ISBW13
SINGAPORE 2018

WORLD SEAGRASS CONFERENCE 2018

INTERNATIONAL SEAGRASS BIOLOGY WORKSHOP 13

ABSTRACTS

SINGAPORE

11–17 JUNE, 2018
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Contents

Information for presenters

Oral presentation

Oral presentation files must be uploaded at the Secretariat Room (Seminar Room 1, Stephen Riady Centre) at least one day before your talk. Speakers who will be presenting on 11 June (Monday) may upload their talks at the Registration desk on 10 June (Sunday). Talks must be in PowerPoint (.ppt or .pptx) format. If there are videos/GIFs included in the presentation, presenters must make sure that they are able to be played after uploading. Each oral presentation is 12 minutes long with a 3-minute Q&A, and the chairperson of the session will ensure that the timings are followed STRICTLY. This is to ensure that all oral presentations start on time and will allow participants to move between concurrent sessions to attend their desired talks.

Poster presentation

Poster presenters may put up their posters for display on the poster-boards outside Auditorium 2 at the Stephen Riady Centre from 10 to 11 June (Sunday to Monday), and posters will be on display till 14 June (Thursday). All posters should not exceed A0 dimensions, or approximately 119 cm (length) by 84 cm (width). Posters larger than these specified dimensions may not be able to fit the provided poster-boards.
Presenters may only attach posters to designated boards (which will be labelled with abstract numbers, ISBWXXX), and will be provided with materials to attach the posters to the poster-boards.

The poster session will be held at 7pm on 12 June (Tuesday) outside Auditorium 2. Canapes and drinks will be provided during the poster session. Presenters should be available by their posters for presentation during the poster session.

ORAL PRESENTATIONS

ISBW002: Lessons learnt from a community seagrass monitoring group: A unique deep water temperate seagrass experience from Rockingham, Western Australia

Elaine Christy, Arthur Christy

Rockingham Bays Seagrass Monitoring Group, RBSMG

RBSMG began in 2001 because of an absconding PhD student with start-up funds to study seagrass in a proposed marine park near Point Peron, Perth, Southwest Australia. The group formed to continue work that had just started. From this unconventional beginning the group expanded work to include two sites in Cockburn Sound and three sites around Penguin Island and Warnbro Sound. It monitored seagrass between 2001 and 2013. Sites were in “shallow” water ranging in depth between 2 and 6 metres composed of patches of temperate long-bladed *Posidonia* spp. Analyses showed no consistent expansion or loss except one site where favourable environmental conditions with gradual change was occurring rather than being subjected to human physical activities, nutrient enrichment or increased thermal exposure from a warming climate and reduced water circulation exacerbated by a causeway and sand movement.
A lack of volunteer scientists to generate robust consistent methods, non-existent collaboration and support from government natural resource agencies including finances and boats, and inconsistent support from local environmental groups made it difficult to provide more valuable monitoring data on threatened long-lived keystone seagrasses supporting important ecological processes in a multiple use marine park and region.
Positives were consistent volunteerism of university students, small handful of key members who cared about their local environment and sporadic funding from Fremantle Ports who did not have direct management responsibility. The Group is now defunct but archiving its monitoring data so the effort and importance of work can be used in current and future management.

ISBW004: Flowers of the intertidal seagrass *Halophila stipulacea* (Forsskål) Ascherson: A new record from tropical coast of Tanzania, Indo-Pacific

Moses Shimba[1], Fredrick Jonah[2]

[1] The University of Dodoma
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Flowers of the seagrass *Halophila stipulacea* (Forsskål) Ascherson in Tanzania are currently unreported. The present study was conducted along the coast of Tanzania, Indo-Pacific, Kunduchi intertidal mudflats. Transplanted cuttings from Kunduchi intertidal mudflats were successfully grown in sand-mud substrate in the growth chamber in a 12 h photoperiod (1,250 µmol photons m-2s-1) and an inductive temperature, salinity, and pH range of 24 to 28°C, 34 to 38‰, and 7 to 8, respectively. Plants began to flower after four months of culturing. No flowers were observed in the first three months; 0.229±0.50 staminate and 0.123±0.45 pistillate were recorded between April and June; 0.440±0.65 staminate and 0.221±0.03 pistillate between July and September, and 0.282±0.36 staminate and 0.105±0.78 pistillate between October and December. Although, further research is required to fully assess the pollination success and sexual reproduction including fruiting of the species, our study is the first to report the presence of flowers *ex situ* in Tanzania.

ISBW007: Ethnophycological aspects of seagrass, a step towards its conservation in Andaman Islands

Mohammed Naufal, Gadi Padmavati

Pondicherry University

The contributions of marine ethno biology have been mainly focused on fisheries and fishery management. In order to assess the ethnobotonical status of marine angiosperms in the South Andaman Island, a qualitative study on distribution of sea grasses in Chidiyatapu was carried out for a period of three months i.e. December 2012 to February 2013. A total of six seagrass species *Thalassia hempirichi*, *Halodule uninervis*, *Halophila ovalis*, *Halophila ovata Cymodocea rotundata*, *Halodule pinifoli*a were identified. Among them, *T. hempirichi*, and *H. ovalis* were reported to have ethnomedicinal value from Tamil Nadu coast. In the present study, communication among the local people exposed the unawareness about the medicinal as well as nutritional values of sea grasses. Our findings provide the first case study on the traditional knowledge of sea grasses as an ethnomedicine from South Andaman. The aim of this study is to assist the local people in conservation efforts regarding sea grasses through identifying Traditional Ecological Knowledge (TEK) from depth and breadth of local knowledge systems of sea grasses for this particular ecosystem which is in peril. A strong and well planned awareness should be done in order to utilize the benefits of these marine angiosperms and the need for conservation to sustain for the next generation.

ISBW009: Experimental Transplantation of 500m^2 of *Posidonia oceanica* in Monaco

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The project of extension at sea of Monaco required the realization of important environmental measures to protect the marine environment. Among differents actions was included a significant experimental measure of transplantation of nearly 500m^2 of *Posidonia oceanica* located in the project area.
To reach this objective we have developed and implemented the SafeBent protocol. The SafeBent protocol allows to sample CLODS of seagrasses (0.8m^2 / 60cm thick) with a marinized TRANSPLANTER (Model Optimal 880) operated with a very long arm shovel (27m) from a jackup. The main advantages of this method are:
- high transplantation rate (up to 32m^2/hour);
- conservation of the structure of the seagrasses in meadows;
- conservation of the sediment;
- easy transport of clods in specially manufactured metal baskets
The transplantation was carried out between 20 March and 15 May 2017. Seagrasses were reimplanted in the ground of the AMP of Larvotto (384m^2) and on the berm of the dam along the port of Fontvieille in specially constructed concrete planters (116m^2).
The present communication aims to present the Safebent method and the results obtained to date.

ISBW010: A Comparison of Ecological Attributes in Degraded and Healthy seagrass beds in Coastal Kenya

Charles M. Muthama[1], Boaz Kaunda-Arara[2], Jacqueline N. Uku[1]

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[2] University of Eldoret

Ecological attributes of degraded and healthy seagrass beds were compared for five months (April – August 2016). Sampling was done off Mwaepe, Mvureni and Chale fish landing beaches within plots of $20m^2$ at 2m - 3m depth during low spring tide. 2 plots, a degraded and healthy plot per station, were targeted, resulting to 6 plots in total. Seagrass cover, shoots and canopy were assessed alongside sediment macrofauna, organic matter and nutrients. Cover between months didn't differ (H=9.148; p=0.058) and stations (H=0.158; p=0.924) but degraded and healthy plots were different (H=213.163; p=0.001). *T. hemprichii, S. isoetifolium* and *T. ciliatum,* dominated healthy areas whereas *H. ovalis, H. stipulacea* and *H. wrightii* dominated degraded areas. Healthy areas had higher shoot densities and macrofauna diversity (Shannon-Weiner Diversity Index, p=0.0127). ANOSIM showed higher faunal densities in healthy areas than in degraded areas (R=0.25; p=0.001), whereas an MDS showed closely related fauna assemblages in healthy areas compared to degraded areas. Organic matter in sediments differed between months (H=97.052; p=0.001) but not in degraded and healthy plots (H=2.892; p=0.089) where sediment nutrients were also similar. A CCA predicted more fauna taxa in sediments controlled by organic matter than by nutrients. Healthy seagrass beds are better in fauna assemblages and organic matter presence probably because of higher shoot density and percent cover of seagrass. However, proximity to degraded areas can influence the fauna and nutrients availability. Restoration of degraded seagrass beds may be a good idea to help achieve full benefits associated with healthy seagrass beds.

ISBW011: GIS-Based Vulnerability Assessment of Seagrass Meadows In Different Study Areas In The Philippines

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[1] IAMBlueCECAM Program: Project 2 LiDAR, Hyperspectral, and Sonar Remote Sensing of Seagrass Meadows (SeaRS)
[2] Phil-LiDAR 2 Project 2: Aquatic Resources Extraction from LiDAR Surveys

Seagrass beds in the Philippines have been declining through the years because of climate change and anthropogenic activities. Vulnerability assessment is an important tool in determining areas which are mostly affected by the different phenomena such as sea level rise, increased ocean temperature, extreme heating events, extreme rainfall, and disturbed water budget. Current studies regarding the vulnerability assessment of resources involved determining its exposure on different phenomena, sensitivity on different criteria, and its adaptive capacity on these threats.

Geographic information system (GIS) has been an important tool for visualization, analysis, interpretation, and solution to spatial datasets to understand its relationships, patterns, and trends. Using the different tools in GIS, a GIS-based vulnerability tool is developed for seagrass meadows.

The Phil LiDAR 2 Program is a project by the Department of Science and Technology and University of the Philippines – Diliman Training Center for Applied Geodesy and Photogrammetry (UP TCAGP) which aims to produce detailed resource maps using the LiDAR technology. As part of its objectives, a GIS-based vulnerability assessment for coastal resources is also developed. With the help of different partner universities from the different parts of the Philippines, a vulnerability assessment maps of seagrass meadows from climate change and anthropogenic activities have been conducted.

The output from different partners and the UP TCAGP provided an overview of the status of seagrass meadows in the different parts of the Philippines. The vulnerability maps will be very useful in providing protection and management in the one of the most neglected ecosystem.

ISBW012: First report of seagrass boring bivalve (Zachsia, Teredinidae) in Malaysian water

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For the first time, we report the occurrence of rare seagrass boring bivalve (*Zachsia*, Teredinidae), from a site off the NW Borneo coast (Sabah, Malaysia). The distinct morphology of the pallets, the key taxonomic character of the family, combined with molecular data from the small (18S) and large (28S) nuclear rRNA sub-units, confirm this tropical *Zachsia* as a new species. It was found within the rhizomes of *Enhalus acoroides* and *Cymodocea rotundata*, with an occupancy of 12% (n=100) and 1% (n=400) respectively. The growth rate of the host seagrass (0.220±0.038 cm day^{-1}) significantly lower compared to unaffected seagrass (0.738±0.036 cm day^{-1}). This finding may be significant, as it suggests, for the first time, rhizome parasitism is another possible and hidden vector in controlling seagrass growth and mortality, a factor that may significantly reduce seagrass meadow ability to recover from disturbance. Furthermore, our investigation of soft literature suggested several possible sightings of *Zachsia* from South East Asia (Thailand and Philippines) to Pacific region like Papua New Guinea. This suggests that the bivalve's distribution may wider across the tropical region and will require more but less destructive quantitative approaches to further understand the distribution and impacts on seagrass growth for long-term conservation outcomes.

ISBW013: Impacts of megaherbivores on expansion of invasive seagrass in the Caribbean

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Our knowledge on the functional role of large herbivores is rapidly expanding, and the impact of grazing on species co-existence and non-native species expansion has been studied across ecosystems. However, experimental data on large grazer impacts on plant invasion in aquatic ecosystems is scarce. We investigated the changes in seagrass occurrence and the impacts of grazing by green turtles on non-native seagrass expansion in Lac Bay (Bonaire, Caribbean Netherlands).
We found that Green turtle grazing behavior changed after the introduction of non native seagrass (*H. stipulacea*) in 2010. Field observations, together with time-lapse satellite images over the four last decades, showed initiation of new cropping patches (65 ha, an increase of 72%) in shallow areas with native seagrass species that had previously (1970-2010) been ungrazed. Green turtles deployed with Fastloc-GPS transmitters confirmed high site fidelity to these patches that were initiated along the sharp border of grazed and ungrazed native seagrass patches. In addition, cafeteria experiments indicated selective grazing by green turtles on native species. In parallel, in exclosure-experiments, introduced seagrass expanded more rapidly in grazed canopies compared to ungrazed canopies. Finally, in 6 years *H. stipulacea* underwent a significant expansion, increasing from 6% to 20% total surface cover.
Combined, our results showed that *H. stipulacea* can rapidly colonize, and replace native seagrasses in the Caribbean. We conclude that green turtle grazing may modify the rate and spatial extent of this invasive species' expansion, due to grazing preferences, and increased space for settlement. We argue that large herbivores play an important but unrecognized role in invasions of ecosystems.

ISBW014: Spatio-temporal dynamics of seagrass in the mariculture parks of Southern Philippines

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The promotion of maricuture parks in the country provides viable economic activity for food production, income and employment to coastal town people. However, improper culture practices may pose potential threat to the environment through increased organic loading and eutrophication. To evaluate possible impact, seagrass community structure was assessed in the three mariculture parks. Seagrass assessment follows the SeagrassNet protocol. Age structure of the dominant seagrass species was also conducted using coring and age reconstruction technique. Other environmental parameters such as sediment organic matter content, pH, grain size were determined using standard protocols.

A total of eight seagrass species has been identified in the three mariculture parks, dominated by *Thalassia hemprichii*, followed by *Cymodocea rotundata*. Seagrass vegetation is relatively rare in Balingasag, patchy distribution in Nabago and extensive in Lopez Jaena. Seasonality did not seemed to influence seagrass cover, except those in very shallow area exposed during daytime low low tide occurring during northeast monsoon season resulting to shorter leaves, hence lower cover. However, seagrass cover and species composition are generally lower in stations near active culture areas. Age structure of *Thalassia hemprichii* is also highest in Lopez Jaena and lowest in Balingasag. Capacity for recovery through rhizome bud formation is possible, but generally low in stations near the culture area in all sites. *Thalassia hemprichii* dominates in all sites, but there is a tendency for *Cymodocea* spp and *Enhalus acoroides* to dominate in stations close to active culture areas.

ISBW015: High levels of genetic diversity and gene flow in the marine angiosperm *Amphibolis antarctica* (Labill.) Asch.

Alex Gorman[1], Michelle Waycott[2], Kor-Jent van Dijk[2], Jennifer Verduin[1]

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The marine angiosperm *Amphibolis antarctica* is an important foundational species throughout its range across southern temperate Australia. The decline of seagrass populations world-wide requires the maintenance of genetic diversity and connectivity. *Amphibolis antarctica* is one of only a few species of seagrass that form viviparous propagules which have the ability to persist in the water column for extended periods after release before recruitment, potentially allowing long distance dispersal (LDD). Population structure of this marine plant will be influenced by the potential for viviparous seedling to move long distances. This study assessed population genetic structure and gene flow in the seagrass *Amphibolis antarctica* around Perth, Western Australia. In addition, we evaluated the broad scale genetic diversity and gene flow among several regions across Western Australia and South Australia. Species specific microsatellite marker loci (14) were used on samples collected from meadows both locally and regionally. Some populations showed evidence of significant clonality although most did not. Overall genetic diversity within and between populations was high. Connectivity was moderate among the Perth metropolitan area populations and the genetic distance among populations increased as the geographic distance two populations increased following a generalized pattern of isolation by distance. Oceanographic movement strongly limits propagule dispersal on both a within and between region scale. This study confirms the recent observations by our group that *Amphibolis antarctica* is a diverse, sexually reproducing seagrass species with a strong capacity to disperse long distances. Dispersal distances are affected by propagule interactions with hydrodynamics.

ISBW016: Evolving ideas for monitoring colonising seagrasses

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Seagrasses found in estuaries tend to be of the colonising type, with rapid turnover and the ability to reproduce quickly and create seedbanks. Historically in Australia, most monitoring and management strategies have been better suited to opportunistic and persistent seagrasses. This talk will outline our evolving approach to monitoring colonising species (*Halophila ovalis* and *Ruppia megacarpa)* and include some surprising findings from 5+ years of monitoring seagrasses within the estuaries of south-west Western Australia. Our initial aim was to use seagrasses as biological indicators of estuary condition, with a focus on including functional-level indicators that might directly inform management actions. We began this work in 2011 for the Swan-Canning Estuary, and in 2014 for the Leschenault Estuary. A hierarchical approach to monitoring was adopted in both programs. While the seagrass population of the Swan-Canning has been relatively stable over the monitoring period, seagrass within the Leschenault Estuary has been undergoing recovery. This recovery was first observed at the finer monitoring scale, and current observations suggest broadscale recovery is occurring this summer, 2017/18. More recently, we have been considering how our long-term data might be utilised to understand the resilience of seagrass and how best to frame a combination of indicators to inform management.

ISBW017: Molecular investigation of heavy metal stress in the seagrass, *Zostera muelleri*

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Submerged plants including seagrasses can be subjected to a wide range of contamination as a consequence of increasing coastal development. Industrial waste as well as agricultural and domestic run-off from lands, often rich in heavy metals have been shown to be major sources of environmental pollutants having deleterious effects on seagrasses mainly at physiological level. The molecular response of heavy metal toxicity in seagrasses however, is comparatively understudied compared to terrestrial plants. Therefore, the study of heavy metal stress in seagrasses at the molecular level and identification of applicable biomarkers can provide valuable information for early detection of toxicological exposure to seagrasses. Hence, in this study, the toxicity response of the seagrass, *Zostera muelleri* was studied with special attention to the effect of elevated levels of copper. RNA was extracted from *Z. muelleri* leaves after 7 days exposure to 0.5 mg/L and 0.25 mg/L of copper concentrations. Molecular mechanism of copper-related toxicity of *Z. muelleri* was identified using HiSeq 2500 Illumina sequencing.
The results of this study can be useful for better understanding the molecular mechanism of heavy metal toxicity in seagrasses, as well as identifying potential biomarkers for early detection of toxic exposure in seagrass meadow. This knowledge can provide valuable information for implementing more efficient conservation strategies for seagrass.

ISBW022: The effects of climate and environmental conditions on *Zostera muelleri* non-structural carbohydrate composition

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We investigated the spatial variability of seagrass non-structural carbohydrate (NSC) composition between temperate and tropical populations of *Zostera muelleri*. NSC function as metabolic reserves of seagrasses, which provides a measurable insight into seagrass resilience at a given time. Environmental factors can significantly alter NSC content in seagrass sink tissues. We investigated if there is a difference in NSC composition between tropical and temperate seagrasses, testing the hypothesis that lower latitude plants store less soluble NSC compared to higher latitude plants.
Seagrass samples were collected at two temperate sites (Port Phillips Bay, Victoria) and two tropical sites (Townsville, Queensland) on the east coast of Australia. For each climate region, we aimed to sample one site with higher mud content as a proxy for terrigenous sediment input. Sample collection occurred in the southern hemisphere spring, when daylight hours in the two regions were close to equinoctial (~ 13 h). The effects of climatic and environmental conditions on *Z. muelleri* NSC compositions were investigated, as well as the relationships between NSC and morphometric variabilities. We anticipate that the outcome of this study will aid the determination of appropriate spatial scales for research, management and monitoring of *Z. muelleri*.

ISBW023: FISHing for cable bacteria in oxic-anoxic microsites of seagrass roots

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Seagrasses thrive in anoxic, sulphide rich sediments. Sulphide is a known phytotoxin, which raises the question of how these plants survive. Here, we combined fluorescence microscopy with 2-D chemical and molecular techniques to map the micro-environment of growing roots of two seagrass species; *Halophila ovalis* and *Zostera mucronata*. We found that when roots leaked oxygen, the abundance of potential sulphate reducing bacteria decreased and sulphide concentrations in the surrounding rhizosphere declined. Roots leaking oxygen also had a higher abundance of filamentous sulphide oxidising cable bacteria within the root hair zone. We propose that oxygen loss serves to protect seagrasses from sulphide intrusion not only by abiotically oxidising sulphides, but also by manipulating the abundance of sulphate reducers and sulphide oxidisers that surround vulnerable growing roots. These results add an unexplored dimension to our understanding of sulphide detoxification in seagrass ecosystems.

ISBW026: Effects of temporal variation and geographical distribution on the synthesis of key biochemical descriptors of *Zostera marina* populations

Pedro Beca-Carretero, Freddy Guiheneuf, Dagmar G. Stengel

National University of Ireland, Galway (NUIG)

Zostera marina is a dominant, subtidal meadow-forming seagrass in temperate regions in the northern hemisphere, including Irish coasts. Despite ranking amongst the most valuable ecosystems worldwide, the status of seagrass conservation in Ireland is currently not clear. For the first time, this investigation assessed the biochemical responses of Irish *Z. marina* populations to temporal changes in temperature and irradiance. Total fatty acid (TFA) content and composition and photosynthetic pigments were studied in healthy green leaves of seagrass shoots (n = 6) collected in April, July, November 2015 and January 2016. *Z. marina* leaves collected in winter accumulated significantly 2-3 fold more TFA and photosynthetic pigments than in summer. Increases in TFA were mainly related with the larger synthesis of polyunsaturated fatty acids and the lower production of saturated fatty acids (SFA) in colder periods. As PUFA are mainly partitioned into structural lipids constituting the cellular membranes, in particular the thylakoid membranes of chloroplasts, they promote their fluidity, as well as electron transport, and thus seagrass photosynthetic activity. These results therefore highlight the large capacity of *Z. marina* to adjust their lipid composition to achieve optimal membrane fluidity under less favourable environmental conditions. Additionally, a comparison of FA composition of *Z. marina* across its latitudinal distribution range (southern Spain to Greenland) was undertaken. Results suggest that populations adapted to warmer *in situ* seawater temperatures had a significant lower PUFA/SFA, indicating that future warming may negatively affect the nutritional value of seagrass with implications for higher trophic levels.

ISBW027: Understanding genetic resilience: spatial patterns and drivers of clonal richness

Kathryn McMahon[1], Richard Evans[2], Kor-jent van Dijk[3], Udhi Hernawan[4], Paul Lavery[1], Ryan Lowe[5], Marji Puotinen[6], Michelle Waycott[3]

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Clonal richness has significant implications for genetic resilience as low clonal richness implies a small population with low genetic diversity and limited ability to resist and adapt to environmental change. In addition it means a low potential to produce viable offspring and develop a seed bank, an important process to enable recovery from extreme events that result in mass mortality. The increase in the number of genetic studies on seagrasses enable us to examine the spatial patterns and drivers of clonal richness. This presentation will assess the drivers of clonal richness in meadows of two tropical seagrass species, *Halodule uninervis* and *Halophila ovalis* in NW Australia over 8° latitude, using general additive mixed models. Disturbance combined with sea surface temperature strongly predicted spatial patterns of clonal richness. Sites with a high probability of cyclone disturbance had low clonal richness, whereas an intermediate probability of cyclone disturbance and the presence of dugong grazing combined with higher sea surface temperatures resulted in higher levels of clonal richness. Under a changing climate, increased severity of tropical cyclones and the decline in populations of mega-grazers have the potential to reduce clonal richness leading to less genetically diverse and resilient populations.

