Angiosperms, living in coastal wetlands and shallow lagoons. These types of habitats often are characterized by a seasonal fluctuation in water-level and salinity, resulting in harsh conditions for aquatic plants and animals. Being merely the only angiosperm surviving here, *Ruppia* is a true engineering species. Micro-and macroinvertebrates find shelter within the Ruppia-meadows or graze upon the epiphytes adhered to the leaves.

During the last decade, scientists started to acknowledge the importance of genetic diversity of a species as an important source of biodiversity. Especially in ecosystems that rely on a single key species, genetic diversity levels can have consequences for the ecosystem's production, resilience and community composition. Being a key-stone species in these *Ruppia*-based communities, we hypothesize that genetic diversity of *Ruppia* may affect ecosystem functions.

Firstly, we will consider the effective genetic diversity of Ruppia in a Mediterranean coastal wetland of the Camargue (France). It consists of many temporal and permanent pools that show a large range of salinities and harbour many *Ruppia* populations. Using microsatellites, we unraveled the genetic identity and diversity of *Ruppia* populations across the area.

Secondly, a mesocosm experiment was set up to determine whether genotypic diversity affects the populations productivity. To test whether genotypic richness will affect a populations ability to cope with stress-factors, we considered different levels of salinity stress (freshwater control; 30‰, 70‰). Climate change predictions forecast longer summer droughts, alternated by more severe storms. Hence, an extra treatment with alternating salinities (15‰-70‰) is added.

Integrating these approaches, we aim to evaluate the quality of the *Ruppia* populations in the Camargue and add useful information to conservation issues dealing with coastal wetlands.

Transcriptome analysis and organ-specific profiling of gene expression in *Posidonia oceanica*

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Posidonia oceanica meadows are declining and seriously threated as a consequence of the human-induced global change. Sexual reproduction represent an important process for the evolutionary adaptation of the species to novel environmental conditions. However, sexual reproduction is not regular in the species and it is one of the poorly understood biological processes. The use of transcriptomic approaches can provide important clues about the molecular basis of flowering in *P. oceanica*, helping in identifying biotic and abiotic factors influencing this reproductive process. In the present study we use a massive transcriptomic analysis to study gene expression profiles of different plant organs including leaves and male and female flower tissues. A total of 172.720.634 high-quality cleaned single-end reads were generated using Ion Proton RNA-Seq technology, de novo assembled into 72,551 non-redundant transcripts and subjected to an organ-specific gene expression analysis. The assembled transcripts and differentially expressed genes were further annotated against public protein databases followed by Gene Ontology (GO) and Kyoto Encyclopedia of Genes and Genomes (KEGG) classification. We also retrieved additional functional information based on domain/motif information. Moreover, statistical analysis of GO-term enrichment of differentially expressed genes in each pair-wise comparison was also performed. Preliminary results of organ-specific analysis of the *P. oceanica* transcriptome revealed significant differential patterns of gene expression (4fold DE; $p<0.001$) between leaves and reproductive tissues, with the largest differences in gene-expression between leaves and male flowers. The functional properties of the differentially genes also displayed differences among the considered organs in accordance with their biological function. Besides, genes with relevance to flowering and metabolic pathways involved in flower development were elucidated. In conclusion, the produced high-throughput sequencing data offer a comprehensive view of *P. oceanica* transcriptome in vegetative and flower tissues and profiled differential gene expression identifying, at the same time, putative genes associated with flowering.

Clonal and genetic diversity of the threatened seagrass *Halophila beccarii* in a dynamic lagoon environment (Hue, Vietnam)

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Hue lagoon (Central Vietnam) is the largest lagoon of S.E. Asia and subject to strong environmental influences, resulting in a dynamic habitat for seagrasses to cope with seasonal changes in water level and salinity. Resilience of each species should allow survival of seagrass beds through strategies in reproduction mode, dispersal distances and establishment. We determined the clonal and genetic diversity of *Halophila beccarii* Aschers. (Hydrocharitaceae), a threatened Indo-Pacific species, but common in Cau Hai lagoon (part of Hue lagoon). A total of 780 *H. beccarii* individuals were collected at 6 sites following a fine-scaled grid pattern. Clonal richness and genetic structure were estimated at lagoon- and site-scale using 7 microsatellite markers. *H. beccarii* showed very low allelic richness (Ar=1.9) and gene diversity (He=0.233). An AMOVA revealed that most of the genetic variation is within (62%) and among individuals (34%), whereas only 4% between sites. Differentiation was very low as can be expected within a same lagoon (Fst=0.027, $p<0.05$). Inbreeding was not an issue in *H. beccarii*, also reflected by high outcrossing rates. When considering multiple copies of genotypes, clonal richness (R=0.15-0.34) as well as the heterogeneity of clones (β Pareto distribution) varied only very slightly among sites. Clonal aggregation ($p<0.05$) was evidenced in all 6 sites and this over very short distances of a few meters. A fine-scale genetic structure analysis showed a high kinship levels between *H. beccarii* individuals, but only significant within 2m and decreasing sharply within 4-5m. This study demonstrated that the resilience of *H. beccarii* beds in the Hue lagoon environment is maintained through local seed recruitment at very small distances and by limited local clonal extension. Implications for conservation are that environmental conditions of the lagoon, allow to maintain local development of *H. beccarii* beds at each site.