ISBW029: Set-backs and successes: Seagrass restoration in the Dutch Wadden Sea

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[2]Dept. of Aquatic Ecology, Radboud University
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[4]Vereniging voor Natuurmonumenten

Seagrass beds form keystone habitats in coastal areas all over the world. However, these precious ecosystems are rapidly declining on a global scale. In the Dutch Wadden Sea, vast subtidal eelgrass (*Zostera marina*) beds determined ecosystem functions before the 1930s. Due to a combination of large-scale construction activities and a wasting disease, all subtidal eelgrass beds (~140 km^2) disappeared and never recovered. There are still some intertidal seagrass beds but they are declining. Restoration efforts to reverse eelgrass loss have been ongoing since the 1990s. In this talk, I will report on recent research results with regard to a seed-based restoration project aimed at intertidal, annual eelgrass. In this project, we managed to take some important steps to counter bottlenecks for seed survival in winter by controlled seed storage and treatment against the newly discovered disease *Phytophthora gemini*. Additionally, by using innovative planting techniques, we have progressed immensely towards target plant densities. Although restoration in the Dutch intertidal Wadden Sea remains challenging, important steps have been taken towards increased restoration success.

ISBW030: Study of seagrass habitats from the Andaman and Nicobar Islands, India

Swapnali Gole, Sohini Dudhat, Prem Jothi, Anant Pande, Rukmini Shekar, Samiha Pathan, Sivakumar K., Johnson J.A.

Wildlife Institute of India

Topographically, the Andaman and Nicobar Islands in India are endowed with varied landscapes such as rocky shore, sandy beaches, backwaters, bays, lagoons, mangrove forests and coral reefs. The continental shelf is narrow and slopes rapidly to great depths. The narrowness of the shelf is compensated by the numerous bays, lagoons, reefs and creeks replete with seagrass habitats. In India, the Andaman Islands support the second highest diversity of seagrasses with 12 species and these habitats are vulnerable to a varied degree of natural (cyclones and tsunami) and anthropogenic (coastal development, fishing activities and tourism) pressures. Despite this fact, huge ecological paucity still exists on their habitat dynamics compared to the adjacent coral reef and mangrove ecosystems. With respect to global studies, no long-term monitoring program is in place to monitor spatiotemporal changes on seagrass habitats of Andaman and Nicobar Islands, India. The present study aims at, (a) spatial and temporal distribution of seagrass, (b) documentation of benthic invertebrates and establishing the role they play in a seagrass ecosystem, (c) analysing threat to suggest conservation action, and (d) undertaking awareness and incentive programs to involve community in conservation of seagrasses of the island groups. Data on water quality and sediment will be correlated with the growth and distribution of seagrasses along a depth gradient.

ISBW035: Impacts of *Sargassum* brown tides on near-shore Seagrass Meadows

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From 2011 until 2016, unprecedented masses of pelagic seaweed *Sargassum* spp. were reported throughout the Caribbean and along the west coast of tropical Africa. The Mexican Caribbean coast experienced a massive influx of *Sargassum* spp. from mid-2014 until the end of 2015. These masses accumulated on the shores, resulting in build-up of decaying beach-cast material and near-shore murky brown water. We named this phenomenon *Sargassum*-brown-tide (Sbt). The effects of Sbt on four near-shore seagrass meadows included reduction in light, oxygen (hypoxia or anoxia) and pH, and increased temperature and ammonia concentration. The monthly influx of nitrogen by drifting *Sargassum* spp. was estimated at 6150 kg km^{-1}, and for phosphorus this was 61 kg km^{-1}, which were respectively, ~30 and ~3 -10 times the usual monthly inputs into the sea through ground-water discharge. Near-shore seagrass meadows dominated by *Thalassia testudinum* were replaced by a community dominated by calcareous rhizophytic algae and drifting algae and/or epiphytes, resulting in 61.6 to 99.5% loss of below-ground biomass. Near-shore corals suffered total or partial mortality. Recovery of affected seagrass meadows is likely to take years or decades or changes could be permanent if massive influxes of *Sargassum* spp. recur. If recurring at intervals of years or decades, the system will change permanently, resulting in increased eutrophication and loss of the ecosystem services provided by the near-shore seagrass meadows, such as facilitating biodiversity, increasing water transparency and beach stabilization.

ISBW036: Reproductive phenology and recruitment in populations of the temperate seagrass *Posidonia australis*

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Ecological data on flowering, fruiting, seed predation and recruitment in seagrasses are critical for understanding the population structure, genertic diversity and demographic connectivitiy among popluations. We have collected such data intermittently over 14 years, and annually since 2013 at Rottnest Island Western Australia for the temperate seagrass *Posidonia australis*. Here we present data on inflorescence density (0 – 120 inflorescences m^{-2}), number of flowers per inflorescence (6-60 flowers inflorescence $^{-1}$), seed set (up to 50% of flowers), number of seeds produced per inflorescence (0 – 18 seeds inflorescence^{-1}), seed predation and recruit survival between 2013 and 2018. There is considerable inter-site and inter-annual variation in seed production (0 – 1182 seeds m^{-2}), that, combined with the stochastic nature of weather affecting dispersal during seed release, and the large but variable influence of seed predation, results in temporal “windows of opportunity” for successful recruitment into adult populations. Seedlings of *Posidonia australis* recruit in distinct age cohorts during these “windows of opportunity” to re-vegetate disturbed areas to replace losses as well as introduce new genotypes into the adult population. These outcomes challenge our previously held beliefs that recruitment from seeds in this seagrass is less important in colonising unvegetated habitats and maintaining seagrass meadows than vegetative clonal growth.

ISBW037: Revising the distribution map of tropical seagrass beds in southeast Asia

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Southeast Asia is the hotspot of the global seagrass diversity, offering valuable ecosystem services to human. However, there have been great scientific gaps in the knowledge of tropical seagrass beds in this region. Information on broad-scale distribution has not been updated since the publication of World Seagrass Atlas which was based on the data mostly taken by the late 1990s. We collected new data on seagrass bed distribution after 2000 from 8 ASEAN countries (plus southern China and Japan), and integrated these data into a GIS-database. Seagrass beds area ranged from 0.3 km^2 in Singapore to 18,700 km^2 in Indonesia. Temporal changes in seagrass bed area were analysed for the 56 sites in 6 countries, which showed that 54 % of the seagrass beds are still declining with the average rate of -22 % yr^{-1}, whereas 16 % remained stable, and 30 % increasing since the late 1990s. Percentage of seagrass beds that are covered with the existing MPAs varied greatly among countries with 50.2 % of seagrass beds located within MPA in Timor-Leste, but only 0.9 % in Cambodia. Revision of the seagrass distribution so far is still insufficient to understand overall status in southeast Asia with more data input required for some key countries such as Indonesia, Malaysia and Myanmar. Nevertheless, the obtained fine-resolution, broad-scale information will be useful to help better conservation and management of seagrass beds in this region that are still under great threats by multiple human-induced stresses.

ISBW038: Site-specific ammonium toxicity in seagrass *Zostera muelleri*

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Seagrasses are important habitat-forming species that provide important ecosystem services. Seagrass habitats around the world are increasingly affected by anthropogenic stressors leading to fragmentation or loss. Excessive nutrient and sediment inputs are believed to be the major causes of this decline. However, the response of seagrasses to nutrient enrichment is believed to be site-specific and directly linking population declines to other environmental factors such as sediment property is difficult. In order to understand what makes some seagrass meadows more vulnerable to nutrient enrichment, we conducted a field experiment with four levels of sediment nutrient enrichment at three sites in Tauranga Harbour, New Zealand. Over the 13 month experiment, nutrient addition substantially increased ammonium concentration in sediment pore water, significantly impaired seagrass health, and altered benthic macrofauna structure. Interestingly, ammonium toxicity was more pronounced in seagrass grown on low-nutrient sandy sediment. Seagrass growing on sand substrate declined when sediment ammonium concentration was around 10mM. But for plants growing in mud, an adverse effect required a much higher concentration (100mM). Benthic macrofauna in the mud sites were also more resilient to sediment nutrient elevation. Based on these findings, we argue that ammonium toxicity in *Z. muelleri* meadows is more pronounced in low-nutrient sandy environments.

ISBW039: Experiences from large-scale transplantation of eelgrass in Danish waters

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The rapid loss of seagrasses worldwide calls for actions to protect or restore these ecologically important habitats. Financed by the Danish Environmental Ministry, the goal of this project is to test the feasibility of establishing large eelgrass transplantations in Danish waters. The broader perspective is to use eelgrass transplantations as a marine measure to combat eutrophication using their function as biological nutrient filters. Site-selection was of main focus and included the use of a variety of transplantation methods with different protective measures against disturbances and stressors. Site selection, including test-sites, was conducted in both a coastal and an estuarine system to increase chances of locating one suitable site. The establishment of the large-scale transplantation consisting of 17.300 anchored shoots in an area of app. 0.5 ha. The transplantation area was enclosed by two protective nets (0.3 and 0.6 m height) with perimeter of baited crab traps to alleviate stress from drifting macroalgae and the destructive shore crab, respectively. The actual transplantation work was completed within 5 days with a team of 10 persons. Survival and growth of transplants was high in the initial months. Shoot density of transplants increased by 100 % within 98 days while natural reference patches only increased by 12%. The large-scale transplantation even survived through a storm without significant losses of shoots. Overall this provides as an example of a successful large-scale transplantation of eelgrass that can be developed into a measure to combat eutrophication.

ISBW041: Responses of invasive and native *Halophila stipulacea* populations to thermal stress

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The seagrass *Halophila stipulacea* is a dioecious tropical seagrass species, native to the Red Sea, Persian Gulf, and Indian Ocean. Following the opening of the Suez Canal in 1869, this species has invaded rapidly to the eastern Mediterranean and in 2002 this species was reported in the Caribbean Sea, where it was shown to displace local seagrass species. With water temperatures in the Gulf of Aqaba (GoA) increasing and predicted to exceed 31.5°C by the end of this century, the native populations of *H. stipulacea* will face increased frequency and severity of thermal stresses. In parallel, global warming and the ongoing tropicalization of the Mediterranean Sea, facilitated by the recent doubling of the Suez Canal, could contribute to the spreading of *H. stipulacea* in the Mediterranean, potentially threatening the local seagrass biodiversity. In this study, we compared the biochemical, fitness, and photo-physiology responses of both native (Red Sea – Eilat) and invasive (Mediterranean Sea – Cyprus) *H. stipulacea* populations to current and expected thermal maxima in a controlled experimental environment (microcosm). While leaf area, effective quantum yield, and chlorophyll content increased with temperature in invasive plants, they decreased in native plants. Interestingly, the invasive population accumulated less antioxidants (SOD) under thermal stress than its native counterpart. The results suggest a rapid adaptation of the invasive population, while the native population to be threatened by predicted climate changes. By including gene expression with the other measurements shown here, we expect to reveal some of the mechanisms responsible for *H. stipulacea*'s adaptation and invasiveness.

ISBW043: Effects of desalination brine and high salinity on the temperate seagrass *Posidonia australis*

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Highly saline brines from desalination plants expose seagrass communities to salt stress but also include chemicals used in various stages of the reverse osmosis process. In a series of experimental studies over 2-6 weeks in mesocosms, we examined responses of the seagrass, *Posidonia australis* to desalination brines and hypersaline seawater at corresponding salinities (54 and 46 psu, practical salinity units) compared to seawater controls, with the aim of separating effects of salinity from other potentially deleterious components of brine, and determining appropriate bioindicators. We tested photosynthetic parameters (chlorophyll *a* fluorescence), water relations (leaf water potential (Ψ_w), osmotic potential (Ψ_π), turgor pressure (Ψ_p), leaf and rhizome concentrations of ions, sugars and amino acids, and survival and leaf growth. In only 2 weeks, the chemical additives present in high concentrations of desalination brines increased the symptoms of stress, and the onset of effects were more rapid compared to plants in hypersaline seawater at corresponding salinities. Over 6 weeks using raised salinity only, responses were dependent on concentration and length of exposure. Bioindicators for impacts associated with brine release from desalination outfalls include leaf osmolarity, ion, sugars and amino acid concentrations. The long term tolerance of germinating seedlings of *P. australis* to brines was also tested at a range of brine dilutions over 6 weeks. In contrast to adult plants, the seedlings proved to be remarkably tolerant to brine, with high survival even at 100% concentration of brine followed by recovery when returned to natural seawater.

ISBW044: Twenty-two years of photosynthetic measurements using PAM fluorometry: Benefits earned and lessons learned

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Our research groups bought some of the first water-proof PAMs (Walz Diving-PAMs, and later the Aquation *in situ* Fluorometers), and have used them extensively. Looking back, we would now like to summarise some of our principal findings regarding their usefulness in seagrass research:

- Electron-transport rates (ETR) correlate well with oxygen evolution (i.e. ~1 mol O_2 evolved from PSII / 4 mol e^- transported) in thin-bladed species, using an easily obtained absorption factor (AF), whereas other forms often show O_2/ETR <0.25.
- Rapid light curves (RLC), whether based on true ETRs or relative rates, is a good indicator of photosynthetic responses to different light fields, e.g. along depth gradients or diurnally.
- If RLCs are initiated immediately after darkening a leaf, the first Y-reading of the RLC (Y_0) equals the maximal effective quantum yield, α. Thus, α does not have to be calculated from the initial slope of an RLC.
- If the effective quantum yields (Y, $=\Delta F/F_m'$) are <0.1 (often the case at high irradiances), they are unreliable.
- Maximal quantum yields (Y, $=F_v/F_m$) can be good indicators of plant "health", and effective quantum yields (Y, $=\Delta F/F_m'$) in light can nicely predict e.g. desiccation damage to seagrasses.
- Our best use of the Diving-PAM relates to photosynthetic responses to various irradiance regimes.
- Using *in situ* approaches, we have found good correlations between diurnal ETRs and O_2 exchange of seagrass communities.

Detailed guidelines on the use of PAM fluorometry for seagrasses are given in "Photosynthesis in the Marine Environment" (2014, Wiley-Blackwell).

ISBW045: Using metagenomics to reveal the taxonomic and functional diversity in seagrass rhizospheres across environmental gradients

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Sediment microorganisms can have profound influence on productivity and functioning of marine ecosystems through their critical roles in regulating biogeochemical processes. However, the identity of sediment microorganisms that mediate organic matter turnover and nutrient cycling in seagrass sediments is only poorly understood. Here, we used metagenomic sequencing to investigate shifts in the structure and functioning of the microbial community of seagrass sediments across a salinity and phosphorus (P) availability gradient in Shark Bay, Western Australia. This iconic ecosystem is oligotrophic and hypersaline with abundant seagrass meadows that directly contribute Shark Bay's status as a World Heritage Site. We show that sediment phosphonate metabolism genes as well as enzyme activities increase in more P-limited and hypersaline conditions. Given that sediment organic P content is also highest where P concentrations in the water column are low, we suggest that microbial processing of organic P can contribute to the P requirements of seagrasses at particularly oligotrophic sites. We also compare seagrass sediment metagenomes to metagenomes from a variety of different aquatic and terrestrial ecosystems, revealing an overabundance of taxonomic and functional groups that could play a crucial role in supporting seagrasses in their unique niche as marine angiosperms.

ISBW049: Normalized Difference Seagrass Index (NDSgI): Standardizing the vegetation index for subtidal seagrass habitats using remote sensing images

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Recent advances in Earth observation in terms of spaceborne and airborne remote sensing technology, cloud computing, and machine and/or deep learning algorithms have created the perfect storm which could aid high spatio-temporal, large-scale seagrass mapping and monitoring, allowing better management and conservation. Here, we propose the Normalized Difference Seagrass Index (NDSgI) for the detection of subtidal seagrasses in multispectral and hyperspectral images. The NDSgI is calculated from the blue and green bands to maximize the differentiation between seagrass and non-seagrass habitats in submerged environments. Accurate atmospheric and water column correction should precede the utilization of the NDSgI to yield the correct spectrum of a subtidal seagrass species. We assess the performance of the proposed method in a wide range of spatial resolutions (0.5 – 30.0 m) using images from five multispectral satellites: Sentinel-2, Landsat 8, WorldView-2, Planet's CubeSats and RapidEye. All the images were acquired during the summer season over the Thermaikos Gulf, NW Aegean Sea (eastern Mediterranean) which thrives in two types of seagrasses: *Posidonia oceanica* and *Cymodocea nodosa*. Following a machine learning-based approach, we provide threshold values for both seagrass species. We envisage that the standardization of this vegetation index for seagrasses and other aquatic vegetation habitats will facilitate the mapping and monitoring of their distribution as well as a plethora of their biophysical parameters (e.g. above-ground biomass, carbon sequestration, leaf area index) given, naturally, relevant in situ data. In addition, future integration of NDSgI to multi-temporal, multi-sensor analyses could resolve seagrass dynamics from seasonal to decadal scales.

ISBW050: Assessing the differences in seagrass meadows from the Eastern Tropical Pacific and the Caribbean: insights from renewed seagrass research in Costa Rica

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Understanding the dynamics of seagrass meadows in different regions is needed to establish successful management and conservation strategies. We analyzed the current knowledge on the seagrass meadows from the Caribbean and Pacific coasts of Costa Rica, Central America. Seagrasses were found at a total of 31 locations in Costa Rica, most from the Pacific coast; 16 of which are reported for the first time. Diversity-wise from a total of seven species for Costa Rica, six species are reported for the Caribbean, and four species for the Pacific. *Thalassia testudinum, Syringodium filiforme,* and *Halophila decipiens* have only been reported for the Caribbean. *Halodule beaudettei* has only been reported for the Pacific coast. *Halophila baillonis, Halodule wrightii* and *Ruppia maritima* have been reported for both coasts. Seagrass meadows from both coasts are vastly different. Along the Caribbean coast, meadows are often dominated by the robust *T. testudinum*, they are extensive and stable, persisting for decades. In contrast, the meadows along the Pacific coast are more dynamic and are dominated by pioneer and smaller ephemeral species, such as *H. baillonis* and *H. beaudettei*. The number of studies on Costa Rican seagrasses is scarce but has been increasing over time, and mostly concern taxonomic reports and basic descriptions of the dynamics of *T. testudinum* meadows from the Caribbean. Research, conservation and management efforts on Central American seagrass meadows need to take into account the differences in seagrass dynamics on the Caribbean *versus* the Pacific coast.

ISBW052: Seagrass-bivalve interactions and lessons for restoration

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Åbo Akademi University

Seagrass restoration success is low (37%), while costs are high. A number of processes appear to be important for ensuring restoration success, including interspecies interactions and feedback. To better understand how these interactions could affect restoration, we undertook an extensive literature review (421 studies) and meta-analysis about plant-bivalve interactions, the mechanisms involved, and in which conditions these interactions were positive and negative.

50% studies showed positive interactions, 23% showed negative interactions, 13% were mixed (positive and negative interactions occurred together), and 10% were non-significant. Within seagrass ecosystems, there were large differences in the types of interactions depending on the habitat and bivalves involved. Interactions in subtidal seagrasses were mostly positive, and included mechanisms such as nutrient enrichment, protection from physical disturbance and predation on bivalves, and sediment stabilisation. However, in intertidal seagrasses, interactions with infaunal bivalves were mostly negative (due to space competition) and those with epifaunal bivalves were mixed (positive: sediment stabilisation, nutrient enrichment, shelter; negative: sulfide stress and increased predation). In addition, interactions with lucinid (sulfide-metabolising) bivalves were mostly positive, while interactions with non-native species were overwhelmingly negative.

To increase restoration success and promote positive interactions and feedbacks, we suggest ensuring that native bivalves are present in subtidal restoration sites (and simultaneous planting of seagrasses and bivalves if necessary). In intertidal restoration, epifaunal bivalves may be helpful, while infaunal bivalves are likely to be a hindrance (which the exception of lucinid bivalves). In addition, invasive species should be managed prior to beginning seagrass restoration projects.

ISBW053: Tropical seagrass mediated iron and phosphate solubilization from oligotrophic carbonate-rich sediment

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Seagrasses growing in tropical environments are often nutrient limited owing to the strong phosphorus and iron fixation capacity of carbonate-rich sediments. Yet they form densely-vegetated, multi-species meadows in oligotrophic tropical waters. Tropical seagrasses thus seem to have evolved nutrient acquisition mechanisms to support their own growth. However, direct evidence of nutrient solubilisation within the seagrass rhizosphere is lacking. Using a novel combination of high-resolution, two-dimensional chemical imaging of O_2, pH, iron, sulphide, calcium and phosphorus, we found that tropical seagrasses are able to solubilize the essential nutrients iron and phosphorus in their rhizosphere via multiple biogeochemical pathways. We show that tropical seagrasses solubilize phosphorus and iron within their rhizosphere via plant-induced local sediment acidification, leading to dissolution of carbonates and release of phosphate, and via local stimulation of microbial sulphide production, causing reduction of insoluble iron(III)-oxyhydroxides to dissolved iron(II) with concomitant phosphate release into the rhizosphere porewater. The demonstrated seagrass nutrient mobilization mechanisms have a direct link to seagrass-derived radial O_2 loss (ROL) and secretion of dissolved organic carbon from the below-ground tissues into the rhizosphere. Furthermore, diel cycles in ROL seemed to favour microbial iron(III) and sulphate reduction, thus co-mobilizing phosphate and iron(II) through reductive dissolution, in the night, while chemical and microbial iron(II) and sulphide oxidation, solubilizing phosphate through protolytic dissolution of calcium-phosphates, seemed to be dominating during the day. Our demonstration of seagrass-derived rhizospheric phosphorus and iron mobilization indicates that active nutrient mobilization is an important factor for the wide distribution of seagrasses in oligotrophic tropical environments.”

ISBW054: Socio-economic valuation of seagrass meadows in the Pulai River Estuary through a well-being lens

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Seagrass ecosystem services valuation is a useful tool in establishing actual costs incurred or habitat values lost when coastal environments are damaged in the name of development. However seagrass habitats have not been assessed as intensely as mangroves and tropical rainforests. Furthermore, most assessments focus solely on ecological services, without considering the socio-ecological-economic relationships, which provide a more holistic assessment of a habitat that incorporates socio-economic values. This study combines the benefit transfer approach with anthropological and local knowledge inputs to determine a more complete assessment of the value of seagrass meadows in Mukim Tanjung Kupang, Johor, Malaysia. We collected data that is site-specific and relevant (locally assessed) to a small-scale artisanal fishery in this area, which includes often excluded measures such as: reported catch landings, gleaning, tourism, and downstream economic values. This study determined a seagrass habitat value of US$57,731.80 (RM 242,473.58) per hectare per year. However, this figure is highly underestimated due to the number of unavailable ecosystem service values, as well as an uncertain future for the area. The research has shown that there are many more components to economic assessments of natural habitats than previously been realised. Further research needs to be carried out to ascertain more ecosystem service values so as to ensure that the importance of seagrass habitats is not underrated and to enable policy-makers to accurately weigh the benefits and costs of coastal development.

ISBW055: "Strategic or Opportunistic?" – Subtidal Seagrass Use by Dugongs in the Sibu-Tinggi Archipelago, Johor, Malaysia

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In Peninsular Malaysia, endangered dugongs (*Dugong dugon*) are localized around the Sibu-Tinggi Archipelago (South China Sea) owing to the presence of extensive seagrass meadows. Field surveys were conducted in 2016 and 2017 to comprehensively study the distribution of seagrass meadows and the dugongs' interactions with their seagrass habitat in the subtidal tropical environment of the archipelago. We examined the spatial distribution patterns of the dugong feeding trails across different seasons using towed underwater video and ascertained whether dugong feeding patterns in subtidal meadows were related to seagrass diversity, biomass, nutrient composition, water depth and/or substrate. Sixteen feeding trails were sampled by SCUBA diving for seagrasses and sediment. Feeding trails were on average 2.9 ± 1.0 cm deep, and were dominated by small and fast-growing species, *Halophila ovalis* (mean shoot density 1077.63 ± 503.68 m^{-2}) and *Halodule uninervis* (mean shoot density 1066.47 ± 903.85 m^{-2}) while *Cymodocea serrulata* (mean shoot density 171.39 ± 118.34 m^{-2}) and *Syringodium isoetifolium* (mean shoot density 605.05 ± 8.26 m^{-2}) were less abundant. Most of these feeding trails occurred in the mid to southern part of the meadow. The distribution of intensive feeding areas across the seasons suggested a practice of regular dugong grazing of sectional swards, called "feeding hotspots". Such regular, non-random feeding patterns imply the dugongs utilize the meadows in a strategic way, driven by the vegetative and physical habitat factors measured in this study. By identifying the most influential drivers, this study provides a seagrass-explicit rationale for designing better protected areas for dugongs.

ISBW057: Land use is a better predictor of tropical seagrass condition than marine protection

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Effective coastal conservation requires a better understanding of how human activities on land may directly and indirectly affect adjacent marine communities. However, the relationship between terrestrial and marine systems has rarely been considered in terrestrial and marine reserve design. Seagrasses are affected by land-based activities due to their proximity to terrestrial systems and sensitivity to fluxes of terrestrially-derived organic and inorganic material. Our study examines how land use patterns adjacent to seagrass meadows influence the ecological integrity of seagrass using a suite of seagrass condition metrics on a landscape level across the Philippine archipelago. Using canonical correlation analysis, we measured the association between environmental variables (land use and seagrass abiotic conditions) with biotic variables (seagrass species richness and abundance). Terrestrial protection adjacent to seagrass meadows, defined as the absence of various anthropogenic land use perturbations, had significant positive effects on seagrass condition. The watershed area, and area of farmland and human development, had the most negative effect on seagrass condition. Using analysis of covariance and regression, we examined how marine protected area (MPA) establishment, size, and age, affected seagrass biotic conditions while holding environmental conditions constant. The relationship between biological and environmental canonical factors did not vary as a function of an MPA. This study provides evidence that land use is more important than marine protection for tropical seagrass condition. Our results demonstrate the complementary connection between land and sea, justifying the ‘ridge-to-reef’ approach in coastal conservation. Proper management of seagrasses should account for stewardship of the adjacent watersheds.

ISBW058: Anther wall development, microsporogenesis and microgametogenesis in *S.filiforme.*

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Syringodium filiforme (Cymodoceaceae) is a dioecious species of marine seagrass of the Caribbean. Even though this species became a subject of study during the late 70's, the information related to its reproductive biology is still scarce. Therefore, the aim of this work is to study microsporogenesis and microgametogenesis in *S. filiforme*. For that purpose, anthers from flowers at different stages of development were examined using Light Microscopy (LM) and Scanning Electron Microscopy (SEM). Results show that the anther wall is comprised by an epidermal layer with high amounts of tannins, an endothecium with no apparent cell wall thickenings, between two and three middle layers and a multilayered plasmodial tapetum which degradation process is not uniform. We have found that after meiosis occurs, microspores go through mitotic divisions that result in tricellular pollen grains that elongate afterwards. The photomicrographs obtained also show that in a final stage of development before dehiscence, clumps of mature and very elongated filiform pollen grains without exine can be observed inside the anthers.
The outcome of this study will set the basis for future research on angiosperms' adaptation to the marine environment, as well as in the development of successful strategies for conservation.

ISBW059: Time is running out! Why we need a new evidence base for monitoring change in vegetated coastal ecosystems

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Mangroves, saltmarshes and seagrasses are important habitat forming coastal plants, which contribute irreplaceable ecosystem services worldwide. Despite this, these vegetation communities are undergoing significant decline. The ability to define the effect of anthropogenic impacts and assess past responses to climate change is highly sought after. This will provide insights into how coastal ecosystems may respond to future changes, improving conservation and management strategies. Traditional methods used to look back in time have so far been limited to direct observations of plant fragments in sediment cores, along with historical reconstruction based on observations from satellite and aerial photography, lipid biomarkers and fossil/subfossil and fossilised pollen evidence. More recently our DNA toolkit has become more sensitive and is now being applied to detecting traces of DNA in environmental samples. Environmental DNA (eDNA) is an emerging field that has the potential to provide a new evidence base for assessing ecological change. We are progressing the tools for utilising advances in DNA technology, including eDNA from marine sediments, to isolate and study changes in species composition at different depths, corresponding to different time periods. A multigene approach has been adopted to build a comprehensive reference library of species identity (seagrasses, mangroves and dominant coastal shrubs and grasses). We are applying this new approach to the analysis of coastal marine sediments in South Australia sampled from different sediment depths, therefore different times.

ISBW061: Genomic vulnerability, resilience and adaptation: the future for the seagrass, *Zostera capensis*

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The southern and eastern African seagrass, *Zostera capensis*, is an integral part of estuarine ecosystems and supports economically important fishery activities. This seagrass is rated ‘vulnerable’ by the IUCN and is experiencing declines in various sites. Yet *Z. capensis* is found along a wide range of physiochemical and climatic conditions, suggesting a high level of plasticity. The importance of further investigating this understudied species is compounded by the potential consequences of its decline for seagrass communities and fishery industries. This study aims to assess the vulnerability, resilience and potential for adaptation in *Z. capensis*. Here we used a reduced representation genomic approach to isolate both neutral and putatively adaptive population-level SNPs and their variation and connectivity across the range of *Z. capensis*. Multiple approaches were used to identify loci that are potentially under selection and these outlier SNPs were categorised as either private and shared among locations. Although neutral variation revealed no structure, sites grouped into a west-coast and east-coast cluster based on eight outlier SNPs. Outlier SNPs appeared at lower frequencies in the west-coast cluster compared to the east-coast cluster, indicating the same suit of genes may be responsible for adaptation to a broad range of conditions. As the same genotypes are present at most sites, there is resilience against local extinctions, but broad scale pressures could threaten the persistence of this species. These outlier SNPs are essential when assessing potential population resilience to pressures and, in addition to neutral variation between populations, greatly aid in ‘future-proofing’ management plans.

ISBW063: Singapore blue carbon: What is the influence of a seagrass bed on mangrove forest carbon dynamics?

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Mangrove forests and seagrass beds play an important role in the tropical seascape specifically for carbon accumulation. Only a few studies have reported the importance of seascape ecosystem connectivity in terms of carbon dynamics. In Singapore, we selected 1 mangrove forest site with seagrass beds adjacent and 2 mangrove forest sites isolated from seagrass beds. In each site, we measured the carbon content of the plant biomass and in the sediment of mangrove forests and seagrass beds. Origin of suspended particulate matter was investigated using a MixSIAR model with stable isotopes signals as tracers. Aboveground carbon storage in the biomass in the connected site was 102±30 MgC ha^{-1}, carbon below ground storage was 45±13 MgC ha^{-1}, and sediment carbon was 34±14 MgC ha^{-1}. For isolated mangrove forests carbon storage the mean results were 76±21 MgC ha^{-1} for above ground 30±7 MgC ha^{-1} for below ground, and 40±9 MgC ha^{-1} for the sediments. While in the seagrass bed, carbon storage was 0.3±0.2 MgC ha^{-1} for the above ground biomass, 0.1±0.08 MgC ha^{-1} for the below ground biomass and 14±4 MgC ha^{-1} in the sediments. Species composition and cover area influenced the carbon content within ecosystems. We found that suspended particulate matter had a mixed origin, and the percentage of the contribution of the sources differed among the places. Connectivity between neighboring ecosystems needs to be considered, when evaluating the role of carbon accumulation in tropical coastal ecosystems, as these could influence the carbon dynamics in adjacent ecosystems.

ISBW064: High rates of herbivory in remote seagrass meadows of the Kimberley, north-western Australia

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We measured direct consumption of seagrass as a proportion of total seagrass production in the remote Kimberley region (north-western Australia), and sought to understand the relative importance of different primary producers to the diet of selected key species of herbivores. We measured higher rates of herbivory on seagrass than anywhere else in the world — in some places during some surveys the rates of consumption were more than ten times the rates of growth. This was particularly pronounced for turtlegrass *Thalassia hemprichii*, for which average consumption across the study was higher than growth. *Thalassia* is one of the most abundant seagrasses in the terraced lagoons that are characteristic of the Kimberley, and the apparent contradiction of high abundance and high consumption is probably reconciled by a combination of fast growth rates and patchy grazing; indeed rates of consumption of *Thalassia* varied by two orders of magnitude among sites and surveys. In contrast, consumption of the seagrass *Enhalus acoroides* was on average lower than growth, and much of its production is probably not consumed by herbivores. The golden-lined rabbitfish *Siganus lineatus* was ubiquitous and abundant in seagrass meadows, and stable isotope and gut-content analyses confirmed that the diet of *S. lineatus* is primarily comprised of seagrass, especially *Thalassia*. Stable isotope and gut-content analyses also showed that *Thalassia* was particularly prominent in the diet of green turtles *Chelonia mydas*. Satellite tags showed that green turtles frequently tended to spend their time in places with abundant seagrass.

ISBW065: The global distribution of the seagrass biome

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There is no global map of marine biomes. Biomes are large areas of biogenic habitat characterized by the same plant life forms, notably of seagrass, kelp, mangroves, zooxanthellate corals and salt marshes. However, mapping the seagrass biome has been limited by the absence of georeferenced records in many regions including the Indian Ocean. Even where geographic records are available, point samples are unlikely to reflect the full geographic area occupied by seagrasses. In the absence of in situ mapping of seagrass at a global scale, existing data could be used in species distribution models to map the biome. As a first step, we have mapped seagrass distribution using species distribution modelling (MaxEnt) of species occurrence records. Environmental data layers were extracted from Global Marine Environment Datasets (GMED) and interpolated into 30 arc seconds resolution to get the finer resolution in the coastal area. The resulting MaxEnt model predicted a similar geographical distribution to the occurrence records. Sea surface temperature and distance from land were the highest contributing variables in training the MaxEnt model. In addition, it mapped areas where previous maps lacked data and predicted seagrass occupies 1,646,788 km^2 of the world. This is double previous estimates and provides a new resource for conservation planning, management and blue carbon budget estimates.

ISBW066: Low oxygen affects photophysiology and the level of expression of two-carbon metabolism genes in the seagrass *Zostera muelleri*

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Seagrasses are a diverse group of angiosperms that evolved to live in shallow coastal waters, an environment regularly subjected to changes in oxygen, carbon dioxide and irradiance. *Zostera muelleri* is the dominant species in south-eastern Australia, and is critical for healthy coastal ecosystems. Despite its ecological importance, little is known about the pathways of carbon fixation in *Z. muelleri* and their regulation in response to environmental changes. In this study, the response of *Z. muelleri* exposed to control and very low oxygen conditions was investigated by using (i) oxygen microsensors combined with a custom-made flow chamber to measure changes in photosynthesis and respiration, and (ii) reverse transcription quantitative real-time PCR to measure changes in expression levels of key genes involved in C_4 metabolism. We found that very low levels of oxygen (i) altered the photophysiology of *Z. muelleri*, a characteristic of C_3 mechanism of carbon assimilation, and (ii) decreased the expression levels of phosphoenolpyruvate carboxylase and carbonic anhydrase. These molecular-physiological results suggest that regulation of the photophysiology of *Z. muelleri* might involve a close integration between the C_3 and C_4, or other CO_2 concentrating mechanisms metabolic pathways. Overall, this study highlights that the photophysiological response of *Z. muelleri* to changing oxygen in water is capable of rapid acclimation and the dynamic modulation of pathways should be considered when assessing seagrass primary production.

ISBW067: Unpacking the steps required for the effective use of seed in seagrass restoration

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Restoration performance in degraded seagrass habitat has been under increasing scrutiny. Recent reviews suggest that the scale of plant cover, density, and diversity are not being re-instated to levels that approximate pre-disturbance conditions. To address these concerns in Western Australia, a global biodiversity hotspot for seagrasses, researchers at the University of Western Australia have been collaborating with leading international seed ecologists and local coastal industries and authorities for over 10 years to develop and mobilize seed-use practices. The core aspect of this research is focussed on unpacking the steps required for the effective use of seeds for restoration and pinpointing, on a species by species basis, bottlenecks during the restoration process. It is well known that more than 90% of seeds fail to establish. For the majority of seagrass species found in Western Australia, there is limited understanding of seed biology or the nuances of the local abiotic and biotic environment in which to guide restoration approaches and improve restoration performance. In this presentation, key findings will be discussed using examples from two widespread species with contrasting life-histories; *Posidonia australis* and *Halophila ovalis*. Outcomes suggest that individual seed and seedling traits, as well as interactions with the local environment, influence restoration performance and the intervention approaches for each species. We conclude this talk with how we are working with local authorities, industry partners and communities to translate this seed management information into real on-ground changes in restoration practice.

ISBW068: Seagrasses in Transition

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In North Carolina, seagrass meadows consist of monospecific stands of temperate *Zostera marina* or mixed meadows containing *Z. marina*, sub-tropical *Halodule wrightii,* and/or eurythermal *Ruppia maritima*. In mixed meadows, dominance is divided temporally, with *Z. marina* most abundant during the late spring and *H. wrightii* increasing after summer daily mean water temperatures increase to ≥ 28 °C. As water temperatures continue to increase, and species-specific thermal limits occur earlier in the year, *Z. marina* is predicted to decline and *H. wrightii* and *R. maritima* are expected to increase in abundance. While seagrass meadows in NC may persist without *Z. marina,* it is unclear if their loss will significantly increase meadow vulnerability to future perturbations, as even morphologically similar foundation species can differ in key characteristics that influence resilience. The research presented here quantifies how large-scale shifts in the community structure of foundation species affect the persistence of seagrass meadows by linking changes in genetic and species diversity to ecosystem resilience at the transition zone between temperate and sub-tropical seagrass regions. Through field observations and molecular analyses, we quantified changes in species-specific structural (biomass, density, % cover), physiological (productivity) and resilience (genetic diversity, seed bank viability) indicators to changing abiotic conditions (temperature °C and light (PAR µmol $m^{-2}s^{-1}$) at 3 sites in southeastern NC. Further understanding of the mechanisms that drive ecosystem resilience and stability and the influences of geographic range shifts of foundation species on these processes is vital to accurately forecast the response of seagrass ecosystems to future stressors.

ISBW069: Seagrass decline in response to a decade of aquaculture effluent disposal in Hainan, tropical China

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Leibniz Centre for Tropical Marine Research (ZMT)

Seagrasses are among the most productive, but also the most threatened coastal ecosystems worldwide mainly due to increasing eutrophication. Over the past decades, the extreme expansion of aquaculture in particular in SE Asia became a quantitatively significant additional cause of eutrophication. On the east coast of Hainan Island, tropical China, approximately 4000 ha of land, mainly covered by mangrove forest, were converted to aquaculture ponds for intensive production of shrimp and fish. Aquaculture effluents are released directly into coastal waters, mainly seagrass-covered, shallow back-reef areas. There we investigated the long-term impact of these nutrient- and organic matter-rich effluents on seagrass performance. We compared seagrass density, species abundance and biomass along offshore transects from three sites under different levels of pond effluent exposure (high, medium and low) between 2008/2009 and 2017. Our data show a direct relation between seagrass degradation and pond effluent exposure. While in 2008/2009 seagrass was found at all three sites, nine years later it had completely disappeared at one site, and it had declined in density and biomass, and occurrence had shifted further offshore at the other sites. The main degradation/loss mechanisms were light limitation by phytoplankton and epibionts and hydrogen sulfide intrusion. Our results highlight the devastating impact of continuous nutrient-enrichment on seagrasses as a consequence of unsustainable aquaculture practices causing seagrass degradation and eventually leading to total loss.

ISBW071: A proposed decision support tool for prioritising conservation planning of Southeast Asian seagrass meadows

Yi Mei Tan, Siti M. Yaakub, Justine Saunders

DHI Water & Environment

The current study examines the efficacy of combining two well-established approaches – ecosystem service assessments and habitat vulnerability analyses – to test a method for determining conservation priority for selected seagrass meadows in Southeast Asia. Seven seagrass meadows around Southeast Asia were assessed for ecosystem services, vulnerability, and a combination of the two approaches. The results differed when meadows were scored for ecosystem services provided, compared to how vulnerable they are to anthropogenic threats. The combined analyses brought the two metrics together to give conservation priority to sites where management intervention will be cost-effective, i.e. where maximum conservation benefit may be gained from the conservation effort. Conservation priority was given to three sites as identified by the tool: Barrang Lompo (Indonesia), Cape Bolinao (Philippines), and Beting Tanjung Kupang (Malaysia). This method is easy to use, and does not require great technical expertise. Furthermore, the assessment is uncomplicated and auditable, allowing for clear and transparent understanding of decision-making processed based upon the method. Lastly, this method can be used as a decision support system to supplement existing spatial planning tools. Future research could include the addition of other criteria such as spatial factors, including the connectivity between seagrass habitats and other nearby habitats.

ISBW072: Response of three tropical seagrass species to in situ nutrient enrichment and seasonality in light availability in Hainan, China

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Leibniz Centre for Tropical Marine Research (ZMT), Germany

Seagrasses are among both, the most productive and the most threatened coastal ecosystems worldwide. Eutrophication is stated to be the principal cause for seagrass loss, but knowledge on the response of tropical multi-species seagrass meadows to nutrient enrichment is still scarce. China is the largest aquaculture producer globally. On the tropical Chinese island Hainan nutrient- and organic matter-rich effluents released from large-scale pond aquaculture caused significant seagrass loss between 2008 and 2017. In order to understand the processes driving this seagrass loss we tested the response of three tropical seagrass species (*Thalassia hemprichii*, *Cymodocea serrulata* and *Cymodocea rotundata*) to a four-week artificial nutrient enrichment with nitrogen, phosphorus and potassium in May and October 2017. Growth rates, morphology, photosynthesis and respiration were determined. Fertilization affected leaf width and leaf length of two species. The effect on photosynthesis and respiration differed by species and season. While oxygen production was higher in *C. serrulata* in May, there was no effect in October. In *T. hemprichii* and *C. rotundata* photosynthesis were not affected in both seasons. Higher respiration rates and less leaves per shoot in all species in October are probably related to efforts of the plant to compensate for lower light availability. It appears that the species-specific response of seagrasses to the seasonality of light availability is also a major factor for seagrass performance under nutrient enrichment. This is critical knowledge for the success of seagrass restoration projects.

ISBW073: Hydrodynamics affects pipefish behavior, metabolic rates and habitat choice in seagrass

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Pipefish (Syngnathidae) form a vulnerable of the ichthyofauna associated to vegetated coastal habitats. The knowledge about their habitat preferences is scarce, although habitats where pipefish can easily get shelter and food seem to be preferred. Swimming ability may also shape patterns of habitat use in fish communities: bigger fin sizes use to be associated to the preference of habitats exposed to higher water movements. *Syngnathids* swim mainly by undulations of the dorsal fin and are slow moving ambush predators and commonly occur in slow moving water or sheltered habitats. Moreover, habitat structure (e.g. seagrass shoot density) and water flow energy interact, with denser meadows providing more sheltered habitats.
Fish behavior under flow exposition was tested in two experiments using a hydraulic flume: 1) the effects of unidirectional flow velocity on pipefish habitat choice (three habitats: sand, low and high *Z. marina* shoot density), and 2)the effect of flow velocity on pipefish behavior (i.e. hold, swim and rest) and stress (i.e. ventilation rate) in two different habitats (sand and seagrass meadow).
Regardless of flow velocity, the time spent by pipefish in denser patches was four times higher than the time spent in sandy or low density patches. The ventilation rates of *S.typhle, S.rostelaltus, N.ophidion* and *E.aequareus* increased with flow velocity, and most of them showed higher stress response to flow velocity in sandy habitat than in the meadows.
This work highlights the link between seagrass dense meadows and pipefish performance and emphasize the importance of habitat management for vulnerable species conservation.

ISBW074: Effects of abrupt hyposalinity exposure on leaf growth and survival of the turtle grass, *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871

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Seagrasses, which thrive in a completely submerged marine environment, are seasonally exposed to hyposaline condition brought by run-offs following heavy rainfalls, storms, and some human-induced activities. In this study, the effects of hyposalinity exposures to *Thalassia hemprichii* were tested in an outdoor experimental set-up in Lapu-Lapu City, Cebu, Philippines. The leaf growth of *T. hemprichii* exposed to 6 salinity levels were measured in terms of its relative growth rate (% of growth day^{-1}), leaf elongation rate (mm day^{-1}), leaf plastochon interval (days), survival and recovery rate (%), for 15 days in the months of January-May 2017. Results indicate that *T. hemprichii* was significantly affected when exposed to lower salinities, showing signs of stress during the experimental period. Optimum leaf elongation was recorded in 35 (control) and 25 psu with 3.68 and 2.7 mm day^{-1}, respectively. Furthermore, *T. hemprichii* showed so much stress that it would take ~85 days for the formation of successive leaf when exposed to 0-15psu. Low survivability was observed at 10-5psu until it reaches 0 psu, where all shoots died after 15 days. Conversely, high survival rate was recorded at 15-25 psu, but only at 25 psu, that high recovery (90%) were observed when shoots were returned to the ambient salinity. Osmotic stress was also evident based on the change in leaf coloration and swelling of the leaf blades that resulted to leaf disintegration. Results suggest that *T. hemprichii* has a narrow range of tolerance to low salinities that further affirms previous reports on the genus *Thalassia*.

ISBW077: Modern carbon burial rates in seagrass ecosystems: strengthening their contribution in the ocean carbon budget

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Seagrass meadows are increasingly credited with burying large quantities of organic carbon (C) in their sediments. However, this process is relatively under-studied, partly due to the difficulty in obtaining reliable accretion rates in these environments compared to other blue carbon ecosystems such as mangroves and saltmarshes. Published estimates of sediment C burial in seagrasses globally average 138 ± 38 g C m^{-2} yr^{-1} (or 50 - 110 Tg C yr^{-1} globally). These estimates, based on measurements of biomass turn-over rates and the few available rates of sediment C burial, were strongly influenced by data from *Posidonia oceanica* habitats, the species with the greatest ability to capture C. Here we review modern (i.e. last century; derived from ^{210}Pb dating) seagrass C burial rates at regional and global scales. We compiled published and unpublished estimates of sediment accumulation and C burial rates in 84 distinct seagrass meadows across the globe. This included data from previously less studied temperate regions in the North Atlantic, North Pacific and Southern Oceans. Our results show that seagrasses bury on average 38 ± 5 g C m^{-2} yr^{-1}, accounting for a global C burial ranging between 7 and 23 Tg C yr^{-1}, representing around 10% of the calculated annual net seagrass production. Although our estimate of seagrass C burial is lower than previously thought, it accounts for 3 to 9% of the burial of C in the ocean, a disproportionately large contribution given they occupy less than 0.2% of the ocean surface.