Estimating seagrass cover using digital images.

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Determining plant cover is necessary for a wide range of ecological research including coastal vegetation assessment and management. It is ideal for seasonal and long-term monitoring as it can be observed non-destructively and is closely related to other key ecosystem variables, such as biomass. Although visual assessment is the most common method, it is time consuming and subject to interobserver variability, whilst existing photographic methods (aerial and satellite) usually require expensive equipment and complex analysis. Here we introduce and test a new method using digital images for estimating seagrass cover based on red, green, and blue (RGB) colour indices. This technique extracts RGB features, calculates RGB-based colour indices, and computes the minimum segmentation error for separating seagrass from the background. Percent coverage was estimated as the ratio of seagrass pixels to total pixels in digital photos. Based on the segmentation error, modified excessive green index (MEGI) showed the highest

potential for segmenting seagrass from sediment background, followed by the difference between red and green values (R-G) and difference between normalised red and green values (r-g). At the threshold MEGI value of 0.019, the segmentation error was the lowest at 0.0386. Validation against simulated images gave an error of <1%. Nevertheless, the method did not distinguish between species of seagrass, and the presence of macroalgae or reflected light caused misclassifications. We conclude that the proposed method is an inexpensive and precise technique for quantifying seagrass percent coverage, which is superior to the traditional method of visual assessments, although care must be taken to avoid bright reflected light and areas with macroalgae.

Satellite-based quantitative assessment of seagrass habitats in Thermaikos Gulf (NW Aegean Sea, Greece)

Dimosthenis Traganos, Peter Reinartz

The Mediterranean Sea hosts 6 of the world's largest and most important seagrass species. These comprise major nursery grounds in depths of 0-50m for up to 18% of all known marine species. Despite being protected under the Natura 2000 network and listed as conservation priority by EU legislation, seagrass habitats are under threat with a recorded global annual loss of 110 km2 since 1980. The major contributors to this loss in the Mediterranean Sea are overfishing, damage caused by illegal trawling and anchoring, eutrophication, coastal expansion and invasive species. In addition, the high absence of data on the distribution, extent and limits of Mediterranean seagrass grounds prohibits the rectification of their degradation trends. The objective of this study is to identify and quantitatively assess seagrasses in the previously uncharted, largest Aegean Sea gulf, Thermaikos Gulf, with focus on Posidonia oceanica meadows, using medium- and high-resolution multispectral satellite images. The test site for the methodology is chosen on the basis of its abundance in Posidonia meadows, smooth depth variance and high water clarity that both increase the efficiency of the satellite-based assessment, and last, but not least, the adjacency of seagrass habitats to urban areas and heavy trawling activities, which renders them more prone to possible regression. The generated depth-invariant bottom indexes utilize the 10-m spatial resolution of Sentinel-2A and the greater penetration of coastal waters by Landsat-8 to provide robust quantitative results about large, homogeneous and smaller, sparse seagrass patches. Field ground truthing validates the robustness of the satellite-derived mapping of seagrass habitats in Thermaikos Gulf. The herein presented methodology offers a cost- and time-effective quantitative assessment with large area coverage, high degree of repeatability as well as minimum environmental pollution for monitoring Mediterranean seagrass distribution, extent and possible degradation, and highlights key units for further restoration and conservation.

Unveiling the structure and function of the seagrass microbiome

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The poster aims to introduce my PhD project and its first results about microbes-seagrass interaction. The PhD project focus on the microbiome of Zostera marina in the local fjord Skjerstadfjorden, Bodø, Arctic Norway. It aim to characterize the abundance and specificity of the microbes associated with Zostera marina over time, space, and environmental conditions. The project focus on 5 meadows that are currently ecologically monitored (light, salinity, nutrient concentration, sediment) and genetically characterized. 3 populations are located inside Skjerstadfjorden and 2 are located at the open coast outside the fjord. Samples are collected every 90 days from Zostera marina leaves, roots, and rhizomes, as well as from the seabed and water surrounding the plants. DNA will be extracted from all samples and Ribosomal rRNA (16S rRNA for Bacteria and Archeae, 18S rRNA for microbial eukaryotes) will be amplified via PCR with universal primers and sequenced on the Illumina MiSeq platform. The sequencing data will be compared to the small subunit ribosomal RNA gene database for taxonomic characterization and estimation of the microbial diversity.

Seagrass-mediated alterations of rhizosphere biogeochemistry result in pronounced shifts in microbial community composition at the microscale level

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The seagrass rhizosphere harbors dynamic microenvironments where plant-derived gradients of O_2 and dissolved organic carbon (DOC) form microhabitats that select for distinct microbial communities (e.g. Moriarty et al. 1986; Nielsen et al. 2001; Jensen et al. 2007). To examine potential mutualistic relationships between seagrasses and rhizospheric sulphide-oxidizing bacteria, we applied high-resolution 16S rRNA amplicon sequencing of artificial sediments surrounding the meristematic tissues (i.e. the basal leaf meristem and root apical meristems) of the seagrass *Zostera muelleri* along with detailed microsensor measurements of the biogeochemical conditions at the basal leaf meristem. The applied transparent, artificial sediment matrix was either enriched with porewater microbes (~50% v/v native porewater) or sterilized (including the below-ground tissue surface); thus allowing for the combined use of molecular and microsensor techniques, without disturbing the below-ground biogeochemical micro-gradients and habitats during microsensor measurements. Higher relative abundances of the often nitrogen-fixing, sulphate-reducing bacterial class *Clostridia* were observed around the meristematic tissues compared to the

bulk sediment, with particular high abundance of sulphate reducers, including OTUs matching *Lachnospiraceae* and *Desulfovibrio* sp., around the root apical meristems. Radial O_2 loss (ROL) from the basal leaf meristem led to a ~300 µm-thick oxic microzone, thus protecting the seagrass *Zostera muelleri* from phytotoxic H_2S intrusion, through chemical sulphide re-oxidation at the oxic/anoxic interface. Slightly higher abundance of sulphide-oxidizing bacteria (mainly Epsilon-proteobacteria, such as *Arcobacter* sp. and *Sulfurimonas* sp.) was observed within the plant-generated oxic microniches at the basal leaf meristem. However, this did not seem to initiate beneficial effects in terms of H_2S detoxification (i.e. similar rates within the porewater enriched and sterilized environments) suggesting limited symbiotic relationship between *Z. muelleri* and rhizospheric sulphide-oxidizing bacteria, as otherwise previously anticipated. Instead, our results provided further evidence of potential mutual beneficial relationships between seagrasses and rhizospheric nitrogen-fixing diazotrophs based on reciprocal nutrient exchange.

Nitrate reductase and glutamine synthetase activity of *Cymodocea serrulata* (R.Brown), under varying concentrations and sources of nitrogen

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To understand the response of seagrasses to increasing nutrient inputs, measuring the physiological changes in activity of enzymes involved in nutrient uptake are important and can demonstrate the ability to respond to higher availability of nutrients in the environment. Most studies on seagrass physiological responses to nutrients have been on Mediterranean and North-Temperate seagrass species. Here, we focus on a tropical species, *Cymodocea serrulata*, from Zanzibar, Tanzania, where we determined nutrient uptake capacity and assimilation under varying nutrient sources and concentrations by measuring the uptake rates of N as nitrate, ammonium, and amino acids in above and belowground tissues in laboratory incubation experiments and linked rates to enzymatic activity of nitrate reductase (NR) and glutamine synthetase (GS). Plants were incubated for 1 hour with varying concentration of each nutrient source in glass chambers that divide above and belowground parts. Nutrient uptake rates of leaves and roots were calculated separately, and plant tissue was then used for measuring NR and GS activity. A second experiment was done using the same concentration of the 3 nitrogen sources at the same time, with one source of nitrogen labeled with ^{15}N each time, enzymatic activity was also measured in this experiment in above and below ground tissues. *C. serrulata* showed similar responses to high nutrient concentration as Mediterranean and temperate species. NR activity was higher in leaves compared to roots, when plants were exposed to high nitrate concentration during the first hour. After 24 h incubation this trend was enhanced and NR activity almost doubled. GS activity was higher in leaves than in the roots and tended to increase with high concentrations of ammonium in the leaves. These results indicate the rapid response of *C. serrulata* to high nutrients of nitrate and ammonium in the water-column.

Nitrogen uptake, transport and allocation in tropical seagrasses under different nitrogen sources

Inés González Viana, Daniel Arturo Saavedra Hortúa, Mirta Teichberg

Seagrass meadows in tropical ecosystems are often exposed to low inorganic nitrogen concentrations in water-column but have higher availability of ammonium in the sediment porewater. However, the current high rates of development taking place along tropical coastlines are associated with increasing nutrient inputs to both the water-column and sediment, which may have major impacts on tropical shallow water communities. Therefore, examining the response of tropical seagrasses to nitrogen availability is essential to understand the greater impact of nutrient inputs to these coastal ecosystems. The uptake rates and preference of nitrogen sources of inorganic (ammonium and nitrate) and organic nitrogen (amino acid mixture) were studied both in above and belowground tissues of *Cymodocea serrulata* and *Thalassia hemprichii.* The existence of transport along the shoot was also determined. Individuals collected from Zanzibar (Tanzania) were placed in two-compartment incubation chambers under laboratory conditions. Uptake rates by leaves and roots were quantified in single-compound solutions and the preferential N source was estimated at a fix concentration of a mixed N solution containing ammonium, nitrate and amino acids. Uptake rates of ammonium in leaves and roots followed a Michelis-Menten kinetic, while uptake rate of nitrate in the roots correlated linearly with increasing nitrate concentration. Ammonium was the preferred N source. The transport of nitrogen taken up from leaves to roots and vice versa was observed and affected by the availability of nitrogen to the opposite part of the plant. In oligotrophic environments, as in the tropics, uptake of amino acids by roots may provide seagrasses with a competitive advantage over macroalgae.