ISBW079: Differences in morphological, physiological, microbial and flowering traits between native and invasive populations of *Halophila stipulacea*

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Halophila stipulacea is a tropical seagrass, native to the Red Sea, Persian Gulf and Indian Ocean. Following the opening of the Suez Canal, this species became a Lessepsian migrant and has since spread to most of the eastern Mediterranean Sea. Recently, this species has reached the Caribbean where alarming studies showed *H. stipulacea* displacing local Caribbean seagrass species.

Aiming to deepen our understanding of the invasiveness of *H. stipulacea*, we recently setup identical permanent monitoring transects at similar depths in both the native (Eilat, Israel) and invasive (Limassol, Cyprus) habitats. Samples were collected in parallel from both sites four times during 2017 and were used for comparisons of morphological, physiological and flowering traits, alongside sampling the microbiome associated with *H. stipulacea* plants in each site.

Above ground biomass and percent cover were higher year-round in Eilat than in Limassol, reaching a maximum in July (Eilat) and October (Limassol). Leaves in Eilat were larger than in Cyprus, however Limassol plants had more apical shoots and larger internodes. *H. stipulacea* plants were female-biased in Eilat, compared with the invasive male-biased populations.

Microbiome epiphyte communities associated with *H. stipulacea* leaves differed between sites and corresponded to the dominant microbial genus present in seawater at each site.

Taken together, results suggest that invasive (Cyprus) and native (Israel) plants are morphologically different. Invasive plants were smaller, had more apical shoots and larger internodes than their native counterparts. Flowering plasticity in Cyprus, might help *H. stipulacea*'s ongoing expansion in the Mediterranean, thereby threatening local seagrasses species.

ISBW080: Recruitment facilitation to rehabilitate lost *Amphibolis antarctica* in South Australia

Jason E. Tanner

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Since 1949, ~6200 ha of seagrass has been lost off the Adelaide metropolitan coast in South Australia. Much of this loss has occurred in shallow waters, with the seagrass line receding seaward, and has been attributed to increased nutrient levels from waste water treatment plants, industrial development and urban runoff. With a concerted effort to reduce nutrient inputs, a seagrass rehabilitation program was commenced in 2002, initially trialling techniques used elsewhere, such as transplanting and planting seedlings. However, the relatively high wave energy along the Adelaide coastline resulted in poor success. This high wave energy, as well as high levels of bioturbation, also limit natural recolonization. The use of hessian (burlap) sandbags has proven to be more promising, as well as relatively low cost, as it works with the life history of the local *Amphibolis antarctica*, which viviparously produces seedlings that have evolved to entangle in things such as exposed *Posidonia* root matte. The hessian sand bags provide a substitute for this root matte, which seedlings naturally attach to, and persists long enough for them to become established. Seedlings can attach to these bags in high numbers, sometimes exceeding 1000 m^{-2}. However, medium-term results appeared disappointing, with stem densities rapidly declining to well below those in natural meadows. It was only after 5-7 years that stem densities again increased in many plots. As well as recovery of the seagrasses themselves, studies of the fauna have indicated that these have also returned to what is present in nearby natural meadows.

ISBW081: Comparison of image collection and data verification methods for mapping seagrass meadows in North Carolina, USA using fixed-wing and multicopter drones.

Kenji Sugimoto, Jessie C. Jarvis, David Wells

The purpose of this study was to compare the aerial imagery taken by fixed-wing and multicopter drones to investigate the distribution of seagrass beds composed of *Zostera marina*, *Ruppia maritima* and *Halodule wrightii* on the North Carolina coast. Images were collected in October 2017 and January 2018 at Topsail Beach (area mapped = 100m x100m). ERDAS IMAGINE 2015 was used for image analysis of all drone data. To analyze the accuracy of images from October 2017, we compared them to quadrat based (0.25 m^2) percent cover data collected in September 2017. To analyze the images from January 2018, we used underwater videos recorded with a 0.25 m x 0.25 m bottom view from 20 randomly selected locations. The fixed-wing drone was able to shoot the same area in about half the time as the multicopter drone, but the amount of white in the collected imagery was increased due to insufficient light intensity. As a result, it was difficult to distinguish the areas with seagrass from those without along the edge of the seagrass meadow, where seagrass density becomes low and appears close in color to the sediment. On the other hand, in places where the seagrass density was high, there is little difference between the data collected by the fixed-wing and multicopter drones. The airplane is advantageous in seagrass beds with a wide spatial distribution and high coverage, but in seagrass beds with a narrow area and low cover, the multicopter is more accurate.

ISBW082: Effects of temperature and salinity on the functional traits and photosynthesis-irradiance relationship of the seagrass *Halophila ovalis*

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Global climate change provides a number of threats to seagrasses including increases in water temperature and in estuarine environments, changes in salinity. A combination of warming events and higher salinity has been proposed as a possible mechanism for recent seagrass die-off in some estuaries of southwest Australia.
We aim to evaluate the response of *Halophila ovalis* to the effects of temperature and salinity increases. This species is widespread, commonly found in estuaries and has experienced die-off events in SWA estuaries. Two short-term experiments were conducted to 1) determine the effects of temperature and salinity increases (individual and joint effect) on plants functional traits and to 2) assess whether the photosynthesis-irradiance relationship of seagrass varied under different temperature and salinity conditions. Two temperatures (24ºC&30ºC) and two salinities (34ppt&40ppt) were selected for the first experiment while a range of temperatures (20ºC-35ºC) and two salinities (34ppt&42ppt) were selected to determine the P-I curves. Interactions with increased temperature and salinity were not found. Some photosynthetic parameters were affected by increasing temperature while salinity did not show any effect. Plant growth was significantly impacted by high temperature but shoot survival was favoured under high salinity conditions. With increases in temperature respiration rates increased and photosynthesis rates decreased. Photosynthesis rates increased with salinity but the respiration rate was not affected. High temperatures are likely to have contributed to the die-off of *H. ovalis* in SWA estuaries but there is no evidence of a negative effect of high salinity on functional traits and survival.

ISBW083: Synergies between warming and eutrophication on seagrass (*Cymodocea nodosa*) health and performance

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In the context of global warming, great efforts have been done to evaluate the responses of a number of key marine species, including seagrasses, to increasing temperatures. However, other concurrent stress factors, such as eutrophication, are rarely incorporated to those evaluations.

We investigate here the importance of chronic eutrophication in modulating the response of the seagrass *Cymodocea nodosa* to short-term thermal stress, simulating a heat wave event. We exposed plants collected in two areas (one eutrophic and another oligotrophic) of Alfacs Bay (Northwestern Mediterranean) at a range of temperatures (20 –control- and 30 and 35°C) for 7 days. Exposure was followed by a recovery period at control temperature of additional 7 days. We then measured their photosynthetic efficiency and growth (expressed either as shoot growth, rhizome growth or shoot recruitment). The maximum quantum yield (Fv/Fm) increased at 30°C (relative to plants at 20 ºC), showing that the species can bear moderate increments of temperature, but clearly declined at 35ºC.

At the end of the experiment (exposure plus recovery) plant growth dropped at 35ºC, and this decrease was significantly higher in eutrophic plants, outlining a synergistic effect between warming and eutrophication.

These results prove that the negative effects of warming, as those experienced during a heat wave event, can be exacerbated by eutrophication, worsening the current predictions about the impacts of global warming on seagrass ecosystems.

ISBW086: Improving seagrass conservation using molecular toolkits

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Despite their global importance as one of Earth's most efficient and long-term carbon sinks and provider of marine habitat and ocean sediment stability, seagrass meadows are under threat worldwide by climate change, urban and port infrastructure development. Current seagrass monitoring and assessment protocols reveal changes in seagrass communities through morphological change and loss of populations, but are severely limited by their inability to diagnose seagrass health in real-time for effective intervention and management. There is, therefore, a critical need to develop new diagnostic tools with fast turn-around and easy to use approach, based on cutting-edge technology, to monitor and respond rapidly to the tipping point of seagrass health to preserve existing meadows and avert seagrass meadow loss.

In this talk, I will present results from previous laboratory and field-based experiments, during which we were able to detect molecular changes related to health in the Australian dominant species, *Zostera muelleri*, long before any significant changes in physiology/morphology. I will further discuss about recent development of a easy to use multiplex gene expression profiling technique (originally from biomedical sciences), which enables researchers to digitally count multiple transcripts with very high levels of precision and sensitivity in several samples simultaneously. While the full validation of these molecular toolkits is still pending, the methods and results pave the way for next-generation methodologies of seagrass monitoring that will provide resource managers with near-real-time impact information before, during and after perturbations.

ISBW088: The potential of Australian blue carbon ecosystems for climate change mitigation - a national assessment

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Carbon sequestration is a valuable ecosystem service provided by seagrass and other blue carbon (BC) ecosystems. Government programs to mitigate greenhouse gas (GHG) emissions through preservation of BC ecosystems require accurate, repeatable assessments of BC storage. Here, we present the most comprehensive assessment to date of Australia's BC resource. We show that Australia has ~13% of the global area of BC ecosystems, and 6% (1500 Tg Corg) of the soil organic carbon in BC ecosystems, sequestered at 5.4 Tg Corg y-1, equivalent to 5% of Australia's CO2 emissions from burning fossil fuels. Seagrasses are estimated to contribute 68% of the national blue carbon soil Corg stocks and 65% of the annual rate of sequestration in BC ecosystems. Differences exist in the seagrass soil Corg stocks among bioregions; subtropical seagrasses have 2– to 7–fold higher stocks than those from other bioregions, while tropical meadows have the lowest stocks. Present losses of Australian seagrasses (~1% y-1) could result in the release of 10-30 Tg CO2 y-1, valued at $100m-1,000m y-1 assuming a carbon trading price of $US 10–35 per tonne CO2. If realised, these emissions from seagrass habitat would increase Australia's annual CO2 emissions from land-use change by an additional 65 – 200% (or 110-325% for all blue carbon ecosystems). These estimated Corg stocks and CO2 emissions can underpin national accounting and assessment of activities to reduce GHG emissions. We conclude with an assessment of the potential to include seagrass ecosystems in Australia's national GHG mitigation program, the Emissions Reduction Fund

ISBW090: Photoprotection of tropical seagrasses in the upper intertidal

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The upper intertidal is a challenging environment. The most common seagrasses found in such habitat along the coast of Thailand are *Halophila ovalis*, *Thalassia hemprichii* and *Cymodocea rotundata*. Here we summarized the results from our studies examining how these seagrasses cope with stressors during low tide i.e. desiccation and high light intensity. In general, the three seagrasses possess a suite of photoprotections common to land plants, such as non-photochemical quenching (NPQ) and antioxidant enzymes. However, their tolerance to photoinhibition and a combination of photoprotective mechanisms were found to be species specific. By applying metabolic inhibitors, we found that NPQ is mediated by the transthylakoid proton gradient and the xanthophyll cycle and that NPQ plays a role in tolerance to desiccation and high light intensity in these seagrasses. Superoxide dismutase and ascorbate peroxidase (APX) activities have been detected but only APX was induced by high light. In some localities, the leaves of *H. ovalis* and *C. rotundata* accumulated anthocyanin. Our results suggested that anthocyanin provides photoprotection by light attenuation. However, both anthocyanin-poor and anthocyanin-rich seagrasses exhibited similar extent of tolerance to high light intensity. An additional photoprotective mechanism was recorded in *H. ovalis*. An aggregation of chloroplast was observed when *H. ovalis* was exposed to high light intensity. This phenomenon likely contributes to a reduction of light absorption under excess light and has been reported in congeneric seagrass species, *H. stipulacea* and *H. decipiens*. Our findings indicate that seagrasses in the upper intertidals are well-equipped to withstand photoinhibitory conditions during low tide.

ISBW093: Latitudinal variation in seagrass herbivory: global patterns and explanatory mechanisms

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Understanding latitudinal patterns in species interactions is becoming increasingly important in the context of a warming climate, as temperature is one of the main variables that changes predictably with latitude. Here we combine a meta-analysis and a field experiment across 12° of latitude to quantify latitudinal variation in herbivore impacts on seagrasses. Our meta-analysis showed that herbivores had a similar net impact on seagrasses across 37° of absolute latitude, with little variation in herbivore exclusion effects at different temperatures. As herbivore impacts are a function of both production and consumption, we simultaneously quantified leaf production and consumption rates, as well as seagrass biomass and nutritional traits (nitrogen, C:N, phenolics), for nine meadows of the seagrass *Amphibolis antarctica* across 1,700 km, from tropical to temperate latitudes in western Australia. Both seagrass production and consumption rates were greatest in the tropics and decreased with latitude. Seagrass nutritional quality was lowest in the tropics, where fish removed ~ 30% of primary production. Consumption of the more nutritious temperate seagrasses was highly variable and dominated by invertebrates. These results will be compared to findings from eastern Australia, where herbivory on *Posidonia australis* is lower and growth rates differ strongly between estuaries but not along a latitudinal gradient. As ocean temperatures continue to rise and overall herbivory levels are expected to increase in temperate regions, the survival of seagrass meadows in higher latitudes will depend on the ability of plants to increase growth at compensatory rates.

ISBW094: Reconstructing the invasion history of the tropical seagrass, *Halophila stipulacea*

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While seagrass declines are a major global concern, seagrass invasions are a growing concern in certain marine ecosystems. Endemic to the Red Sea, Persian Gulf and Indian Ocean, *Halophila stipulacea* first invaded the Mediterranean Sea in 1894, following the opening of the Suez Canal, where it coexists with native seagrass species. A second invasion into the Caribbean was first documented in 2002, where it has quickly expanded across Caribbean Sea displacing local seagrass species, monopolizing space, and altering local seagrass communities. Reconstructing its invasion history is critical in understanding the success of its invasion. While it is hypothesized that the Caribbean introduction occurred via boat, it is unclear whether this invasion represents a serial introduction from the Mediterranean, an independent introduction from the native range, or an admixture from multiple native/invasive populations. To test these hypotheses, we examined population genetic structure and genetic diversity from multiple locations spanning across the native, historic, and recent invasive ranges of *H. stipulacea*, including the Indian Ocean, Red Sea, Mediterranean Sea, and Caribbean Sea. Data from 1,809 SNP loci at >20x coverage revealed significant genetic structure among all four regions. Genetic structure was lowest between the Red Sea and Mediterranean (FST- 0.181). The Caribbean was most similar to the Mediterranean Sea (FST- 0.224), suggesting a serial introduction, from the Mediterranean. However, these FST values were surprisingly large, suggesting that the invasion history in *H. stipulacea* is older or more complex than believed, or that local selection may increase differentiation among the four regions.

ISBW095: Fishery food webs vary among seagrass types in the Great Barrier Reef World Heritage Area

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One of the key values of seagrass meadows is their food webs and the fisheries they support. The Great Barrier Reef World Heritage Area (GBR), Queensland, Australia, contains around 35,000 km^2 of seagrass, accounting for 10% of the GBR. Within the GBR, urban and coastal development pose one of the biggest threats to seagrasses. Fifteen seagrass species occur within the GBR, providing widely varying structural habitat for animals. The ecosystem services provided by these habitats are therefore likely to differ and we need to understand the value of these differing habitats to decide where protection is needed most urgently. We measured the biomass of invertebrates and fish, and their Carbon, Nitrogen and Sulfur stable isotopes, to determine food web structure in 10 meadows across 1,000 km of the GBR coastline. The meadows represented five species in three genera, covering a range of structurally different seagrass types. Animal biomass and food webs varied greatly among meadows. Animal biomass was higher in *Zostera muelleri* than in all other meadow types. The isotopes of seagrass leaves themselves also varied among meadows, with *Halophila spp.* having depleted C isotopes and enriched S isotopes compared with all other genera. The trophic structure also varied among meadows, correlated predominantly with the structure of the plants. Our results highlight important differences in food webs among meadows across the GBR, a finding that can help support management decisions about how best to protect these ecosystems and mitigate impacts from anthropogenic activities.

ISBW097: Resistance and recovery of an estuarine seagrass to extreme summer rainfall events

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Extreme climatic events (ECEs) greatly influence physical and chemical properties of estuarine ecosystems, with potentially greater effects on seagrasses than climate change and anthropogenic stressors. The relationships between ECEs, water quality and ecosystem response is critical to estuarine health but remains obscure. We investigated the resilience of the widespread seagrass *Halophila ovalis* to an extreme summer rainfall event in temperate Western Australia. These events result in rapid changes in salinity, light and nutrient delivery causing seagrass decline. We characterised an event in the Swan River Estuary by applying metrics previously used for marine heat waves. Changes in resistance (biomass and cover) and recovery (growth and seed bank density) traits were measured at sites along the estuary. At downstream meadows, higher biomass (343.3g DW m^{-2}) did not confer greater resistance to the flood, with 72% (±15.04SE) lost within two months compared to 24-57% (±13.91SE) at upstream sites. Changes in salinity were greater upstream (±20 PSU) compared to downstream (±15 PSU), yet resistance traits returned to pre-flood levels within 7 months exclusively at upstream meadows ($p > 0.05$). Acclimation to freshwater exposure may explain the different responses of up and downstream meadows. We demonstrate the need for metrics to characterise ECEs, monitoring indicators which respond more consistently to extreme flooding and the need to account for differences in population resilience. Under projected increases in the intensity and frequency of ECEs, more adaptive management guided by resilience frameworks and metrics will help toidentify, and mitigate the loss of, less resilient seagrass meadows.

ISBW098: Mass seagrass declines, composition and spatial changes instigated by a marine heat wave in Shark Bay Marine Park

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The collection of extended time-series data provides a strong capacity to understand trends in seagrass declines and increases the capacity and confidence to inform management with greater certainty. Here, we present data from a long-term monitoring program in Shark Bay, an area that contains some of the most diverse and extensive seagrass meadows in the world, to illustrate the extent of spatial and temporal changes caused by an extreme climatic event. An unprecedented marine heat wave (peak SST were 2-5°C warmer than average) impacted several marine communities along the West Australian coastline during the 2010–2011 La Niña. Our combined assessments of extent and in-situ measurements detected significant changes in seagrass density and species composition at the landscape scale. For example, a loss of 21.5% in seagrass habitat occurred between 2002 and 2014, and major declines in the proportion of dense (>40% cover) seagrass occurred between 2002 and 2016 (from 72% to 55% of the total area). Broad-scale community composition assessments also demonstrated declines in the mean canopy cover of *Amphibolis antarctica* from 41% (±13.6 SE) in 1996 to 1.5% (±0.99 SE) in 2016, with the cover of sparse *Posidonia australis* meadows and bare sediment increasing. This work provides an example of utilizing habitat mapping as a tool (alongside in-situ measurements) to improve our understanding of seagrass declines, alterations in community composition as well as the implications in terms of the associated changes in ecosystem function; thereby providing knowledge to assess management effectiveness and refine practices to improve conservation efforts.

ISBW099: Contrasting trajectories of recovery for Great Barrier Reef coastal seagrasses: the key role of propagule supply and recruitment.

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Many seagrass meadows along the Great Barrier Reef coast suffered major declines between 2010 and 2012 as a result of severe storms combined with the effects of multiple years of La Nina climate conditions. We present the results of a range of studies that show the recovery trajectories since have varied substantially across the region. In some locations seagrasses have made a strong and fast recovery but in others recovery has been slower or absent. One of the principal reasons for this difference relates to differences between species and meadows in propagule supply and recruitment success. Results of our monitoring and investigations of seed banks and seed viability reveal that for many meadows a relatively small seed bank with a low number of viable seeds may be sufficient to generate large scale seagrass recovery in the order of 3 to 5 years. Recovery is significantly enhanced when even a small remnant population of adult plants remain to facilitate rapid clonal recovery. In addition many meadows in the GBR are highly connected through propagule dispersal that may facilitate recovery. Despite these successes, recent climate events have pushed some meadows beyond the point where recovery is likely without assistance. Results of our studies suggest that restoration efforts for many tropical meadows may be possible at much lower planting densities than equivalent temperate seagrass systems. We present a management framework for restoration or assisted recovery decisions for the GBR based on these results.

ISBW101: Connectivity in coastal seascapes: macro to micro-scale processes driving nutrient uptake in seagrass systems

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Seagrass ecosystems are generally highly productive, yet they often flourish in nutrient poor waters. This is partly explained by the high levels of internal recycling of nutrients within the meadows. However, large amounts of detritus (nutrient pool) can be lost through the export of leaf material to other ecosystems. The import of dissolved organic nutrients (DON) and particulate organic matter (POM) is therefore likely to play a critical role in the nutrient balance of these ecosystems. Here, we synthesise the findings of a suite of studies that have examined processes of seascape connectivity leading to nutrient uptake in seagrass ecosystems in south-western Australia. Macro-scale processes provide POM such as kelp detritus from neighbouring systems to seagrass meadows, where it is trapped and has been shown to enhance the densities of macro-grazers and provide an important food source to those grazers. Micro-scale processes provide bioavailable nutrients through the mineralisation of DON that is either released from POM, or imported from the water column. Recent studies have shown that microbes are far more abundant on the leaves of seagrasses than other compartments in the seagrass meadow (i.e. sediment and water column within and above the canopy). These microbes have been shown, through controlled experiments involving stable isotope labelling and NanoSIMS, to convert DON to bioavailable inorganic nitrogen that is taken up within the seagrass cells. We conclude that imported POM and DON play important roles in primary and secondary productivity in seagrass ecosystems, and management needs to consider these seascape connectivity processes.

ISBW102: Guiding environmental flow delivery to a hypersaline lagoon: importance of considering life-stage specific habitat requirements for seagrass recovery

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A hydrodynamic-biogeochemical model (TUFLOW-FV–AED2) was used to simulate at high-resolution the hydrodynamic conditions, water clarity (light and turbidity), nutrients and filamentous algae in the Coorong coastal lagoon system in South Australia. Outputs from the model were used to drive a habitat assessment, which was designed to take into account various environmental sensitivities for different stages of the *Ruppia tuberosa* life-cycle, including seed germination, adult plant growth, flowering and seed production, turion formation and turion sprouting. The model predicted maps of high and low quality habitat allowing for an assessment of where *R. tuberosa* would be likely to establish under any given hydro-biogeochemical conditions. The model was run for 2014, 2015 and 2016, and for ten additional scenarios testing different flows through a system of barrages in the north or through an alternative source of inflow from the south (Salt Creek), in order to guide environmental flow delivery decisions. The complexity of the system and different requirements of each life phase make it difficult to generalize about flow conditions that would lead to optimum overall *R. tuberosa* survival. However, the scenarios did highlight the magnitude of benefits in *R. tuberosa* habitat that would occur across the spectrum of flow conditions typically experienced and for a number of different environmental flow delivery options. Further dedicated scenario simulations are recommended that span a broader range of conditions, time-periods and water delivery strategies to better allow for the definition of optimum conditions for *Ruppia tuberosa* establishment and recovery.