Effects of ocean acidification on seagrass gene expression: insights from *Posidonia oceanica* at CO_2 vents

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Ocean acidification (OA) is one of the major threats to global oceans. Establishing its effects on marine foundation species is of primary importance for the persistence of associate organisms and communities. While most of the OA research to date has focused on calcifying organisms, little information is available for marine photoautotrophs, such as marine angiosperms.
Several recent studies have evaluated the physiological impact of low pH and elevated CO_2 concentration on seagrasses, however very few studies have focused on underlying molecular responses. In this context we investigated, for the first time, the effect of CO_2

enrichment on gene expression in the seagrass *Posidonia oceanica* at two natural volcanic vents (islands of Ischia and Panarea, Italy).
The expression levels of 35 antioxidant and stress-related genes, together with 23 genes involved in photosynthesis, CO_2 fixation, metabolic carbon assimilation pathways and chlorophyll metabolism, were characterized by RT-qPCR.
Our study revealed a differential regulation of most analysed genes in *P. oceanica* at the two sites, with gene expression at the Ischia vent more coherent with the expected response of plants under prolonged exposure to high CO_2 levels. Specifically, high CO_2 here resulted in a severe down-regulation of enzymes involved in carbon fixation and utilization (e.g. Rubisco activase, Phosphoenolpyruvate carboxylase and β Carbonic anhydrase). On the contrary, the same genes were up-regulated or not significantly affected in the Panarea site. Similarly, genes involved in free radical detoxification and heat shock proteins were only activated in Panarea and not at Ischia.
Globally, these results indicate that high CO_2 substantially alters the expression of genes involved in key metabolic processes (e.g. carbon assimilation), but also that plant response can vary due to intrinsic environmental characteristics of the vents sites, and careful consideration of factors that are at play other than CO_2 and acidification is required.

Oxidative stress response of *P. oceanica* to short-term heat stress

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Posidonia oceanica and *Cymodocea nodosa* are marine angiosperms widely distributed in the Mediterranean Sea. As habitat builders they have crucial importance for the coastal ecosystem; however because of human activities and environmental changes population are in regression. Studies indicate that increased maximum annual seawater temperature in the Mediterranean Sea leads to increased seagrass mortality. High temperature induces oxidative stress and damages photosynthetic apparatus. During oxidative stress, the amount of reactive oxygen species production increases and they start to give damage to proteins, lipids and DNA. Even though heat-stress induced oxidative stress is studied in some model species, there is a lack of knowledge for seagrass species which actually can help to understand the response of species to global warming. Scope of this study is understanding the response of two important seagrass species to a realistic heat-wave simulation. Within the frame of this study, 4 different genotypes of *P. oceanica* and *C. nodosa* were collected from -5m and -25m depth in Murcia, Spain and exposed to short-term heat stress in mesocosm. They were sampled at three time points, including the beginning and end of the heat wave and after recovery period. RNA extraction was performed by using adult leaf samples and gene expression analyses were performed after RT-qPCR experiments. Results demonstrate that there are interspecific and intraspecific differences in adaptation to stress conditions. *P. oceanica* individuals are more responsive to stress conditions comparing to *C. nodosa*. Results are discussed in the framework of selecting genetic markers for heat-stress assessment in seagrasses.

The effect of light quantity and spectral quality on the physiology and growth of the seagrass *Halophila ovalis*.

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Seagrass meadows provide crucial ecosystem services but are globally threatened. Much of the seagrass loss to date has been due to activities that reduce the quantity (amount of photosynthetic photon flux density) and alter the spectral quality (wavelengths within the visible spectrum) of light reaching seagrasses, such as dredging, flooding and eutrophication. These activities often result in a shift in light quality towards the yellow-green spectrum. While a significant amount of work has focused on the responses of seagrasses to reduced quantity of light, little work has examined the effects of altered spectral quality. This study used an aquarium-based experiment with specially designed LED aquarium lights to emit the quality of light measured in a typical dredge plume consisting of 15 mg/L TSS at 3m depth (termed the 'dredge spectrum'). We used these to test the interactive effects of both light quality (2 levels: dredge and full-spectrum) and light quantity (2 levels: 50 and 200 µmol m^{-2} s^{-1}), on the physiology, productivity and morphology of the widespread seagrass *Halophila ovalis*. There was a significant effect of light quantity ($P<0.05$) on photosynthetic efficiency, chlorophyll and xanthophyll pigments. With regards to productivity and morphology, rhizome extension rate and root length were significantly ($P<0.05$) higher in the ambient light conditions compared to the low light treatments. These results suggest that the physiology and below-ground compartments of *H. ovalis* responded rapidly to reduced light quantity, but there was no significant effect of light quality or a significant interaction between reduced light quantity and the yellow-green dredge spectrum. Whilst it is positive to conclude that this seagrass is not heavily impacted by both light quality and quantity factors, future studies should aim to establish recovery rates under dredge plume scenarios so that we can better inform management for the recovery of impacted meadows.

Toolbox development to survey the evolution and the ecological status of French tropical seagrass beds

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Seagrass species richness, high in tropical coastal waters of French overseas territories, was estimated between 16 up to 18 species. They are found in the Caribbean Sea (Martinique, Guadeloupe, Saint-Martin and Saint-Barthélemy), the Indian Ocean (Réunion, Scattered Islands and Mayotte) and in the Pacific Ocean (New Caledonia, Wallis and Futuna and French Polynesia) where they form remarkable and diversified habitats. At a local level, each French overseas territory has its own historical, technical and biological specific features, which requires various monitoring protocols and stations network. In this context, the seagrass network of the French Coral Reef Initiative (IFRECOR), a national declination of the International Coral Reef Initiative (ICRI), have the ambitious and the complex goals to regularly evaluate the health status of seagrass beds through local, regional and national levels. At the scale of French ultraperipherical regions of the European Union (Martinique, Guadeloupe, Réunion and Mayotte), the French National Office for Water and Aquatic Environments (ONEMA), in charge of the implementation of the Water Framework Directive (WFD), retained seagrass as a biological quality element to assess the ecological status of coastal waters. To have coherence and pool the station network, both IFRECOR and ONEMA joined their efforts to develop an integrated toolbox of protocols and indicators in order to meet their respective issues.
After the establishment of a seagrass bed classification and reflexions about relevant seagrass protocols for the different issues, our main objectives are to test the parameters identified along environmental gradients of pressure to assess measurements which can go into the indicators construction and to propose an operational toolbox. Guadeloupe and Mayotte territories were selected to adapt methodologies to local specific features. Our expected results are the improvement of French tropical seagrass ecosystems monitoring and conservation in order to adjust management solutions in a context of global change.

A one year survey of *Posidonia oceanica* (L.) Delile primary productivity in a Corsican bay (Calvi, France) using the Diving-PAM

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Marine magnoliophytes are major primary producers in coastal benthic habitats worldwide. They play a crucial role in the global carbon cycle (one of the more efficient blue carbon wells). Hence, it is necessary to characterise the eco-systemic services seagrass meadows provide. *Posidonia oceanica* (L.) Delile, the main Mediterranean seagrass species, has high

foliar and belowground biomass production. Several methods have been used so far to measure its primary production (e.g., using incubation bells, optodes, biomass and elementary content measurements). A less used method relies on chlorophyll fluorescence measurements through the Pulse Amplitude Modulated (PAM) fluorometry method (Diving-PAM). In the framework of the STARECAPMED project, this study aimed to determine weekly to bimonthly over a one-year period the photosynthetic responses (Yield, relative Electron Transfer Rate, Rapid Light Curve) of *P. oceanica*. The survey was performed at 10m depth in a pristine meadow (Calvi, Corsica, France). To obtain reliable and comparable data, the protocol was standardized: measurements were performed on the convex middle part of the third leaf, at zenith, during shiny and calm weather days. Results showed that the plant displayed a well-marked seasonality. The mean ETR ($\mu mol\ e^{-}\ m^{-2}\ s^{-1}$) of the plant ranged from 2.17 in winter to 21.9 in summer and was linearly correlated throughout the year with the *in situ* irradiance (PAR irradiance taken perpendicularly to the surface, in the average leaf orientation). The ETR plateaus of the RLCs, ranging from 10.9 to 35.0, and their corresponding maximum PAR intensities evolved similarly. These results demonstrated both the adaptation and the seasonal plasticity of the meadow's photosynthetic system. Overall the non-destructive PAM technique is a powerful and cost-effective tool to assess the primary productivity of seagrass meadows where other techniques (e.g. optodes) cannot be used and when direct sampling (e.g. biomass measurements) is not allowed.