ISBW103: Tropical seagrass meadows need help to retain its status as a high-capacity carbon sink: contextual evidences from blue carbon studies in Malaysia

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Studies at the global level attest to the significance of seagrass meadows as blue carbon sinks. At the regional scale, however, predictions on carbon sequestration trends may not necessarily fit into such generalisations. Recent studies showed that certain trends are observed for tropical Indo-pacific seagrass meadows. We present our findings from two studies in Malaysia that fit into the trend, i.e. a profile of relatively modest organic carbon (OC) sequestration capacity. Our first study, at the Sungai Pulai Estuary, showed OC accumulation was up to 4.9 g OC m^{-2} yr^{-1}, with OC stocks ranging at 4.6-7.0 kg OC m^{-2} (1 m depth of sediment). In comparison, the offshore meadows at Pulau Tinggi, which are located in a Marine Protected Area, has stocks at a maximum of 3.5 kg OC m^{-2}. Between the two sites, Bayesian mixing models on OC provenances indicated the highest proportional contributions of seagrasses to the organic pool is at 28%. This indicates that non-seagrass derived OC, including mangrove- and macroalgal-derived OC, assisted in contributing to the bulk OC in seagrass sediments. Synthesised findings from the above studies together with other regional studies points to the fact that the high capacity for seagrasses to sequester carbon – as reported in other regions – does not apply to Indo-pacific meadows. A regional-specific context is therefore warranted and suggestion will be made on the direction of Indo-pacific blue carbon research, as well as its implications for seagrass management.

ISBW105: Sand-capping muddy sediments improves the benthic light climate and the anchoring capacity for eelgrass

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Decades of high nutrient loading and high phytoplankton production have increased the turbidity and organic matter sedimentation in estuaries. In Danish waters, high turbidity has diminished the area of seabed with sufficient light intensity to support growth of eelgrass (*Zostera marina*). Former eelgrass areas have therefore turned into bare bottom areas with frequent resuspension events maintaining the systems in a turbid state. Furthermore, lowered anchoring capacity of eelgrass in areas with historically high deposition of organic matter has contributed to loss of eelgrass. When harbour authorities dredge navigation channels at the outer boundary of Danish estuaries they typically remove ~100.000 m^3 of sandy sediment and ship to sites far afield. If this material instead is used to consolidate adjacent muddy areas by sand-capping, it results in a win-win situation. We demonstrate that sand-capping of muddy sediment with 10 cm of sand can consolidate the sediment, and reduce the magnitude and frequency of resuspension events. Erosion thresholds increased from current velocities of about 10-12 cm s^{-1} for mud to 40 cm s^{-1} for sand-capped mud, a large enough change to substantially improve anchoring capacity. Additionally, erosion rates are lowered from 5 g suspended solids m^{-2} min^{-1} in muddy areas to about 0.2 g suspended solids m^{-2} min^{-1} in sand capped areas, leading to improved light climate. Altogether, the increased anchoring capacity and improved benthic light regime has the capacity to recover the otherwise lost eelgrass habitats.

ISBW106: Seagrass Mapping in the Philippines using Landsat 8 imageries

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The Philippines is home for 18 species of seagrass out of 72 species documented worldwide. These coastal resources is known to provide a lot of benefits to the coastal ecosystem such as key indicators of ecosystem health, stabilize the sea bottom, delivers food and habitat to other marine organisms, maintains water quality and support the local economy. Although the services are large, the seagrass remains to be the least studied coastal habitat in the Southeast Asian region. Its proximity to the coastal zone makes it vulnerable to disturbances. In order to protect and manage these resources, it is important to know the current status of the seagrass in the Philippines. Complementing remotely sensed images for mapping out environmental resources have been practiced over the last decades due to its temporal availability and extent. This study focuses on mapping out the seagrass cover using Landsat 8 imageries obtained from 2015-2017. There were three main processes for the extraction namely pre-processing, classification and post classification. The pre-processing method includes radiometric correction and calibration. Mixture Tune Matched Filtering algorithm was used for the classification. This utilizes the Matched Filtering (MF) and Infeasibility scores. Values with low infeasibility scores and MF scores above the background distribution around zero were selected. After the classification, a majority analysis was performed for the post classification. Validation points were used for accuracy assessment. This method was applied to the other tiles to map out the seagrass cover of the Philippines.

ISBW107: Population dynamics and growth patterns of *Thalassia hemprichii* in mixed seagrass beds in Southern Guimaras, Philippines

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Population dynamics and growth patterns of the seagrass *Thalassia hemprichii* populations were assessed in the mixed seagrass beds in southern Guimaras, Philippines, using age reconstruction techniques. Core samples were collected in four stations. Positive net recruitment was observed in Tando (0.15 ln units yr^{-1}) while negative net recruitment was observed in Calapran (0.24 ln units yr^{-1}) indicating an expanding and declining population respectively. Almost balanced recruitment and mortality rates were estimated for populations in Nabinbinan (0.08 ln units yr^{-1}) and Sto. Niño (0.07 ln units yr^{-1}) indicative of a stable state population. Shoot age distributions from all stations were skewed to younger shoots (<1 year) suggesting that the population experiences high mortality after more than 1 year of age. Seasonal trends in shoot growth was evident. However, the timing of growth minima and maxima varied between sampling stations and between years. Vertical growth peaked during the SW monsoon months (July to September) in Tando and lowest during the NE monsoon months (November to February). In the contrary, shoot growth generally peaked during the NE monsoon months in Calaparan. Differences in estimates of vertical and horizontal elongation rates, branching frequency and mean shoot length between sampling stations indicate small-scale variations in environmental factors. Understanding the current status of the seagrass population and the different natural and anthropogenic factors that drive its dynamics is necessary for its proper management and conservation.

ISBW108: Carbon storage in seagrass ecosystems along the Andaman coast of Thailand

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Seagrass ecosystems are important contributors to mitigation of climate change, since they are responsible for large carbon sinks. However, limited knowledge regarding carbon storage in various ecosystems has provided us with imprecise regional estimates. In this study, we estimated carbon storage in several structurally different seagrass meadows along the west coast of Thailand and determined whether geomorphological factors, disturbance, and meadow type influenced carbon storage within these meadows. Carbon content within the living vegetation was on average 3.87 ± 2.74 Mg ha^{-1}, whilst average storage of carbon in the sediment was 122.92 ± 35.38 Mg ha^{-1}. Meadow type and disturbance had significant influence on total carbon storage in the ecosystem, while geomorphology of the bay did not show great difference. Uniform meadows had higher average of total carbon storage than mixed meadows (133.16 ± 36.23 and 110.66 ± 41.32 Mg ha^{-1}, respectively). Undisturbed meadows had higher average of total carbon storage than disturbed one (140.68 ± 36.57 and 103.68 ± 34.80 Mg ha^{-1}, respectively). Obtained results contribute towards our understanding of carbon storage on an ecosystems scale and can provide a baseline for proper management, conservation, and climate change studies in the region.

ISBW109: Blue Carbon Stocks Assessment of *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871 in Selected Sites of Pujada Bay, Philippines

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This study highlights the potential of *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871 in stocking significant amount of carbon in their biomass. By using the method of Fourqurean (2012) and (Yamamuro, 2015 pers. com). The carbon concentration by different parts of seagrass species was accounted. The final “Blue Carbon” stocks in the three selected sites of Pujada Bay namely; Irish, Badas, Guang-guang and Gregorio were obtained. Possible environmental gradients were also noted that may affect the carbon storage of this marine flora.
The analysis found that rhizomes (109 g/m^2) have the largest amount of carbon stored among the seagrass parts, followed by leaves of 80 g/m^2 and roots of 41 g/m^2. Guang-guang had the highest concentration of Blue Carbon (110 g/m^2) among the three selected sites of Pujada Bay. The second site with the largest amount was Gregorio with 77 g/m^2 and the least concentration of Blue Carbon was recorded in Irish, Badas (43 g/m^2). The seagrass ability to store carbon was associated to its dimension and its abundance in each site. The importance of environmental gradients such as temperature, salinity, depth, pH and substrate were noted and recorded in the study.
This study advocates careful management of *T. hemprichii* as one of the most dominant and widely distributed seagrass species in Pujada Bay which can provide efficient carbon stocking. People should be aware of these resources as not only meant to be habitat and food for some marine organisms but also a potential contributor to hamper climate change.

ISBW110: High Macrophyte Canopy Complexity Enhances Sediment Retention and Carbon Storage in Coastal Vegetative Meadows at Trangken Bay, Phuket, Southern Thailand

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Marine macrophytes help protecting coastal habitats by modifying the energy of their environment, attenuate wave action, and stabilize the sediment. The aim of this research was to examine the effect of above grounds, through habitat complexity index, of different seaweed and seagrass species on deposition, retention, physical (dry bulk density and grain size) and chemical properties (organic carbon content and organic carbon density) of sediment between 2 seasons. The study was carried out by using *Halimeda macroloba, Cymodocea rotundata* and *Halophila ovalis* as model organisms as they were commonly found in an intertidal sheltered bay of Tang Ken Bay, Phuket, Thailand. Interestingly, the results suggested that the highest canopy complexity index was in the *H. macroloba* patches which have highest dimensional of leaf blade. The shoot density of macrophyte in the summer was lower than in the rainy season most likely due to damage from long exposure during low tide. The wave action in the rainy season affected the sediment in manner of higher sediment deposition and movement, which increased sediment instability and led to changes in sediment properties. The sediment retention and percent of organic carbon content was affected mainly by seasons; and higher canopy complexity patches were likely to retain more sediment and store more organic carbon than lower canopy complexity patches and bare sand. Our results indicated that the seasons and canopy complexity of marine macrophytes influenced both, sediment retention and properties of the sediment.

ISBW112: The Dugong and Seagrass Research Toolkit

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The Dugong and Seagrass Research Toolkit is a free, web-based application intended to be used by dugong, seagrass and coastal community researchers and conservation practitioners. The toolkit is based on a decision tree, helping users to select the most appropriate methodologies for dugong and seagrass research and defining the human community factors that influence dugong and seagrass conservation by identifying threats and possible management solutions. It's development was mainly driven by the incompatibility of datasets and lack of standardized methods for assessing dugong populations and seagrass distribution and status. Furthermore, it responds directly to the capacity needs of dugong range states. It has been developed by a team of specialists from the Convention of Migratory Species, Dugong MOU's Technical Group who are eminent dugong, seagrass and community specialists giving it a robust scientific basis and academic credibility. We anticipate that it will be used by thousands of members of universities, research institutes, governmental and non-governmental organizations with mandates for coastal and marine research and conservation. There are some 85 seagrass range states including 46 dugong range states whose researchers are expected to benefit from the toolkit. The Dugong and Seagrass Toolkit is the outcome of a close and fruitful partnership. Generous sponsorship was provided by TOTAL and Total Abu Al Bukhoosh. The Dugong and Seagrass Research Toolkit is a novel and innovative contribution to dugong, seagrass and coastal community research and conservation.

ISBW113: An overlooked role of below-ground biomass in reducing sediment erosion by seagrass beds

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Is generally assumed that coastal vegetation stabilises the sediment, but the role coastal vegetation in sediment stabilisation has been mainly focused on the full effect of the canopy interaction with the water flow on bed-level dynamics. In contrast, the mechanism on how sediment may be stabilised in cliffs by below-ground biomass (roots and rhizomes) has not been fully described, even though cliffs are commonly observed features. We study the latter by collecting in the field intact sediment samples with different densities of seagrass *Zostera marina* and exposing them to wave conditions using a hydraulic flume. Sediment erosion was measured by reconstructing 3D images using photographs at different time steps. The magnitude of erosion reduction caused by below-ground biomass at vertical sediment edges, was also compared with the erosion reduction caused by above-ground biomass for horizontal sediment beds, using models parameterised by data from our study and from other experimental *Z. marina* studies. Results showed a strong correlation between below-ground biomass and the erosion rate in sandy sediments. In contrast, there appeared to be no significant correlation in muddy sediments. These results suggest that the density at which roots and rhizomes are present is important for determining erosion rates in non-cohesive sandy sediments. Model predictions supported the important and overlooked role of below-ground biomass in reducing sediment erosion from cliffs in seagrass beds. Present results imply that management strategies should be developed for using seagrass to enhance the stabilization of sandy sediment, while restoration could be more successful in relative table cohesive muddy sediment.

ISBW114: Ten years conservation effort enhances seagrass cover and carbon storage at Koh Tha Rai, Nakhon Si Thammarat Province, Thailand

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Seagrasses are known as engineering ecosystems which have important roles in coastal ecosystem. Globally, seagrass areas have been declining and to prevent their further disappearance many conservation projects have been done. The aim of this work was to estimate how successful conservation efforts have been at seagrass meadow at Koh Tha Rai, Nakhon Si Thammarat Province, southern Thailand in a terms of meadow extent, coverage and carbon storage. Seagrass area from the previous study in 2006 was compared to the recent observation in 2017 and the results show that the area increased by 0.7 ha. (from 4.4 ha to 5.1 ha.) with the increasing rate of approximately 0.06 ha $year^{-1}$. The total coverage of seagrass increased around 3 times, with *Halodule uninervis* having the highest increase (12.3 times in sandy site and 34 times in muddy site). Moreover, total organic carbon storage in sediment increased from 2006 by 25.32 MgC (from 255.59±33.07 MgC to 230.27±27.35 MgC). There was the positive relationship between dry bulk density and organic matter and organic carbon content (R^2 = 0.137 and R^2 = 0.717, respectively). In conclusion, this study clearly shows the importance of successful conservation efforts in terms of increase of seagrass meadow area, associated characteristics of the meadow and increase of the performance of the healthier meadows.

ISBW115: Keep off the grass: using exclusion cages to understand the interactions between herbivores in structuring seagrass meadows

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Seagrasses provide important habitat that delivers ecosystem services and provides food to a wide diversity of herbivores globally. In the Great Barrier Reef (GBR) we find the full size spectrum of herbivores; from small mesograzers such as amphipods, to macrograzers such as fish and large megagrazers such as turtles and dugongs. These herbivores can structurally alter seagrass beds in either positive or negative ways depending on their size, feeding preferences and methods and grazing intensity. These structural changes can subsequently interact with the delivery of other ecosystem services, or the benefits to humans, provided by the seagrass meadow. In the tropics, we know little about the impact of herbivores and how different groups interact to structure seagrass meadows, despite the number and variety of herbivores present in tropical seagrass habitats. We carried out exclusion experiments that targeted each herbivore group individually and in combination in subtidal and intertidal seagrass meadows in Queensland, Australia to understand the role of herbivores in structuring meadows and the interaction between herbivore groups. Our results show different feeding strategies of herbivores in each habitat, especially megaherbivores, and these impact the meadow in different ways. The effects on biomass, shoot density and shoot height depended on the type of grazing observed. All herbivore groups acted to structure the seagrass and interacted to influence overall meadow properties. Grazer mediated changes in meadow structure will have important implications for the ecosystem services delivered by tropical seagrass ecosystems.

ISBW116: Leaf plastochrone interval and rhizome growth dynamics of *Enhalus acoroides* (L.f.) Royle in a muddy coast: Implications for age-reconstruction techniques

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Determining the leaf plastrochrone interval (LPI) variability for the long-lived *Enhalus acoroides* in a muddy coast, using the individual shoot-based LPI method, provides insights on its applications for age-reconstruction techniques on its rhizomes. The rhizome study, in turn, can yield information on seagrass growth dynamics in the past. The study aimed to 1) determine the temporal variability of *E.acoroides* LPI and other young leaf growth parameters on a seasonal scale; and 2) determine rhizome internodal growth trends along different temporal scales; and 3) correlate these leaf and rhizome growth patterns with records of environmental parameters.

The annual mean LPI of *E. acoroides* was 26.6 days with the average quarterly LPI ranging from 22 to 30 days. Larger LPI values were associated with the highest rainfall months, indicative of high turbidity regimes. Leaf elongation rates were positively correlated with sea surface temperature, while young leaf surface growth rate with PAR levels. Based on 5 to 10 year old rhizomes, the annual mean LPI ranged from 18 to 46 days with over-all mean at 27.5 days. Rhizome internodes showed unimodal annual growth cycles, with growth maxima occurring during periods indicative of less turbid conditions. On an interannual scale, longer internodes were observed during periods associated with La Niña events typically characterized by watershed-derived sedimentation and turbidity. Shorter internodes were observed during the El Niño events, indicative of dry periods. Over-all, the study demonstrated how the effect of light on growth of *Enhalus acoroides* varies along different temporal scales in the turbid environment of the muddy coast.

ISBW117: Increasing seagrass habitat complexity enhances crab's density: a case study from Koh Tha Rai, Thailand.

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Seagrass conservation and awareness are important to promote the importance of seagrass ecosystem service to government, non-government as well as local communities especially in the South East Asian region where seagrass are greatly threatening due to coastal development. The present study investigated species, size and density of crabs in difference seagrass habitat complexity (bare sand, low and high seagrass coverage). The seagrass coverage and crab data were collected in May 2006, September 2010 (before the awareness campaign) and August 2017 (after the awareness campaign) at Koh Tha Rai, Gulf of Thailand. The results showed that the conservation activity in this area helped increasing seagrass coverage. Seagrass increased up to 2.34 times at the previous low coverage site in 2006 and 2010; and the dense healthy seagrass was observed in this area. A generalized linear model showed that crab density, *Thalamita crenata*, a common carb species, increased with increasing of seagrass coverage (log-likelihood ratio test = 31.71; df = 1,160; P-value ≤ 0.0001). The results of this study underlined the importance of seagrass conservation and awareness which help promoting the importance of seagrass ecosystem service in the region.

ISBW118: Diurnal and Sub-diurnal Impacts of Tropical Seagrass Community Metabolism on the Seawater Carbonate System

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Seagrass management and restoration has recently gained traction as a potential ecosystem engineering approach to ameliorate ocean acidification on a local scale. However, understanding the variability and feedback between seagrass metabolism and water column chemistry is critical to evaluating if, and how, seagrass meadows may be utilized to mitigate ocean acidification on coral reefs. Here, we present an 18-day study from Ngeseksau Reef, Republic of Palau, where dense beds of seagrass are fringed with healthy coral communities and seagrass and corals are often collocated. Our analysis of coupled biogeochemical and hydrodynamic measurements provides a high-resolution record of seagrass productivity across a range of light availability, velocity, and residence time. Seagrass net community production (NCP) was quantified over a 571-meter transect on Ngeseksau Reef at the mouth of Nikko Bay. This site is characterized by a tidally driven uniaxial current flow over the bed, and NCP was quantified with an “upstream-downstream” approach using autonomous measurements of dissolved oxygen and pH. Current velocity was measured with an Acoustic Doppler Velocimeter and drifter deployments confirmed flow along the transect line. To assess the spatial influence of the seagrass bed, surface measurements were made using a flow through system (pCO2, pH, salinity, temperature, and dissolved oxygen) aboard a small vessel. Our results illustrate the diel pattern of seawater chemistry modification by the seagrass metabolism. Chemical buffering was enhanced (high pH, high O_2) under daytime conditions of high irradiance, low tide, and long residence time, whereas nighttime respiration intensified acidic conditions (low pH, low O_2).

ISBW123: Influence of Habitat Complexity and Proximity to Adjacent Habitat on Fish Communities in Tropical Forereef Seagrass Meadows

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Seagrass meadows are highly productive habitats that provide trophic support and refuge for commercially and ecologically important fish and invertebrates. How the structure of seagrass habitats and the presence of nearby coral reefs influences fish communities is not fully understood, and is the subject of this study. Fish-habitat relationships were examined in the tropical forereef seagrass systems of Tinggi Island and Babi Besar Island, Malaysia, by documenting seagrass habitat complexity attributes (canopy height, shoot density, coverage and species richness) and proximity to adjacent coral reefs within 2 x 2 m quadrats (n=30). Fish assemblages were recorded using the Remote Underwater Video Station method with a total of 2252 individuals from 85 species recorded and enumerated. Generalized Linear Models identified seagrass percent cover and proximity to adjacent coral reefs as the best explanatory variables for fish density (adjusted D^2=33%) and species richness (adjusted D^2=27%). In summary, fishes in seagrass meadows perceive the complexity of its habitat may not depend as much on typical 3-dimensional attributes such as canopy height and shoot density but instead rely more on a 2-dimensional seagrass cover. Furthermore, in seagrass-coral habitat continuum, the diversity and abundance of fish observed in seagrass meadows may also include the presence of multiple-habitat users from the adjacent coral reefs.

ISBW124: Impacts of Recent Climate Change on Seagrass's Carbon Sink Potential

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Climate change has become a critical environmental challenge for modern society, and methods for mitigating this by removing carbon from the atmosphere are of global importance. Oceans and coasts are the most efficient natural systems at removing Carbon from the atmosphere, particularly mangroves, saltmarshes and seagrasses, collectively named 'blue carbon'. Advances in blue carbon research protocols provide an important resource to reduce and mitigate the impacts of climate change, as well as promote the use of coastal ecosystems as carbon sinks. Carbon captured by seagrass ecosystems can persist stored in their sediments for long periods of time, up to millennia, contributing significantly to the net removal of global atmospheric CO_2. However, climate and land use change, erosion, and anthropogenic degradation processes threaten the environmental role of these coastal ecosystems. Management of carbon within coastal ecosystems is key to avoid these systems becoming carbon sources. Therefore, in order to better understand the processes that influence carbon storage within seagrass it is vital to investigate how carbon storage and sequestration rates have altered over time. This study investigates the relationship between the influence of recent climate change and carbon sequestration and storage in seagrass meadows in the Solent, UK. Results from this study will improve the understanding of the factors that influence carbon sequestration and storage within temperate seagrass ecosystems and how predicted climate change impacts will influence their carbon sink potential. This will provide a useful source of information to support the implementation of carbon management policies for these coastal ecosystems.

ISBW127: Effects of low light on the optimal temperature for productivity in the tropical seagrass *Halophila ovalis* (R.Br.)

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Seagrass meadows are impacted by turbidity due to high sediment inputs into coastal waters. This might increase their susceptibility to predicted changes in sea surface temperatures associated with climate change. This study aims to investigate whether the optimum temperature of net productivity of the tropical seagrass *Halophila ovalis* changes in response to reduced irradiance levels. As photosynthetic rate may decline while respiration rate remains unchanged at lower light levels, it is hypothesised that the optimal temperature of net productivity may decline to reduce respiration rate and balance respiratory carbon demand with smaller quantity of carbon synthesised during photosynthesis. An in-situ shading experiment was conducted between August and November 2017 at Chek Jawa, Singapore. Three shading levels were stimulated: High shade (68% shading), low shade (49%) and control (0%). Changes in seagrass percentage cover, shoot density, leaf area, and chlorophyll content were monitored monthly. Compared to control, shoot density decreased by 36% in low shade and 61% in high shade while leaf surface area decreased by 7% in low shade and 17% in high shade. Seagrasses were collected from each treatment for respiration and photosynthesis measurements in the laboratory across six temperatures - 22°C, 26°C30°C, 34°C, 38°C and 42°C. A response-temperature model was fitted to the measured photosynthetic and respiration rates to determine the temperature-dependence of photosynthesis and respiration. After three months of experimental shading, seagrass recovery was monitored for two months. Results of this study could help understand how turbidity affects seagrass resilience to warming oceans.