The characteristics of leaf litter of seagrass Thalassia hemprichii and its response to the fish farming in Xincun Bay, Hainan Island, South China

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To examine the effects of fish farming on the dissolved organic matter (DOM) release from leaf litter of tropical seagrass *Thalassia hemprichii* in Xincun Bay, Hainan Island, we studied the characteristics of the leaf litter production and leaf traits of *T. hemprichii* through field investigation, and we studied the DOM released dynamics from leaf of *T. hemprichii* during decomposition through laboratory experiment. The result showed that the mean value of leaf litter production of *T. hemprichii* in Xincun Bay was 0.26±0.05 $g/m^2/d$, and showed a decrease trend as the distance to fish farming increased. However, leaf length and leaf weight of *T. hemprichii* showed an inverse trend. Fish farming reduced leaf nonstructural carbohydrates and amino acids contents, resulting in lower maximum release rate of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) from leaf litter of *T. hemprichii*, respectively; while fish farming enhanced leaf carbon and nitrogen contents, leading to higher cumulative release amount of DOC and DON during leaf decomposition, respectively. Through calculations, the mean value of DOM production from leaf litter of *T. hemprichii* was 12.08 ± 0.17 $g/m^2/d$, and showed an increase trend as the distance to fish farming decreased. Therefore, fish farming enhanced the production of seagrass leaf litter and DOM release, thereby may affect the biogeochemical cycles of carbon, nitrogen and phosphorus in seagrass bed.

Germination of Eelgrass in relation to seed size and sediment burial depth

Martin S. Jørgensen & Birgit Olesen

Sediment burial of eelgrass seeds is an important factor that contributes to the successful recruitment of new seedlings, by reducing their accessibility to herbivores, dispersal into unfavorable environments, and by exposing the seeds to suitable stimuli that induce germination. However, sediment burial can also have negative effects, given that seeds buried to deep may have insufficient energy reserves to reach the surface. In this study we investigated the influence of seed size and burial depth on germination timing, seedling emergence success and subsequent growth. Unsorted seeds were planted at seven different depths (0.1, 1, 2, 3, 4, 6, 8 cm), and seeds sorted by size (large and small) were planted at three different depths (2, 4, 6 cm) in an outdoor mesocosm. Seedling emergence was significantly influenced by burial depth, and was highest at depths of 1 (57 %) and 2 cm (50 %), and lowest at depths of 6 (12 %) and 8 (5 %) cm. In addition, time of emergence was significantly influenced by burial depth, and tended to occur later from higher depths. The influence of seed size on seedling emergence success and time was not apparent, but seed size had a significant effect on seedling size as large seeds tended to give rise to larger seedlings, indicating that the mobilization of metabolic reserves may be important during initial seedling development.

Progress in ecological restoration of *Zostera nigricaulis*

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Heterozostera nigricaulis is a common and wide-spread seagrass species found in protected coastal habitats of temperate Australia, including Tasmania. Since the species was discovered in 1867 the systematics and biology of the species has confounded researchers, yet the critical role the species plays in carbon sequestration, fisheries habitat and abatement of coastal erosion has been recognized. Due to advancing climate change in polar regions and the naturally transient nature of many of these meadows, we may assume the need for human intervention to assist in the recovery of declining seagrass beds in the future. Unfortunately, methods in place for restoring seagrasses in the northern hemisphere are not immediately transferable or relevant to seagrass restoration in Australia. This is likely due to unique genetic, morphological and geographical characteristics of *Heterzostera* and its extant meadows. As such specific research into ecological restoration of this species is greatly needed. Our study aims to understand the role of biogeochemical pressures on the resilience of *Heterozostera* meadows and establish methods for large-scale restoration of *Heterozostera nigricaulis.* We present the results of our restoration trials (through the

use of reproductive propagules of *H. nigricaulis,* including rhizomes, plantlets and seeds) in both laboratory and field conditions in Victoria, Australia. Differences in effective grow-out techniques and restoration strategies are discussed, along with preliminary suggestions for optimum success.

Fast expansion and fragments of the invasive seagrass Halophila stipulacea in Lac bay, Bonaire

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In the Caribbean, the invasive seagrass species Halophila stipulacea , originating from the Red Sea and western Indian Ocean, has become established since 2002. The continuous expansion of H. stipulacea at the cost of the native seagrass species Thalassia testudinum may have unintended ecological consequences, including altered canopy structure and belowground productivity. Additionally, T. testudinum is the primary food source and preferred species of the endangered green sea turtle, Chelonia mydas. We studied H. stipulacea development in Lac bay, Bonaire (7 km2) by assessing expansion rates since its establisment in 2010, both on large and small scale. Seagrass cover was measured at 48 permanent GPS points throughout the bay in 2011, 2013 and 2015. In 2011 H. stipulacea was present at 5 of these points, in 2015 it had expanded to 13 points in total. Average H. stipulacea cover in the bay increased from 6% in 2011 to 20% in 2015 while T. testudinum decreased from 52% to 33%. If this invasive species continues to expand at the current rate, seagrass cover in Lac bay is expected to shift from T. testudinum to H. stipulacea dominance around 2017. Additionally we measured the rate of settlement and growth of fragments of H. stipulacea, released in reaction to physical disturbance and turtle grazing. Free floating fragments were collected and attached to ropes on the sediment. Within 12 days we recorded a success rate of 96% settlement and all these fragments were rooted. Shoot production was on average 0.91 day-1 . Our results may help in modelling future expansion throughout the Eastern Caribbean and beyond. The observed shift from T. testudinum to H. stipulacea dominated meadows will have serious consequences on the productivity, habitat structure, food availability for C. mydas and stability and resilience of the Caribbean seagrass ecosystems.

SeaArt – Long term establishment of SEAgrass ecosystems through biodegradable ARTificial meadows

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Seagrass meadows are important ecosystems which provide a wide variety of ecosystem services. However, they are under threat from anthropogenic pressures. Consequently, a global decline has been observed over the last decades. Restoration efforts are inherently difficult as the absence of seagrass leads to enhanced hydrodynamic energy and turbidity levels which restrict seagrass growth. To overcome this feedback loop, we are developing artificial seagrass (ASG) which looks and feels similar to natural seagrass and provides the ecosystem services that enable natural seagrass to establish within and around the artificial structure: The artificial seagrass will provide suitable hydrodynamic and light conditions as well as stabilise the sediment to allow natural seagrass to either grow from seeds, take root after transplantation or expand existing meadows more easily. A key aspect is the use of fully biodegradable materials for the development of the ASG to ensure that no potentially harmful non-degradable substances will be introduced into the system and no structures remain in the system. The aim is to establish a purely natural seagrass meadow long-term without the need to manually remove initial structures as they will disintegrate over time. Within the project we:
(i) Assess the required and critical biological and environmental conditions for seagrass establishment.
(ii) Design ASG including an anchoring system that can provide these conditions.
(iii) Identify biodegradable materials and their potential use as ASG through assessing their degradation behaviour in the marine environment and the role of additives in this process.
(iv) Explore means of commercial use of the ASG and output materials (e.g. seagrass detritus).
Based on the gained insights, we will to produce a prototype during the second half of the project and test its performance and stability under controlled, yet extreme, conditions in a full scale flume experiment.

Two years of seagrass restoration in the northern Venice lagoon (Italy) under the LIFE SeResto project: environmental constraints at multiple spatial scales to restoration of seagrass fish assemblages

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The Venice lagoon (Northern Adriatic Sea, Italy) is a highly heterogeneous ecosystem featuring multiple spatial gradients. In its northern basin, seagrass meadows have largely reduced during the last 30 years as a result of anthropogenic activities. The project LIFE12 NAT/IT/000331 – SEagrass RESTOration (SeResto) started in 2014 to favour the restoration of meadows in this area by means of small transplantations of seagrass sods. This is

expected to trigger the natural re-colonisation of meadows and of associated fish assemblages on a large scale. Aim of this work was to investigate the environmental determinants driving the success of restoration of seagrass fish assemblages, at both site scale and habitat mosaic scale (i.e. the habitats' complex in which each restoration site is located). Water and sediment physico-chemical parameters and seagrass development were measured at each transplantation site, with also fish fauna being monitored in a subset of sites. In addition, each site was characterised in terms of habitat mosaic composition and configuration, by computing a set of metrics based on relative surface occupied and spatial arrangement of habitat typologies within 500 m-radius circular buffers. At the site scale, a correlation analysis showed that high water turbidity and nutrient enrichment were the major constraints for meadow development and subsequent fish colonisation. A cluster dendrogram, based on mosaic metrics, was then compared with one based on vegetation cover and patch diameter: groups of sites showing similar mosaic characteristics showed also similar performances in terms of restoration success. In particular, sites located in mosaics with less tidal creeks and channels were also characterised by lower seagrass expansion, with consequently lower abundance and diversity of target fish species. The work highlights the importance of taking into account also the environmental characteristics at the seascape scale, when evaluating the potential constraints to restoration of seagrass fish assemblages.

Seed size affects viability and germination in the seagrass *Zostera nigricaulis*

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Factors influencing germination and seedling survival in seagrass is crucial for understanding population resilience and long-term viability. *Zostera nigricaulis* is a common nearshore seagrass in southern Australia, yet little is known about its reproductive biology. In Port Phillip Bay seed morphology varies between populations but is not linked to the number of seeds produced in these populations. Seeds were consistently larger and heavier seeds in the south of the bay (mean seed weight 2.37 ± 0.06 mg) than at 2 sheltered sites that produced small seeds (1.80 ± 0.04 mg, 1.70 ± 0.04 mg) and a third population in the east of the Bay that produced intermediate sized seeds (2.14 ± 0.06). Variations in seed size may be related to environmental adaptations and can have implications on seed viability, germination and seedling success (both establishment and survival). Viability was tested in stored seeds after 3, 6, 12 months and varied between populations over time but was not influenced by seed size. We detected a strong site effect on seed viability in field transplant experiments and there was evidence for adaptation where local seeds remained viable for longer than seeds collected from outside the site. In laboratory experiments overall percent germination was greater and mean time to germination longer in seeds from site with large and intermediate seeds compared with small seeds. These results show seed size has a clear effect on *Z. nigricaulis* seed viability and germination success. Variations in seed size across

sites appears to result from adaptation to local environmental conditions and may limit populations to recover from input of seeds from non-local sites.