ISBW129: Multiple anthropogenic disturbances on *Posidonia oceanica*: synergies, early warnings, and conservation tips

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Seagrasses are globally declining and often their loss is due to synergies among stressors. The interactive effects of eutrophication and burial on the Mediterranean seagrass, *Posidonia oceanica* were investigated. A field experiment was conducted to estimate whether shoot survival depends on the interactive effects of three levels of intensity of both stressors and to identify early changes in plants (*i.e.* morphological, physiological, and expression of stress-related genes) that may serve to detect signals of imminent seagrass collapse. Sediment burial and nutrient enrichment produced interactive effects on *P. oceanica* shoot survival, as high nutrient levels had the potential to accelerate the regression of the seagrass exposed to high burial (HB). After 11 weeks, HB in combination with either high or medium nutrient enrichment, caused a shoot loss of about 60%. Changes in morphology were poor predictors of the seagrass decline. Likewise, few biochemical variables were associated to *P. oceanica* survival (phenolics, ORAC and leaf $\delta^{34}S$). By contrast, the expression of target genes had the highest correlation with plant survival: photosynthetic genes (ATPa, PsbD and PsbA) were upregulated in response to high burial, while carbon metabolism genes (CA-chl, PGK and GADPH) were down-regulated. Therefore, die-offs due to high sedimentation rate in eutrophic areas can only be anticipated by altered expression of stress-related genes that may warn the imminent seagrass collapse. Management of local stressors, such as nutrient pollution, may enhance seagrass resilience in the face of the intensification of extreme climate events, such as floods.

ISBW132: An ecosystem service approach to decision-making in the Ria Formosa lagoon (south Portugal)

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The key to the sustainable development of coastal areas is achieving a balance between the human uses of the ecosystems and the preservation of the benefits they provide. This approach requires the assessment of the services provided by the ecosystems and the evaluation of how management decisions may alter their provision. Ria Formosa is a protected coastal lagoon along the southern Portuguese coast, which is dominated by coastal vegetation including seagrasses, macroalgae beds, and salt-marshes. The lagoon is subjected to physical disturbances such as bait and clam digging, clam farming, dredging events and high nutrient loads from both wastewater treatment plants and groundwater inputs from agricultural areas. These impacts may cause qualitative changes of the ecosystem, leading to seagrass decline, which in turn alter the provision of ecosystem services. Here we quantified the ecosystem services of coastal vegetation, namely blue carbon sequestration, water purification, and the role of seagrasses on the recruitment and support of commercial molluscs, crustaceans and fish. Changes in the delivery of these ecosystem services are estimated by running spatially-explicit models under different management scenarios based on real interventions in the system, such as channel dredging and harbour developments. The outputs are successfully providing a framework to help protected area authorities in their decision-making. This approach is contributing to seagrass conservation in Ria Formosa lagoon and to the long-term maintenance of the services provided by this ecosystem.

ISBW133: REASE: A regional network to raise awareness on ecosystem services provided by seagrass meadows in the Algarve (south Portugal)

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The Environmental Education Network for Ecosystem Services (REASE) is a recently founded initiative in the Algarve (south Portugal) by institutions of scientific research, education, science outreach and a regional environmental NGO. The REASE aims to develop environmental education projects in the area of ecosystem services (ES), especially those provided by coastal vegetated ecosystems, including saltmarshes and seagrasses. The network is currently working on: 1) capacity building for school teachers and environmental managers in order to promote scientific knowledge on the services provided by coastal ecosystems; 2) the creation of an “incubator of projects” to design innovative, formal education ES projects to be developed in local schools; 3) raising awareness of students and general public on the role of vegetated ecosystems for human well-being through exhibitions and talks at science outreach centres; 4) publication of a booklet for children on the ES of seagrasses, with a community-based participatory design (illustrations made by schoolchildren); 5) the launch of a Citizen Science project for schools to evaluate the Blue Carbon stock in the Algarve, for which schools have been provided with field and laboratory kits, and scientific support; 6) the development of an app to directly upload field measurements and blue carbon data into the website of the project, where data will be scientifically validated and analysed. The actions and events are being successfully welcome by the local community and having high media impacts and participation rates.

ISBW134: Shaping the coast: Hydrodynamics and bottom complexity inducing eelgrass seed trapping.

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Seed dispersal has great relevance for the emergence of seagrass meadows. Depending on mechanism of transport, the seeds of eelgrass (*Zostera marina*) can travel between a few meters and several kilometres far. Using a hydraulic flume, we tested how habitat complexity, in form of different densities of biogenic structures (eelgrass shoots, oysters and blue mussels), affects the transport and the trapping of seeds. Our results suggest that both shape (e.g. length, width, volume) and density of the objects considerably influence seed trapping. At current velocities below 18 cm/s eelgrass shoots were more effective in trapping seeds compared to bivalves. The proportion of trapped seeds thereby decreased with current velocity. Further increase in current velocity, however, lead to an increase in trapping success for bivalves and weakened for eelgrass shoots due to enhanced sediment erosion. The scouring area behind objects thereby was dependent on both object width and velocity. Flow measurements with an acoustic Doppler velocimeter showed that bivalves and eelgrass shoots reduce current speed after the objects and generate turbulence, which in turn is affecting erosive processes behind these structures. When the resulting scouring pits had reached a certain magnitude, they were able to trap seeds effectively. These results highlight that ecosystem engineering of both plants and bivalves can have a significant impact on seed trapping and thus facilitates the emergence and retention of eelgrass patches under varying hydrodynamic regimes.

ISBW140: The effect of nutrient enrichment outweigh ocean warming on performance of seagrass *Zostera capensis* from the West Coast of South Africa

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Global change stressors pose significant threats to biodiversity and ecological resilience in marine ecosystems across the planet. In this paper, we experimentally aimed to disentangle the direct effects of warming and eutrophication on the physiological performance of Cape eelgrass, *Zostera capensis* from the West coast of South Africa. Morphological features, photosynthetic efficiency and elemental content in seagrass tissues were assessed. Result indicates that number of shoots, leaf length, aboveground biomass and effective quantum yield were negatively impacted with increased levels of nutrient and temperature ($p < 0.05$). The growth rate, number of leaves, and leaf width decreased significantly with increase in nutrient levels but not temperature. In addition, epiphytic load on seagrass leaves was significantly enhanced by both temperature and nutrient enrichment but not their interaction. Generally, our findings highlights the important effects nutrient enrichment and increasing temperatures have on *Z. capensis*, they also have key implications for predicting changes in regional ecosystem functioning in the face of global change. Therefore increasing levels of both stressors are likely to lead to shifts in architectural attributes of *Z. capensis*, principally involving reductions in overall plant size, density and growth rate, which are likely in turn to induce cascading alterations to multiple ecological functions and processes.

ISBW142: Modelling the relationship between coastal discharges and seagrass habitat suitability for the Adelaide Coastal Waters

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Some 6,000 hectares of seagrass were lost in Adelaide's Coastal Waters between 1949 and 2007. To provide a quantitative assessment of the relation between coastal discharges and seagrass health, a modelling instrument (Adelaide Receiving Environment Model or AREM) was developed. AREM uses a habitat suitability index (HSI) approach to quantify the impact of eight locally most relevant environmental parameters (light penetration to the canopy, shading by epiphyte cover, substrate, temperature, salinity, wave exposure, currents and tidal exposure) on the nine seagrass species in the study area (4 *Posidonia* spp., 2 *Amphibolis* spp., *Heterozostera tasmanica*, *Zostera muellerii* and *Halophila australis*). The relevant environmental parameters are quantified using well-established coupled wave-hydrodynamics, suspended sediments and biogeochemistry models. By feeding these into the HSI method, habitat suitability maps are compiled that express where and to what degree current environmental conditions are favouring/preventing seagrass growth and survival. The HSI has been validated by hindcasting the period of earliest seagrass mapping (1940s), the period of maximum anthropogenic pressure (1970s) and the present period (based on 2011 data). The results of the model confirm that light availability is the most critical pathway for coastal discharges to affect seagrass health, both through direct shading (particles, CDOM, phytoplankton) and by stimulating rapid growth of filamentous epiphytic algae on the seagrass leaves. Light availability for seagrasses is also affected by wave-induced resuspension of fines from the seabed, especially in shallow nearshore areas without seagrass cover, leading to an atypical low light zone in-shore. Recent mapping data (2013) demonstrates that no further net losses of seagrass have occurred since 2007 and revealed the first signs of seagrass recovery at some sites. Further load reduction scenarios will be tested with AREM to devise the most cost-effective management strategy to prevent any further seagrass loss and promote seagrass recovery along Adelaide's coastline.

ISBW146: Recreating the shading effects of ship wake induced turbidity to test acclimation responses in the seagrass *Thalassia hemprichii*

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Elevated sediment delivery and resuspension in coastal waters from human activities such as shipping can have detrimental effects on seagrass health by limiting light penetration. Managing seagrasses requires knowledge of their light acclamatory abilities so guidelines for coastal activities (e.g. ship movements) that influence sediment dynamics can be created. Guidelines typically focus on ensuring that seagrasses can meet their minimal light requirements (MLR). MLRs can be achieved by different light regimes, but it remains unknown whether a chronically low yet stable light regime is less or more detrimental than a highly variable regime with periods of extreme low to no light. To test this, we compared the physiological and morphological responses of *Thalassia hemprichii* among three light regimes: an open control (30-40% ambient light), a shaded control with (11-15% ambient light), and a fluctuating shade (4-30% ambient light). The MLR for the *T. hemprichii we* studied was lower than previous reports illustrating enhanced light acclimation in Singapore's chronically turbid waters. Seagrass shoots in the shaded control, however, exhibited significantly more morphological stress symptoms, with reduced shoot growth and lower below ground biomass. These data suggest that for seagrass exposed to periods of acute light stress, energetic costs associated with photo-acclimation to more variable light regimes can be offset if the plant can meet its daily light requirements during periods of high light. Management of seagrass beds should incorporate regular light monitoring and move towards an adaptive feedback-based approach to ensure the long-term viability of these vulnerable ecosystems.

ISBW147: From environmental education to community capacity-building: Kelab Alami and community engagement through seagrass

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In 2010, Kelab Alami's co-founder presented a case study on the use of environmental education for seagrass conservation at ISBW2010 in Trang. Ten years on since the start of this initiative, the youth who first learnt about seagrass and other coastal habitats with Kelab Alami are now running the show. They teach other youth about the local marine and fishing heritage and help the wider community earn supplementary incomes through guided habitat tours and other initiatives. Kelab Alami has become the voice of the underprivileged in this community, and its co-founders and youth staff have leveraged on the presence of the local seagrass meadows to engage with local authorities and developers in the area. By demonstrating their knowledge of the seagrass meadows and expounding on its importance to the local fishery, Kelab Alami youth successfully convinced a large international developer to support them in protecting the larger seagrass meadow (Beting Tanjung Kupang) and are now working with the Johor Port Authority to begin research on the second seagrass meadow (Beting Tanjung Adang). The youth also collate and consolidate scientific knowledge garnered from myriad scientist-advisors with local ecological and traditional knowledge to create and share more complete information on their habitats.

ISBW149: Unlikely nomads: Settlement, establishment, and dislodgement processes of vegetative seagrass fragments

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The dispersal of seagrasses is important to maintaining the genetic diversity and resilience of populations, and consequently, their long-term survival. The majority of the research on long-distance dispersal to date has focused on sexual propagules while the dispersal of vegetative fragments has been mostly overlooked, despite the important role this mechanism might play. In this study, we propose a conceptual model that categorises vegetative fragment dispersal into seven fundamental steps: i.e., *i)* fragment formation, *ii)* transport, *iii)* decay, *iv)* substrate contact, *v)* settlement, *vi)* establishment, and *vii)* dislodgement. We present two experiments focusing on the final steps of the model from substrate contact to dislodgement, which are critical for dispersed vegetative fragments to colonise new areas. We first conducted a mesocosm experiment to investigate the effect of fragment age and species on settlement (and subsequently establishment rates. To determine dislodgement resistance of settled fragments, we also subjected fragments under different burial treatments to wave and currents in a flume. We found that both initial settlement and subsequent establishment rates increased with fragment age. *Halophila ovalis* was the only species that successfully established within the study period. After settlement, dislodgement resistance depended primarily on burial conditions. However, growth form also played a role, as smaller species *H. ovalis* and *Halodule uninervis* were also able to settle more successfully, and withstand higher bed shear stress before being dislodged, compared to the larger species. We discuss the implication our findings have on the dispersal potential for different species and the conservation of seagrasses.

ISBW150: Distribution patterns of *Portunus pelagicus* in Talibon, Bohol and Concepcion, Iloilo, Central Philippines: Significance of seagrass and mangrove habitats on early life stages

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The blue crab, *Portunus pelagicus*, makes up a valuable fishery in the central part of the Philippines. To ensure sustainability of this resource, fishing should be regulated and critical habitats need to be protected. A trawl survey was conducted in Talibon, Bohol and Concepcion, Iloilo, Philippines to examine juvenile fish and invertebrate assemblages in seagrass beds. *Portunus pelagicus* is commonly found in both areas. An examination of their density and age distributions shows that in spite of apparent differences in the seasonal abundance of crabs in the two areas, juveniles show highest abundances in grassbeds that are nearest to mangroves. In Talibon, Bohol, these grassbeds are close to the main shoreline, while in Concepcion, mangroves are most dense in the islands. The distribution patterns in both areas are compared to determine critical habitat factors for early stage crabs. By determining these critical habitats, a more holistic and refined management plan can be carried out.

ISBW153: Lipids of seagrass *Halodule uninervis* in varying environmental conditions in Bolinao, Philippines

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The tropical Indo-Pacific is the largest and most diverse bioregion in seagrass species. Most seagrass lipids studied, however, are from the temperate regions. This study aims to fill this knowledge gap by providing a detailed above- and belowground lipid profile of *Halodule uninervis*, a common and widely distributed seagrass in the Indo-Pacific. We are also interested to know how *H .uninervis* adapt to various environmental conditions and analyze its lipid composition as it is the main component of the cell membrane, the first line of defense/adaptation to environmental factors. Samples were collected from contrasting areas of sedimentation, dissolved oxygen content and open water conditions along a discharge pathway from Tambac Bay to Lingayen Gulf in Bolinao, Philippines. *Halodule uninervis* was present in all sites, even monospecific in the most turbid, anoxic, hottest (34.4°C) and saline (34.5 PSU) site. As with seagrass lipids in the temperate areas, C_{16} and C_{18} fatty acids, comprising 92% to 99% of the total fatty acids, predominate. We verified this in the above- or belowground components. The tri-unsaturated moiety, $C_{18:3}$, linked to photosynthetic activity, is consistently higher in aboveground components than in their belowgroundcounterparts. Moreover, $C_{18:3}$ systematically varies with seagrass density. Aboveground component of *H. uninervis* has a carbon range C_{21} to C_{25}, whereas below component has longer, C_{21} to C_{29}. Odd-numbered carbon predominance in the anoxic area reflects better preservation of seagrass lipids, whereas branched hydrocarbons in more open conditions indicate prevalence of oxidative biodegradation.

ISBW154: Feasibility of *Posidonia oceanica* restoration after mechanical damage

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Seagrass planting is among the most expensive and less successful (average survival rate 38%) type of restoration project. *Posidonia oceanica* slow growth and unpredictable flowering make its restoration specially challenging. However, the essential role of *P. oceanica* as an engineer species, associated to a highly diverse community and the widespread meadow regression, encourage the efforts for technical and logistical improvements of restoration methods. In this work, we used fragments of adult plants and seedlings to test the feasibility of meadow restoration after a mechanical damage, the laying of an underwater electrical connection. We planted in two consecutive years in two substrates, 1) sand gaps in meadow produced after the laying, trenching and burial of the cable 2) gravel-filled hemp bags placed to consolidate the cable trench, and three depths (15 m, 20 m, and 25 m). We found fragment survivorship between 62.18 % ± 18.72 and 97.44 % ± 2.56 (mean ± SE) on gravel bags and 68.16 % ± 8.28 and 52.14 %± 10.40 on sand, with statistically significant effects of substrate and depth. An average of 17.80 % ±9.6 of the surviving fragments produced new shoots after one year; and small-sized planted fragments (with 3 shoots) showed higher survival and growth rates than fragments with a larger number of shoots. Seedling survival was below 10% after one year in both substrates. The unit cost per fragment and seedling of restoration works (collection, culturing and planting) was valued in 15.1 € and 7.84 €, respectively.

ISBW155: Spatial data for managing coastal seagrasses in Queensland, Australia.

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Queensland's coasts have significant and diverse tropical seagrass habitats that have been mapped and researched for 30 years. This includes the Great Barrier Reef World Heritage Area (GBR) with ~35 000 km^2 and Torres Strait with ~15 000 km^2 of seagrass ecosystem. Programs have documented these seagrasses since the 1980s and early 2000s respectively including: (1) GBR-wide coastal seagrass mapping (1980s-1990s); (2) seabed biodiversity mapping (2004-2005); (3) mapping marine environments in Queensland's shipping lanes and ports (2002-2014); (4) long-term (>15 years) mapping at Cairns, Thursday Island, Townsville, Abbot Point and Gladstone ports Until recently managers could not access the full suite of seagrass spatial data in a format that included a range of spatial scales, site and meadow information; nor could they interrogate the reliability and age of the dataset. We evaluated and incorporated over 300 seagrass spatial data sets (seagrass presence/absence, species present, dominant species, meadow area and survey date) and some 60,000 data points spanning 30 years into a publicly available set of GIS layers. This tool allows coastal managers and scientists to reliability interrogate seagrass data in these areas for management decision making. Seagrass data of this reliability is not available for the western Queensland coast and for much of the coastal areas to Australia's north and west. We look at a recent climate related ecological event in northern Australia and make a case for using our spatial approach and to advocate for improving both the reliability and availability of seagrass data.

ISBW156: Fish assemblages in an undisturbed seagrass habitat

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Little is known about the ecology of oceanic seagrass habitats in cold temperate waters. The Furneaux Island group off North Eastern Tasmania, Australia, is an isolated region with little human disturbance. Seagrass along the coasts of these islands form large beds at depths up to 20m. We used baited underwater videos (BRUVS) to compare fish assemblages within different seagrass species and depths at Trousers Bay, Flinders Island. Seagrass within Trouser Bay consisted of dense *Amphibolis antacrtica*, *Posidonia australis* and *Heterozostera nigricaulis* supporting a diverse fish community including leatherjackets, wrasse, flathead, rays and sharks. Fish communities varied across the different depths but there was little overall difference between seagrass species. Many of the species recorded were large (e.g. sharks) and/or commercially important (e.g. flathead). These results provide an insight into the quality of the pristine seagrass of the Furneaux Islands and the range of fish species it supports. Further research is required to determine its importance to commercial fisheries and function as a nursery habitat.

ISBW158: Seagrass ecosystem services – what's next?

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Seagrasses, provide a wide range of ecosystem services, defined here as natural processes and components that directly or indirectly benefit human needs. Recent research has shown that there are still many gaps in our comprehension of seagrass ecosystem service provision. Furthermore, there seems to be little knowledge by the public of seagrasses in general and the benefits they provide. This begs the questions: how do we move forward with the information we have? What other information do we need and what actions do we need to take in order to improve the situation and appreciation for seagrass? Based on the outcomes from the expert knowledge eliciting workshop during the 12th International Seagrass Biology Workshop, three key areas to advance seagrass ecosystem service research were identified: 1) Variability of ecosystem services within seagrass meadows and among different meadows; 2) Seagrass ecosystem services in relation to, and their connection with, other coastal habitats; and 3) Improvement in the communication of seagrass ecosystem services to the public. Here we will report back about the discussions and findings during the last ISBW. We will present ways forward to advance seagrass ecosystem service research in order to raise the profile of seagrass globally, as a means to establish more effective conservation and restoration of these important coastal habitats around the world.

ISBW159: Seagrass-Watch: two decades of participatory scientific monitoring and science-based education provides insight into global seagrass resource status

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Scientists globally have recognised a need to focus efforts on more effective science based education, conservation, monitoring, and management of seagrass ecosystems. The participatory science program Seagrass-Watch, established in 1998, is globally recognised as an example of successfully engaging and building the scientific literacy and capacity of local stakeholders to contribute to environmental science. Seagrass-Watch is an expanding, global ecological monitoring program that investigates and documents the status of seagrass resources and the threats to this important and imperilled marine ecosystem. The program partners scientists and amateur experts using traditional scientific approaches to produce high-quality data which is essential for resource managers. Both contributory and collaborative partnerships are involved which enables multiple levels of participation; from entry-level crowdsourcing to high-level science. Acquiring long-term data from preliminary ad hoc sightings to methodical and rigorous scientific measures, facilitates greater confidence in reporting seagrass condition at local, state and national levels. We will present how the program is sustained and governed, how the globally standardised protocols were developed using design thinking, how data are managed (e.g. centralised, archived), the strict QAQC controls implemented to ensure data reliability and scientific rigor, and how data is used. The Seagrass-Watch program has provided early alerts to coastal environmental problems before they became intractable, improved our understanding of seagrass ecosystem dynamics, and contributed to a number of local, regional and national assessments and management plans. We will present examples from the Asia-Pacific, Western Europe and the southern east coast of the United Sates.

ISBW163: What do we know of seagrass ecosystem resilience – a systematic review

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Understanding how ecosystems respond to environmental change, and to what extent we can reduce negative impacts on biodiversity and ecosystem services, is a major challenge to 21st century society. Consequently, ‘resilience’ has become one of the buzzwords of the decade in science as well as policy. Yet, in many cases we do not yet understand what factors that make ecosystems resilient, which may hamper our ability to operationalize resilience in management. At a workshop at ISBW12, we initiated a systematic and critical review of seagrass resilience research, to understand if there are common factors or properties of seagrass ecosystems that increase their resistance to, recovery from, and/or potential adaptation to, disturbance and/or environmental change. We critically reviewed ca. 1400 research publications (published 1960-2016) relating to at least one aspect of resilience; resistance, recovery and adaptation. Preliminary results suggest that even though seagrass resilience research has grown exponentially, it is highly skewed to a few seagrass species, geographic regions, types of disturbances/environmental changes, and potential ‘sources of resilience’ (ecosystem properties that increase resilience). Moreover, while there is good support that some factors - e.g. high seagrass genetic diversity - generally increases seagrass resistance, most studies did not assess/test what properties mediate resilience, and/or cannot be used to systematically assess their general importance. Finally, a substantial proportion of the studies have in fact not studied aspects of resilience. We therefore identify a set of key questions and principles to guide future seagrass resilience research, in order to help reduce continued seagrass loss.

ISBW165: Robust rates of blue and black sequestration for two *Enhalus* seagrass meadows (Sabah, Malaysia) using a validated SIT geochronology and corrected for measured rates of decomposition over centennial time scales

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Centennial scale rates of carbon sequestration down seagrass sediments have traditionally, but erroneously, been calculated from their total organic carbon content (TOC) and rates of sedimentation through an un-validated ^{210}Pb geochronology. The underlying assumptions behind such an approach are that the shape of the unsupported ^{210}Pb profile is self-validating, the sedimentary record was not interrupted by large depositional events, buried carbon remains stable over centennial time scales, and no identification and subtraction of allochthonous recalcitrant forms, such a black carbon that do not require the protection of sedimentary burial. Here, for the first time we report a continuous ^{210}Pb geochronology for two *Enhalus* seagrass meadows using sediment isotope tomography, validated from variance in ^{137}Cs and the convergence of a pivotal depositional storm event. Average sedimentation rates between the two meadows were high at around 1.31 cm yr^{-1}. Corrections for organic mineralisation, taken from a 1.5 year incubation study to characterise the decay constants, indicated little change in black carbon for both surface and bottom sediments. However, after one year, carbonates showed a more complex time series consistent with sulphate reduction. In contrast, the 2 year old surface TOC deposit fell by *ca* 32% after 100 hundred years of deposition compared to *ca* 20 % for the bottom 20 year old deposit. These falls reflect the bias inherent in traditional methods of measuring organic carbon sequestration. The article will discuss the implications to current world seagrass sequestration estimates, and modifications required to future or current blue carbon programs.

ISBW168: Preliminary findings following the relocation of the seagrass Halophila beccarii and first record of seagrass in Pulau Bedukang, Brunei Darussalam

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Seagrass meadows and the services they provide are adversely affected by coastal development. Therefore, impact assessments and subsequently mitigation measures prior to any coastal development near sensitive coastal ecosystems are required. However, the questions of practicability and efficacy of these mitigation measures are still raised by environmental practitioners. This study briefly describes the translocation of the vulnerable *Halophila beccarii* as one of the measures taken to mitigate the impact of a coastal development in Pulau Muara Besar, Brunei. A small patch of *H. beccarii* was successfully translocated to two sites, Pulau Muara Besar and Pulau Bedukang in November 2017, a first for this species. The ensuing monitoring found no changes in percent cover of the relocated seagrass in December 2017. However, overall health and percent cover dropped in January and February 2018, possibly due to bad weather. As the monitoring is still in the early stages, whether the translocated exercise is ultimately successful remains unclear. A preliminary seagrass survey was also conducted in Pulau Bedukang prior to the translocation. Five species (*Halophila ovalis, H. beccarii, Halodule pinifolia, Enhalus acoroides, Thalassia hemprichii*) were recorded with total distribution estimated to be 0.05 km2 based on aerial imagery. Other than this study, little information is available regarding the seagrass meadows of Pulau Bedukang and their role in supporting the marine megafauna documented in Brunei Bay. Nevertheless, protection of Pulau Bedukang should be considered due to its relatively extensive and diverse seagrass and the coastal development pressures in other areas of Brunei.

ISBW169: Overcoming the seed of doubt for improved seagrass restoration

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With general agreement that successful seagrass restoration is linked to scaling up of restoration efforts, the use of seagrass seed offers a method to overcome impacts on donor meadows and logistical difficulties in the transplant of adult plants. However, successful germination of tropical seagrasses is recognized as a knowledge gap limiting Australian seagrass restoration. There are several factors which may impede germination process, such as storage technique after collection, sterilisation technique, viability of seeds after being stored for a long period of time, and the physiological ability of seeds to adapt to various environmental conditions. To support seagrass restoration efforts in Sub- tropical Queensland this study collected preliminary data on the changes in seed condition/viability through time, emulating conditions encountered by the seeds under different dispersal mechanisms, including human transplantation. Under natural conditions seeds may become buried, moved to deeper waters with low light levels or anoxic conditions, or pass through the gut of large herbivores. Focusing on the species *Zostera muelleri* we report on the results of multiple experiments to investigate the influence of seed age and colour, sterilisation techniques and environmental factors influencing germination and early seedling survival. The results are discussed in the context of restoring of seagrass meadows in Central Queensland.

ISBW176: The Sedimentation Rates of Coastal Water in the Middle Bank Seagrass Meadow

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Middle Bank Seagrass (MBS) in Penang is one of the largest intertidal seagrass meadows in Peninsula Malaysia. With the mega reclamation projects that are currently on-going in the island, activities such as dredging may increase the suspended solids in water column and cause an adverse impact to the marine organisms. Well-known as an ecosystem engineer due to its ability to influence the hydro- and sedimentary dynamic of coastal water, seagrass encourages sedimentation by reducing the current and trapping the solids as it passes through their canopies. 'J-shaped' tube sediment traps (H/D ratio of 15) were used to collect the sediment depositions. Because of the nature of the intertidal zone, the sedimentation includes the resuspension of bottom sediments. The efficiency of seagrass in promoting sedimentation rates depends on the meadow structures. Hence, this study focused on how the MBS biomass and Leaf Area Index (LAI) affect the sedimentation rates in the meadow. Higher biomass and LAI enhance the sedimentation rates. However, the dry weight of the sediments deposited decreases as the biomass and LAI increases. This shows there is a possibility that denser seagrass strongly binds and holds the sediments, thus reducing the resuspension of bottom sediments. Since the importance of the MBS to the ecosystem is poorly explored, this study aims to fill in the knowledge gap of this meadow.

ISBW177: Exploratory analysis of how seagrass biological attributes affect their bed sediments

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The seagrass canopy, made up of seagrass leaves extending into the water column, presents a flexible resistance to slow down water velocity. The resultant modification of their physical environment makes seagrasses important ecosystem engineers. Despite their importance, understanding of how biological attributes of seagrasses affect their physical environment is limited. To examine the influence of seagrass properties on sediment composition, seagrass meadows in Singapore, Phuket (Thailand) and Malaysia, many of which host multiple seagrass species, were surveyed. Across the meadows examined, seagrass cover and leaf area index ranged between 5-98% and 0.02–13.11 respectively. Seagrass biomass, shoot size (leaf area per shoot) and shoot density were quantified, while bed sediments are collected with a corer and sorted with a particle size analyser. Seagrass properties were compared with sediment composition using exploratory analyses. Preliminary results indicate that sites which had larger seagrass shoots tend to have a greater proportion of finer-sized sediments (<63 μm). Conversely, smaller seagrass shoots tend to be found in sites with more medium-sized sand (250-500 μm). Sites having a greater proportion of coarser sediments (>500 μm) were positively correlated with higher shoot density and below-ground biomass. Together, this suggests large shoot size might be more important than shoot density in sediment trapping. This postulation needs to be tested under different flow conditions and with different species that can exhibit wide morphological variation. Pinpointing specific seagrass properties contributes to the understanding of the mechanisms underlying the processes of sediment trapping and retention in seagrass meadows.

ISBW178: The drivers of blue Carbon stocks in seagrass meadows of the Andaman and Nicobar archipelago, India

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Nature Conservation Foundation

In recent years, there has been considerable emphasis on assessing blue carbon stocks in marine systems and understanding the drivers that contribute to the addition or reduction of these reserves. We studied the blue Carbon trapped in seagrass meadows of the Andaman and Nicobar archipelago, India. Here seagrass meadows are relatively untouched, are comprised of both short and long-lived species, are exposed to fluctuating sediment regimes and are used extensively by large herbivores such as dugongs. They provided an ideal experimental set-up where blue Carbon was assessed along a gradient of seagrass species composition, sediment influx, and herbivory. While Carbon could be higher in areas of high sedimentation (as the depositing sediments will trap Carbon and store it for millenia), herbivory, especially by the dugong, that engages in a very destructive mode of feeding (uproots seagrass shoots and thus constantly churns the bottom sediments), might be responsible for the release of trapped Carbon. Further, seagrass meadows with long-lived species are thought to sequester more Carbon than short-lived species due to the stronger root and rhizome systems that trap organic Carbon and the persistent nature of these species. We found that sedimentation played a much greater role in trapping organic Carbon. Seagrass meadows with long-lived seagrass species trapped lower carbon that short-lived species as they also mainly occurred in areas of low sedimentation. Dugong herbivory did not show any significant impact on organic Carbon.

ISBW179: Size-specific shoaling behaviour of the key Mediterranean herbivore fish *Sarpa salpa* and its importance for their feeding strategy

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Several species show a wide flexibility in grouping behaviour as individuals attempt to optimise the relative costs and benefits of solitary and group living. When the grouping species is also an important ecosystem modifier, its decisions can have serious implications for how and where its function is distributed. We examined shoaling choices and foraging behaviour in *Sarpa salpa*, the most important fish herbivore in nearshore Mediterranean systems. Shoals were strongly size assorted, with individuals choosing to group with conspecifics of a similar body length. This was most likely to reduce the conspicuousness of odd-sized individuals to potential predators. In addition, there was a significant positive relationship between body length and shoal size – as individuals grew larger they tended to aggregate in larger shoals. Finally, feeding behaviour was highly influenced by shoal size. Individuals within smaller shoals all fed simultaneously, whereas in larger shoals, individuals participated in partial and rotational feeding, with individuals taking turns to feed in seagrass patches. These behaviours were unique to the largest shoals. Rotational feeding strategies probably allow larger individuals to access the most nutritional basal leaves and ensured that large shoals foraged voraciously at the same spot until most of the seagrass canopy was consumed before moving to another location. These individual shoaling strategies have important consequences for how herbivory is distributed across the landscape. Meadows dominated by smaller schools are likely to be more homogenously grazed while large shoals create a more patchy, intense mosaic of herbivory.

ISBW181: Green turtles mediate fish community assembly in seagrass meadows

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The feeding activity of large herbivores can ripple through ecosystems, influencing not merely productivity and structure, but also causing major changes to assemblages of habitat-dependent groups. Balancing the conservation needs of large herbivores with maintaining ecosystems and their constituent species is seldom easy, particularly given the emblematic nature of many megaherbivores. Over the last decade, we tracked how seagrass fish communities responded to changing habitat condition as a result of green turtle foraging activity in the Lakshadweep archipelago, Indian Ocean. The archipelago has a resident high-density green turtle population that has, over the last 15 years, been travelling between lagoons. Sustained turtle foraging causes compositional shifts in seagrass species from late successional *Thalassia hemprichii* to earlier successional seagrass species. We examined how fish communities responded to turtle-induced changes in seagrass species composition and physical structure by comparing assemblages before turtles arrived, two years, and 5 years after turtles populated each atoll. Fish composition was heavily influenced by seagrass canopy, and declined significantly within a few years of turtle foraging at a meadow. After five years of grazing, seagrass structure reduced significantly, with major consequences for fish assembly. Our results show that green turtle herbivory can be a major determinant of seagrass fish assemblages. When the affected species are additionally important for local fisheries, their loss can be a large source conflict with fishers, seriously compromising efforts to conserve these iconic megaherbivores.

ISBW183: Estuary management and seagrass meadows: Using stable isotope analysis to maintain ecosystem health

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Seagrass and epiphytes perform a diverse range of services to the estuarine environment. The decline of coastal seagrass meadows on a global scale can be attributed an increase of anthropogenic pressures including catchment derived nutrients from multiple sources, including agricultural inputs such as fertilisers and effluents. These inputs can be temporally dependent, with natural fluctuations occurring between seasons. Stable isotope analysis is an effective tool for identifying ecological patterns, nutrient source points and shifts in environmental systems.

This research used stable isotope analysis to determine the temporal and spatial variability of nutrient sources in Lake Macquarie, a large urbanised estuary on the NSW coastline. Seasonal sampling of *Zostera muelleri* and epiphytic algae occurred at 34 sites in Lake Macquarie during 2014 and 2015. The evidence obtained from this study indicated that not only do the stable isotopes $\delta^{13}C$ and $\delta^{15}N$ vary between seasons on the larger scale (>1km), there is also a high amount of variability on the smaller scale (<1km) within the sections of the lake both temporally and spatially, independent of known nutrient sources. These results further suggest that although Lake Macquarie is a highly dynamic system with multiple stakeholders, effective and sustainable management of catchment derived nutrients is essential for maintaining the balance between anthropogenic needs and ecosystem health.

ISBW186: Seagrass condition targets in the Great Barrier Reef

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We are developing seagrass condition targets for habitats of the Great Barrier Reef (GBR) as benchmarks against which to report on ecosystem health. A spatially-explicit habitat classification scheme was developed for the entire GBR based on water depth and water quality. In addition, at a case study location in Cleveland Bay near Townsville, in north-eastern Australia, there is long-term community composition and biomass data, which was used to test a seagrass community-based habitat classification. We fitted Multivariate Regression Trees to the biomass of each species in a multivariate response (community response). Environmental variables included in the analysis were sediment type, low tide exposure, depth, and the frequency of exposure to turbid water as derived from remotely sensed imagery using water colour classification. The multivariate analysis resulted in seagrass community clusters, which are analogous to habitat types. All of the environmental response variables tested had some influence on the clustering into these habitat types. We are developing a framework for setting and reporting seagrass condition targets in each of the habitat types in the GBR-wide habitat classification scheme, and in the Cleveland Bay habitats. These targets will consider both seagrass state and seagrass trajectory. This analysis draws on decades of mapping and monitoring of some 30,000 km^2 of seagrass across the 2,300 km length of coastline. Despite the long historical data sets, some habitat types have little or no data. The condition targets will be used to assess decline and will be linked to triggers for management actions.

ISBW187: Engaging multidisciplinary science students in a seagrass fieldwork project at St John's island (Singapore)

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A fieldwork project on seagrass was organised for second-year undergraduate science students in the context of an integrated science programme. The project was developed and supported by the Special Programme in Science at NUS and the St John's island national marine laboratory. Most of the participants in the project had never done a fieldwork project, and they knew little or none about seagrass research. Additionally, they would probably never have such experience in their disciplines (especially those in physics and chemistry). This project had several aims; expose students to ecological research, project planning, and the importance of seagrass in the earth system. Students had to submit their research proposal on seagrass at St John's island and Lazarus. All proposals were discussed in class with a field expert and educators. Students conducted their planned fieldwork, analysed their results and reflected on their personal experience. Data were collected from class and fieldwork observations, students' questionnaires and reflective writing. This presentation will show the impact of this fieldwork project on the personal development of students.

ISBW188: Implications of population genetic diversity and connectivity *of Zostera muelleri* over the species' range

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Zostera muelleri Asch. a monoecious seagrass widely distributed in Australia is found in tropical environments from the north-eastern Torres Strait, south to Tasmania and west to South Australia, and even a few populations extend to Western Australia. This species also occurs in New Zealand, where it is the only seagrass species. Three largely geographically based subspecies are currently recognised, subsp. *capricorni*, *mucronata* and *novazelandica*. Very few population genetic studies have been done on this widespread species, and most have been on a local scale. In this study samples were collected throughout whole species range, with a total of 41 populations and more than 1400 samples. The samples were genotyped with 12 microsatellite loci. A very strong divide between tropical populations (Queensland) and temperate populations (South and Western Australia) occurs. Populations located between these two groups show a complex mixed signal, indicative of a hybrid zone. Some of the loci in these populations exhibit more than the two peaks expected in diploid organisms, exhibiting up to four alleles, a tetraploid signal. Not all loci in the hybrid zone appeared tetraploid, some appear diploid, and the loci varied among the populations. It is possible that individual plants or even populations in this putative hybrid zone have an abnormal chromosomal compliment. The distribution of the subspecies either side of the hybrid zone follows the pattern of genetic diversity detected. However, the hybrid zone itself requires further investigation as it implies a more complicated genetic history and options for this investigation will be discussed.

ISBW189: The Red Sea Seagrass Microbiome

Neus Garcias-Bonet, Carlos M. Duarte

Red Sea Research Center, King Abdullah University of Science and Technology (KAUST), Saudi Arabia

Seagrass ecosystems are highly productive ecosystems. Seagrasses fix carbon photosynthetically and bury it in their sediments, acting as efficient net carbon sinks and, therefore, having an important role in climate change mitigation. Seagrasses normally thrive in hard environments: oligotrophic waters and highly anoxic sediments leading to high sulfide concentrations. These marine plants have physiological adaptations to grow under these conditions but only recently the role of the microbiome in sustaining these ecosystems has been pointed out. The microbiome can shape host fitness by increasing nutrient availability, detoxifying sediments and protecting against infections. However, we are just starting to describe and understand the microbial community associated to seagrasses. The Red Sea offers a unique opportunity to study the microbiome of seagrasses adapted to its extreme environmental conditions. Here, we analyze the microbiome of 6 different seagrass species naturally found along the Red Sea coast and exposed to gradients in temperature, nutrient availability and salinity. Understanding the role of the microbiome in the adaptation of seagrasses to this harsh environment is crucial for the preservation of these endangered ecosystems.

ISBW190: Role of carbonate burial in "Blue Carbon" ecosystems budgets

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Sediments accumulate in seagrass ecosystems and contribute to seabed elevation, providing a natural coastline protection against sea level rise (SLR). Calcium carbonate ($CaCO_3$) often represents a significant part of the accreted materials. The role of carbonate accretion in seabed elevation is particularly important in tropical marine ecosystems as they are area of intense calcification. In the dry tropics, regions deprived of water runoffs, marine carbonates can be the main source of sediments supporting seabed elevation in seagrass meadows. However, $CaCO_3$ formation emits CO_2 and there has been concerns that the accumulation of carbonates in seagrass sediments reveals large emissions of CO_2, from intense calcification activity by the seagrass associated communities. This may partially offset the role of seagrass ecosystems as CO_2 sinks through the burial of organic carbon (C_{org}) in their sediments.
To illustrate the role of carbonates in SLR remediation, we conducted a study on the decadal and centennial soil accretion rates and carbonate burial rates in seagrass ecosystems of two tropical desert seas, the Red Sea and the Arabian Gulf. We show that sediment accretion keep pace with SLR and is supported at 40 to 55% by carbonates. We also conducted a meta-analysis showing that, globally, $CaCO_3$ support ~40% of the sediment accretion in seagrass ecosystems, with burial rates of inorganic carbon (12 % of the $CaCO_3$) of 13 to 52 TgC yr^{-1}. This may correspond to an offset of 30% of the net CO_2 sequestration associated with C_{org} burial. However, mass balance analyses indicate that the carbonate inputs are mostly supported by allochthonous sources, and that seagrass ecosystems could be sites of net carbonate dissolution. Hence, carbonate burial contributes to the capacity of seagrass ecosystems to locally offset SLR without reducing their role as intense CO_2 sinks.

ISBW191: Thermal dependence of seagrass ecosystem metabolism in the Red Sea

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The Red Sea is one of the warmest seas with shallow seagrass ecosystems exposed to extreme temperatures, in excess of 35 ˚C, during the summer months. Seagrass meadows are net autotrophic ecosystems but respiration increases faster than primary production with increasing temperature. This may lead to a shift from an autotrophic to a heterotrophic system at the highest temperatures experienced. Although tropical seagrasses are adapted to high temperatures, the metabolic rates of Red Sea species during the summer months have not yet been reported. Here, we assessed the community metabolism of two tropical seagrass ecosystems: an *Enhalus acoroides* monospecific meadow and a *Cymodocea serrulata* and *Halodule uninervis* mixed meadow, located in the central Red Sea. We measured *in situ* net community production (NCP), community respiration (R), gross primary production (GPP) and photosynthesis-irradiance (PI) relationships along their natural temperature gradient over one year by measuring diel fluctuations in dissolved oxygen. While the *E. acoroides* meadow remained net autotrophic along the year, the *C. serrulata* and *H. uninervis* mixed meadow was heterotrophic during part of the warmest period. In both seagrass meadows, R increased with increasing temperature. These findings suggest contrasting responses in tropical seagrass species to rising temperature, showing the potential vulnerability of seagrasses to ocean warming.

ISBW193: Seasonal metabolic rates of seagrass communities along a latitudinal gradient in the Red Sea

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Tropical seagrass meadows are among the most productive ecosystems on Earth despite thriving in oligotrophic environments. The Red Sea, an oligotrophic ecosystem characterized by a strong N-S latitudinal nutrient gradient, is a suitable setting to explore patterns *in situ* of nutrient limitation in seagrasses and their metabolic performance under different nutrient regimes. Here we measured the metabolic rates (GPP, R NCP and P/R) of 5 species of seagrasses (*Halodule uninervis*, *Halophila ovalis*, *Halophila stipulacea*, *Thalassia hemprichii* and *Thalassodendron cilliatum*) along with the nutrient, iron and chlorophyll concentrations in their leaves. We performed light and dark incubations of seagrass cores collected at 6 latitudes along the Saudi Arabian coast during the summer and winter of 2017. Our results show higher gross primary production rates during the summer months regardless of the latitude. Only one species, *Halodule uninervis*, displayed a clear N-S latitudinal pattern. Gross primary production rates were below the species-specific global average except for *Halodule universis*, which surpassed this threshold, but only during the summer and in the two most southern locations.

ISBW203: Short-term genetic consequences of fragmentation for the tropical seagrass *Enhalus acoroides*

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Habitat fragmentation is considered to be a threat to the global biodiversity, which can reduce population size and gene flow, resulting in loss of genetic diversity. Therefore, understanding the consequences of habitat fragmentation is critical to the preservation of biodiversity and the future decision-making for management. Here, we evaluated the clonal diversity and fine-scale spatial genetic structure (SGS) in the fragmented and continuous meadows of *Enhalus acoroides* using neutral microsatellite markers to: 1) indirectly estimate the relative importance of sexual vs. asexual reproduction for the population persistence; 2) assess the consequences of fragmentation by comparing of autocorrelation pattern and flowering output between the two habitats. As we expected, *E. acoroides* exhibits high clonal diversity in line with the luxurious sexual reproduction trait. Significant SGS pattern was found at the ramet-level and the genet-level in related to clonality and limited dispersal of propagules. By comparison, we found that fragmentation appears to decrease the strength of ramet-level SGS as well as the total flowering output in the patchy plots due to the massive death of shoots. However, no significant heterogeneity was found between the two habitat types at the genet-level. A possible mechanism is that the response of genet-level SGS to fragmentation may delay temporally owing to the repeated seedling recruitment into the disturbed patchy area. Our study is useful for understanding the response of seagrass to habitat fragmentation and for future restoration.

ISBW206: The contribution of beach-cast seagrass wrack to CO_2 emissions under wet and dry conditions

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Along coastlines globally, the microbial break down of seagrass wrack represents a large source of atmospheric greenhouse gas emissions. There is evidence that moisture within seagrass wrack could contribute to elevated greenhouse gas production, however the exact rate of greenhouse gas flux from seagrass wrack, and its response to moisture, is still unknown. To address this gap, we carried out a 30-day laboratory decomposition experiment on seagrasses *Zostera nigricaulis* and *Amphibolis antarctica*, under moist and dry conditions. After 30 days, decomposition average 7.6 and 3.5 mmol g^{-1} DW carbon (C) lost from the wrack *Z. nigracaulis* and *A. antarctica*, respectively. A double exponential model was best fitted ($R^2 > 0.92$) to the CO_2 flux rate, which suggests the CO_2 flux is linked to the leaching and microbial remineralization during seagrass decomposition. According to the 30 days' integral of CO_2 releasing rate, the CO_2 releasing amount ranged from 120 to 1400 µmol g^{-1} DW which accounted for 0.4–6% of the total wrack C. At a global scale, the annual CO_2 releasing amount of seagrass wrack can be roughly evaluated between 1.31 and 19.04 Tg C yr^{-1}. Furthermore, dry conditions reduce CO_2 flux by 73% when compared to wet conditions, therefore the resources managers, removing seagrass wrack from coastal areas, can be suggested to keep the seagrass wrack in a dry condition, which can help reduce emissions of CO_2, and limit global warming.