A first detailed assessment of current environmental pressures affecting the performance of *Zostera marina* in western Irish populations.

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Eelgrass, *Zostera marina* L., the most widely distributed seagrass in the northern hemisphere, plays a key role in the coastal zone due to high productivity, stimulation of biodiversity, protection of the coastline, carbon storage and nutrient retention. However, despite these key functions within marine ecosystems, its conservation status and distribution in Ireland is not clear, partly because of inaccessibility of potential eelgrass habitats. This project represents the first detailed assessment of current environmental pressures affecting the performance of *Zostera marina* in western Irish populations. To characterize and identify seasonal changes we compared three different meadows on the west coast. Locations were chosen due their different environmental conditions. Seasonal characterization was conducted using permanent monitoring transects at different depts. We assessed temporal and spatial changes related to density, percentage cover, biomass and morphology of the seagrass populations, as well as variation in fatty acid and pigment concentrations. Additionally we observed interactions between *Zostera marina*, *Sargassum muticum* and maerl communities. Most plant descriptors were considerably influenced by seasonal shifts, by location, and by depth. When comparing biometric parameters we observed significant higher values in winter than in summer, and also higher values at greater depth. On the other hand, biomass, density, percent cover were higher in summer than in winter. As eelgrass populations are under threat globally, an accurate characterization of eelgrass in Ireland will be critical to define adequate future conservation policies. This project therefore constitutes an essential study to contribute to current efforts in seagrass monitoring and management across Europe.

First record of seagrass in Cape Verde, eastern Atlantic

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The Cape Verde archipelago consists of 10 volcanic islands in the eastern Atlantic Ocean located 570 km off the coast of Western Africa. While the shallow benthic communities have been studied in some detail no seagrasses have been previously reported for the Republic of Cape Verde. The seagrass *Halodule wrightii* Ascherson was found and described at one location at Praia, Santiago Island. There it formed a number of patches (≈10) covering a total of ≈ 20 m^2 at 1.4-1.6 m depth on fine sand soft bottoms. Some population characteristics are also reported. Two other sites with seagrass are also reported for the first time. The current record fills a knowledge gap regarding the distribution of seagrasses in the Tropical North Atlantic and it is expected that seagrasses will be found at other suitable sites within the archipelago.

Seagrasses in Costa Rica: from the dynamic and modest Eastern Tropical Pacific to the mighty Caribbean

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Seagrass meadows provide a multitude of ecosystem services, yet research on seagrasses in Costa Rica has been limited. This is a small country in Central America privileged in having two ocean bodies on either side: the Eastern Tropical Pacific (ETP) and the Caribbean. These two regions are separated by only approximately 250 km of land in Costa Rica, yet their seagrass meadows and climate regime vary greatly. Here, we carried out a review of research on Costa Rican seagrasses in order to assess the level of current knowledge and key gaps to address. We carried out extensive literature searches, including grey literature, and visited the herbariums of Costa Rica to include samples that have not been published. We found that seagrass meadows in the ETP are more modest in size and have a dynamic presence. There have been multiple reports of seagrass meadows in the ETP, as well as documented reports of seagrass loss. Since 2010 new meadows have been developing in the southern Pacific coast of Costa Rica. These seagrasses are being consumed by sea turtles in the area and by undetermined fish species. A new seagrass meadow in the northern Pacific is reported in this study for the first time. Seagrass meadows in the Caribbean are larger in size and are more persistent, typical for the Caribbean region. Past research has focused on Caribbean meadows, while information for seagrasses in the ETP is very limited. In this study, we present an up to date analysis of the current knowledge of seagrasses in Costa Rica, highlighting key differences between meadows in the ETP from those in the Caribbean, for consideration in conservation and management initiatives. We also present key knowledge gaps in the current research and our latest plans to address these key gaps.

Taxonomy of the genus *Ruppia* in China

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Ruppia is a cosmopolitan genus and the species identity within the genus has been often confusing due to high plasticity in morphology. We used nuclear ribosomal DNA internal transcribed spacer and seven chloroplast DNA fragments combined with morphological traits to distinguish *Ruppia* species along the coastline of China, and to infer the potential mechanisms shaping their distribution patterns. Molecular and morphological data distinguished three congruent clades corresponding with three species: *Ruppia brevipedunculata* n. sp., *Ruppia sinensis* n. sp., and *Ruppia megacarpa* Mason. The geographical ranges of *R. sinensis* and *R. brevipedunculata* coincided closely with coastal current breaks by the Taiwan Strait; *R. sinensis* was found in 17 locations mainly in the north, whereas *R. brevipedunculata* was common in the south, most likely to be the result of differentiated adaptation to optimal temperatures of growth and/or seed germination. *Ruppia megacarpa*, usually considered as an endemic species of Australia and New Zealand, was first reported in China at two bird stopover sites, Qingdao and Yancheng. The transoceanic dispersal by migratory birds may contribute to the presence and distribution of *R. megacarpa* in China.