ISBW208: Pressure-impact relationships assessment: a first step towards the development of integrated toolbox for the evaluation of ecological status of French tropical seagrass beds

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Seagrass beds are one of the most remarkable and diversified habitats of French overseas territories coastal waters. Most of them are affected by the increasing development of human activities and more recently by the successive passage of severe hurricanes in the French West Indies. A better understanding of seagrass ecological status is needed to respond to requirements of public policies and local environmental management. Our main objective is to develop an integrated methodological toolbox to assess the ecological status of the French tropical seagrass beds in a context of multiple disturbances. An experimental study is currently conducted both in Caribbean region (Guadeloupe, Saint-Martin, Saint-Barthélemy) and the Indian Ocean (Mayotte) to validate protocols. We selected a range of abiotic and biotic criteria representing most of the biological compartments, based on existing knowledge. Thirty parameters are tested *in situ* under contrasted environmental conditions. A focus is made on the most impacting pressures related to water quality degradation as nutrient inputs, organic matter and sedimentation. Ongoing field data and lab (CNP, $\delta^{13}C$, $\delta^{15}N$, trace metals) analysis will allow the evaluation of the relevance of the selected parameters on local seagrass beds. Data will be discussed during the talk. The most responsive parameters will be incorporated into operational protocols and associated indicators elaboration. Finally, the toolbox will be adapted and extended for other French overseas territories. The assessment of seagrass beds health status and their associated environment will be used to implement appropriate management actions and improve ecosystem quality and long term resilience.

POSTER PRESENTATIONS

ISBW003: Effects of ocean acidification on single and mixed seagrass-species meadows in estuarine waters of the Northern Gulf of Mexico

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Seagrasses are thought to benefit from increased carbon availability from ocean acidification but this hypothesis has been little tested for estuarine systems where temperature, salinity, and light are quite variable and mixed species meadows occur. In an outdoor mesocosm, we tested the hypothesis that ocean acidification would benefit seagrasses in the estuarine waters of the Northern Gulf of Mexico in single and mixed species beds of *Halodule wrightii* and *Ruppia maritima*. Cores of each seagrass bed habitat were collected where both species grow in patches that border each other and were placed into aquaria simulating single and mixed seagrass beds. Then, half of the aquaria were exposed to natural conditions (pH of 8.1) and the other half were exposed to high CO_2 levels (pH of 7.7) during a month. Contrary to ocean acidification expectations, we found no clear benefit of the high CO_2 treatment for either seagrass species. The average shoot height of *R. maritima* appeared reduced under high CO_2 conditions for both single and mixed species aquaria. Unrelated to pH, *H. wrightii* above ground growth was reduced when both species were grown together. We conclude that, in this estuarine environment, increased carbon availability has no clear benefit to seagrass production, which suggests that future changes in carbonate chemistry will not stimulate the vegetative growth of *H. wrightii* and *R. maritima* to alter seagrass community composition in this environment.

ISBW005: Flowering and fruiting of the Tropical Intertidal Seagrass *Halophila stipulacea* under Controlled *ex-situ* conditions: Understanding the Effects of Climate change on Sexual reproduction of World's seagrasses using *Ex-situ* set ups - A case of Tanzanian coast

Moses Shimba

The University of Dodoma

Flowers and fruits have not been reported for tropical seagrass *Halophila stipulacea* along the coast of Tanzania, Indo-Pacific, but after transplanting from Kunduchi intertidal mudflats to experimental cultures, flowers and fruits were observed. Transplanted cuttings from Kunduchi intertidal mudflats were successfully grown in sand-mud substrate in the growth chamber in a 12 hr photoperiod (582 Lux, approximately 20 µmol photons m^2s^{-1}) and an inductive temperature and salinity of 24 **-** 28 °C, 34 **-** 38 ‰ respectively. Plants began to flower after three months of culturing, while fruits were observed after seven months. A total of 79 flowers and 10 fruits were recorded from January to December; where 54 staminate and 25 pistillate flowers (2:1) were observed throughout the experimental culture. The presence of viable seeds and seedlings demonstrated the successful pollination and sexual reproduction of *H. stipulacea* in culture. The results of the present investigation suggest that flowering and fruiting in *H. stipulacea* is related primarily to temperature and salinity; and that differences in flowering and fruiting in responses to temperature or salinity account for the nearly synchronous phenological timing in natural *H. stipulacea* meadows at different locations along tropical coast of East Africa. This could therefore form the foundation in assessing the impacts of climate change on the world ocean seagrasses; this will therefore allow incorporation of seagrasses into a global science policy for the world's oceans.

ISBW008: Conservation of Seagrasses in St. Martin Island, Teknaf, Bangladesh

Md. Shafiuddin

BARI, Bangladesh

The Coast line of Bangladesh extended about 710 km around the head of the Bay of Bengal from Teknaf in the south-east to Khulna in the south-west. The investigated area of St Martin's Island is situated in between 92 18 E-92 21 E and 20 34 N-20 38 N and about 12 kilometer South from Southern most part of the main land of Bangladesh. The whole shelf area of Bangladesh i.e. up to 200 m depth contour is about 70,000 km^2. Saint Martin Island is the only coral island in Bangladesh which is very attractive for tourists home and abroad. The shores of the island are sandy- rocky beach. It is situated at the south-west of the Naff river estuary, the western side of the Mayanmar Peninsula and the south-eastern side of Bangladesh main land. It is about 12km south from Teknaf sea beach. In worldwide there were only 60 spp of seagrasses recorded in where were 5 spp found in Bangladesh coast. The seagrasses were such like resource which could serve coastal poor people to change their livelihood higher to higher. Seagrasses were not only a marine flowering plant but also an ornament organism. It was important to protect water and sediment pollutants, and coastal erosion. Seagrasses are potential sources of fodder and fertilizer. Seagrasses were the main food of the dugong, turtles and other marine animals and provide necessary surface for attachment, growth and development of many epiphytic seaweeds and small organisms which are important food for many marine animals. Seagrasses were also important for nursery ground of fishes. Such type of marine plant was important to reduce global warming and climatic effects.

ISBW018: Long term disturbance of tropical seagrass results in alteration of faunal community and wipe-out of functional groups, in Gazi Bay, Kenya.

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Tropical seagrass meadows are productive and house a large variety of fauna. Unfortunately, seagrasses suffer from a 1.5% global loss of areal distribution annually. Tropical meadows are typically poorly studied and the impact of their loss is therefore unclear. Functional groups of epifauna were monitored in longterm disturbed seagrass areas, and compared to intact areas of an intertidal meadow in Gazi Bay, Kenya. Infauna and epifauna was visually monitored, sampled, identified down to the lowest feasible level of identification (predominantly family level), dried and weighed. Functional groups were designed based on literature and sampled fauna. The results show a significantly altered faunal community in degraded areas as analysed by a one-way ANOSIM in PRIMER (Global R: 1; significance: 2.9%). The alterations in the faunal community are explained by a complete loss of two functional groups (“brittle stars” and “deposit feeding pelagic organisms”), over 85% loss in abundance of five functional groups (among which “<10mm crustaceans”) and a large increase in two functional groups (“>10 mm crustaceans” and “>10mm pelagic fish”). There were significant lower counts of mounds and burrows in controls compared to removal areas as tested by a repeated measures ANOVA ($F_{(1,6)}$ = 20.88, p <0.01 and $F_{(1,6)}$ = 99.34, p <0.01, respectively). The increase in mounds and burrows and alterations in fauna abundance as a result of seagrass removal suggest.

ISBW019: Conservation and Management of Seagrass Habitats through Rehabilitation in Palk Bay, Southeast India

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Palk Bay has shallow basin with muddy bottom inshore. Both luxuriant and patch seagrass beds are found from the shore towards marine zone up to 9 km. Fishermen of over 50 coastal villages depend on seagrass-associated fishery for their livelihood. The seagrass beds face anthropogenic and natural threats. This is evident from the decrease of seagrass area from 254 km^2 in 2011 to 209 km^2 in 2015. As part of a long-term conservation and management strategy in Palk Bay, seagrass rehabilitation was initiated in March 2017. A low-tech, low-cost transplantation technique with 1 m^2 PVC quadrats was employed. A total of 400 quadrats were transplanted in two blocks of 200 each. Five native species namely *Cymodocea serrulata, Thalassia hemprichii, Syringodium isoetifolium, Halodule uninervis* and *Halophila ovalis* were transplanted at a depth of 3.0 to 3.5 m. Each frame was tied with a minimum of 6 rows of jute ropes holding seagrass shoots. In each row a minimum of 20 shoots were tied. The shoots were collected from nearby healthy seagrass beds, not exceeding 5%. Monthly monitoring of rehabilitated blocks between April 2017 and January 2018 showed the appearance of new aerial shoots in the second month of transplantation. Mean seagrass cover increased from 12.35 % (April 2017) to (29.35 %) (January 2018); shoot density from 86.32 to 210.35 m^{-2}; fish abundance from 15 to 110.25 60 m^{-2} and macro faunal density from 1.58 to 25.47 5 m^{-2}.

ISBW020: Tropical Seagrass Impact from Riverine Turbidity in Face of Extreme Storms: SW Puerto Rican Rivers.

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The loss of tropical seagrass appears episodically occurring from extreme storms impacts. In our study of tropical riverine turbidity, six Puerto Rican Rivers' mouths show impact for Normal and Extreme Storm conditions of seagrass as 5% of control abundance and 15% control biomass in the inner "normal" plume (controls beyond impact region). The extreme storm conditions measured through riverine gauges, rainfall, river lengths, and remote-sensing imagery capture of watershed type, plume extent, show 0.91 m^3 s^{-1} disgargement and aerial extents of "extreme" plume 10-32 times greater than "normal" riverine flow. The impact within the outer reaches of "extreme storm" events includes 50% less abundance than non-impacted controls, lesser spectral reflectance health, no solitary or clumped corals, fewer endangered species siting's, compared to controls beyond impact. Wind and wave turbidity resuspension in extreme storm plumes was evident many months after the events. Significant correlation of impact with watershed types included tilled soil, pastureland, a mean watershed of 37 km^2 per river. Normal impact mean plume size is 0.8km^2 per river whereas extreme impact on 6 rivers is 9.87 km^2 extent. For the 178 Puerto Rican rivers the total; impact would be 142km^2, with a 5000 km shoreline. SW Puerto Rican Corals previously showed a significant riverine turbidity impact.

ISBW021: Effects of shading on photosynthesis and nitrogen metabolism in *Halophila ovalis* (R.Brown) J.D.Hooker

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Due to their high light requirement, seagrasses are particularly sensitive to shading. This study aims to examine the physiological responses with a focus on photosynthesis and nitrogen metabolisms of a common tropical intertidal seagrass, *Halophila ovalis* in response to four weeks of in-situ manipulative shading. Three levels of shading (control, 50% and 65%) were applied in the monospecific meadow of H. ovalis at Chek Jawa, Singapore and physiological data were collected fortnightly. Rapid light curves (RLCs) were constructed using PAM fluorometry and nitrogen (nitrate and ammonium) uptake rates were assessed in leaves and rhizome complex in the laboratory. The results showed that shading reduced maximum electron transport rates after four weeks while the highest shading level also reduced minimum saturating irradiance. Uptake rates of ammonium (relative to day 0) in the leaves significantly increased in the treatment with lowest light availability while slight changes were observed in rhizome complex. On the contrary, relative uptake rates of nitrate in the leaves and rhizome complex decreased in response to shading. A shift in nitrogen utilization from nitrate to ammonium which is less energy-demanding suggests an acclimation to limited light availability. However, no change in C, N or C/N content in leaves and rhizomes was observed. Our results demonstrated that although shading modulated both photosynthesis and nitrogen metabolism of *H. ovalis*, the seagrass were able to maintain their carbon and nitrogen balance. RLCs and a shift of nitrogen source may be used as potential biomarkers for the monitoring of early light-limitation in seagrasses.

ISBW024: The species composition and distribution of Seagrass in the Valaichchenai Lagoon, Sri Lanka

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Valaichchenai Lagoon is encompassing of an area about 13.21 Km^2 and categorized as having the highest index of annual fresh water influx per unit area (0.665 $Mm^3ha^{-}1yr^{-1}$). The species composition and the distribution of different seagrass of Valaichchenai Lagoon have been investigated in detail for the first time. A study was conducted in five selected sites and sampling surveys were conducted representing all habitat types in the main lagoon and lagoon branch (Nasivanthivu to Puliyadora Aru). Field survey was carried out in four field visits of which each lasting three consecutive days from May to October 2017. A vegetation sampling was carried out using three transect (50 m) laid perpendicular to the shoreline and with 5 m intervals between each transect using a three replicate 50 x 50 cm^2 quadrate. Seagrass sampling and photography of each quadrate was conducted using skin diving. Species were identified based on the key developed and identification verified in consultation with a globally recognized seagrass taxonomist. Cloud free Landsat 8 satellite imageries of February to October 2017 were selected as remote sensing data sources to define seagrass area of the lagoon. After image pre-processing, supervised image classifications were performed using maximum likelihood method to mapping seagrass coverage.

Patchy distributed seagrass were recorded along both sides of the lagoon, and extending inland approximately 2 km from the lagoon mouth, including a lagoon branch (~5 km). Four species of Seagrass were recorded during the study period namely; *Halophila beccarii* (nationally endangered), *Halophila ovalis* (most recorded species), *Halodule uninervis*, and *Halodule pinifolia* (first record of the eastern coast of Sri Lanka). Extent of the seagrass distribution in the main lagoon and lagoon branch is approximately 3.72 km^2, which accounted 28% of the total lagoon area. Recorded anthropogenic activities as; multiday fishing vessel movements, collection of shells on the seagrass beds, solid waste disposal into the lagoon, harmful fishing gears and boat traffic in shallow waters. Reduction of seagrass in Valaichchenai Lagoon would negatively impact to food security and income generation of fishers. Results from this study will help in the development of the short term and long term management strategies which need to be implemented for the conservation and management of seagrass in Valaichchenai Lagoon.

ISBW025: Effects of ocean acidification and warming on *Zostera muelleri* from Brisbane Waters, Australia

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Anthropogenic activities have increased the carbon dioxide concentration in the atmosphere leading to ocean acidification and ocean warming which is expected to have impacts to marine ecosystems and organisms. Non-calcifying organisms such as seagrass may benefit from near-future climate change scenarios. This study investigated the impact of ocean acidification and ocean warming and photosynthesis and productivity of the seagrass *Zostera muelleri* from Brisbane Waters, New South Wales, Australia. *Z. muelleri* were exposed to a combination of 2 temperature (21 and 25°C) and 2 pH levels (equivalent to a pCO_2 of 400 and 1,200 µatm; A1F1). After 4 weeks, photosynthetic activity were examined through Chlorophyll *a* fluorescence (Diving-PAM), pigments contents and oxygen production and respiration. Above- and below-ground carbon and nitrogen were determined using CHN analyser. The results showed that seagrass under elevated CO_2, elevated temperature and a combination of elevated CO_2 and temperature treatments had significantly higher effective quantum yield of PSII than control. However, there were no significant differences in oxygen production, P:R ratio and Chlorophyll *a* and *b* contents among treatments. Above-ground carbon and nitrogen contents were significantly lower in pH 7.8 and 25°C treatment. This study shows that temperate seagrass *Z. muelleri* would exhibit a competitive advantage over other marine species under this climate.

ISBW031: Sediment-effect thresholds for seagrass *Zostera muelleri* in Porirua Harbour, New Zealand

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New Zealand's seagrass meadows have declined substantially in the last 50 years, especially in estuaries affected by human activities. This is also a trend that is evident globally. In New Zealand, the sole seagrass species, *Zostera muelleri*, has a national threat status of "at risk – declining". Globally, different factors are implicated in causing the decline of seagrass ecosystems. In New Zealand, fine sediment is considered to be the most pervasive stressor of estuarine environments and the most likely cause of seagrass decline in these systems. To increase our understanding of this threat-response issue, our research aims to determine acute and chronic fine sediment-effect thresholds for *Z. muelleri* in terms of light attenuation factors and sediment smothering. The research is based primarily in Porirua Harbour, North Island, New Zealand, where approximately 40% of seagrass meadows in the upper estuary have been lost since the 1980s. Both field study and mesocosm experiments will be used to explore the research aims. Previous investigations in the harbour have suggested that alteration to sediment biogeochemistry and/or smothering of plants is probably responsible for seagrass loss rather than sediment effects on the water column light climate. Thus, our research will address the complex and multi-faceted effects of sediment inundation on the seagrass growing environment. Ultimately, the thresholds identified will be incorporated into source-to-sea hydrodynamic models to enable robust determination of the sediment loading rates to receiving environments, which will provide for the protection and restoration of estuarine seagrass meadows.

ISBW032: Methods for successful restoration of seagrass (*Zostera muelleri*) in the subtropical waters of Queensland, Australia

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Zostera muelleri is one of the dominant seagrass species in estuaries and coastal lagoons along the east coast of Australia, including in the subtropical waters of the Gold Coast, Queensland. It has high ecological and economical value through the provision of well-functioning ecosystems with high fauna diversity. Despite their ecosystem services, in recent decades seagrass distribution has declined markedly on the Gold Coast, particularly in the southern part where urbanisation has dramatically altered the coastline and reduce water quality. Natural recovery seems unlikely, due to biological stressors and physical disturbance from, for example, reworking activity of burrowing polychaetes and crustaceans and potential lack of seed dispersal from remaining seagrass meadows. In previous transplant experiments in subtropical Australian waters, survival and growth rate of transplanted shoots were low compared to seagrass restoration attempts elsewhere. The aim of this study, therefore, was to develop and test optimal transplantation techniques for the subtropical waters of Queensland. Transplantations of mature seagrass shoots, using 4-5 different techniques, were conducted in Feb 2016 at 4 locations along the Gold Coast. All stations were impacted by various stressors, such as human activity, physical impact, burrowing activities and grazing. Over the 10 month monitoring period, success rates varied among locations. At two locations transplants grew very successfully and spread well beyond transplanted patches. Protection above (cages) and below (hessian mats) transplanted shoots significantly increased success by protecting against intensive grazing by the fish *Girella tricuspidata* and burrowing activity of *Trypaea australiensis*.

ISBW042: Differences in flowering sex ratios between native and invasive populations of the seagrass *Halophila stipulacea*

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Deviations from the 1:1 sex ratio are common in dioecious plants. The tropical seagrass *Halophila stipulacea* is among an extremely rare group of dioecious plants which is widely recognized as female-biased. We sampled plants and quantitatively recorded flowering in both the native population (the northern Red Sea – Eilat, Israel) and two invasive populations (Mediterranean – Limasol, Cyprus) during the flowering season (July - October 2017). Here we report an unprecedented difference in sex ratios between native and invasive populations. While in the native region, *H. stipulacea* populations were female-biased, invasive populations were either male- or female-biased. The existence of both sexes simultaneously in the Mediterranean invasive population, might help its ongoing expansion in the Mediterranean, thereby threatening local seagrasses species. Our study, as well as long-term monitoring, may provide better understanding of the factors affecting invasiveness of *H. stipulacea*.

ISBW056: Application of the deep-learning technics for the extraction of seagrass beds: over 30 years changes of beds at Futtsu in the Tokyo Bay, Japan and Hat Chao Mai National Park, Thailand.

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Remote sensing is the best ways to observe long-term seagrass dynamics. The advent of deep-learning technology has led to advances in this methodology. To test this, we investigated the long-term dynamics of seagrass beds in the natural area, Hat Chao Mai National Park, Trang, Thailand (where ISBW9 held) since 1970's. We compared image classification methods including, pixel based/object-based supervised classification (semi-automatic) and deep-learning (automatic classification).
As a result, accuracy of the classification was 84%±6.48% and κ=0.31±0.18 for semi-automatic classification and 89%±6.6 (κ=0.50±-0.13) for automatic classification without consideration of the density class (sand or seagrass). Evaluation including two classes of the density (projection coverage) was 55%±15.8% and κ=0.28±0.17 and 63%±4.48, κ=0.35+-0.07 successively. Because semi-automatic classification normally requires supervise data for each image (which takes long times to produce), automatic classification using a pretrained model provide a quick (within a 10's second) extraction. However, it still have challenges such as artefact observed at the edge of the analysis unit.
As a result of the dynamics across the entire area, the seagrass bed showed relatively stable dynamics. However, the seagrass in local areas, especially the shallow area close to a river mouth, varied greatly depending on sand and channel movement. Although this change will be mainly due to natural factors, the effect of river easily affected by terrestrial human activities. Consideration of terrestrial impact will be challenging issue.
We will also show an example at Futtsu tidal flat in the Tokyo Bay, Japan which we previously analysed annually over 30 years.

ISBW062: Assessment of organic carbon stocks in multispecies and macroalgae dominated seagrass meadows in Gazi bay, Kenya

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Organic carbon budgets of seagrass ecosystems are mainly composed of estimates from monospecific beds. This creates uncertainties of estimates and perhaps undermines the relative potential of seagrass ecosystems in carbon sequestration. This study provides an empirical estimate of the organic carbon stocks in multi-species meadows (seagrasses and macroalgae) in Gazi Bay. Sampling was done in twenty-one 0.25m^2 random quadrats along three 100m parallel transects. At each quadrat canopy cover and species composition was determined by visual observation. Above-ground materials were obtained through harvesting whereas below-ground organs and soil samples were obtained through coring. Live materials were oven dried and weighed for biomass, sediment C_{org} was determined through Loss on Ignition (LOI). One-way ANOVA was used to test the difference in above and belowground biomass between mixed and macroalgae dominant seagrass stands whereas variation in sediment C_{org} between mixed and macroalgae dominated seagrass stands was tested using two-way nested ANOVA. Above ground biomass was significantly higher in macroalgae dominated stands compared to mixed seagrass stands ($F_{(1, 18)} = 4.414$, $P < 0.01$), while below ground biomass was not significantly different between the stands, as can be expected due to the absence of belowground biomass in macroalgae. Sediment C_{org} was significantly higher in macroalgae dominated stands ($F_{(1, 27)} = 18.58$, $P < 0.01$) but depth effects were not significant in both stands. These results demonstrate the relative contribution of macroalgae to carbon capture and storage in seagrass meadows. Therefore there is need to include macroalgae in global carbon accounting.

ISBW075: Spatial and temporal distribution of submerged aquatic vegetation in a tropical coastal lagoon habitat

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Submerged aquatic vegetation (SAV) is considered as a keystone habitat, contributing significantly to structure and function of coastal lagoons. However, limited understanding of the factors driving SAV distribution and abundance across a wide range of salinity in tropical coastal lagoons restricted the effectiveness of managing and preserving the ecosystem services in coastal lagoon habitats. This study examined the distribution and abundance of SAV seagrass species in the growing season in relation to water physico-chemical variables and grain sizes of sediment types in a tropical lagoon in Viet Nam. The results revealed that *Najas indica* and *Halophila beccarii* were the dominant species in the community of 7 SAV species, accounting for 70% of the total cover and 55% of the total biomass sampled. Variation partitioning showed that both water and sediment variables were important in explaining spatial distribution and abundance of SAV species across the coastal lagoon. Salinity was the most significant predictor variable that accounted for the variation of SAV species data. The study implied that changes of salinity and silt (versus sand) particles can lead to different SAV assemblages in the lagoon.

ISBW078: The biomass-density relationship in seagrasses and its use as an ecological indicator

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Biomass-density relations have been at the centre of an index which describes the health of seagrass meadows. However, this search has been complicated by the intricacy of seagrass demographics and their fuzzy biomass-density relations, a consequence mainly of their modularity and clonal growth. Concomitantly, biomass-density upper boundaries have been determined for terrestrial plants and algae, reflecting their asymptotic maximum efficiencies of space occupation. Each stand's distance to its respective boundary reflects its effective efficiency in packing biomass, which has proved a reliable ecological indicator in order to discriminate between taxonomic groups, functional groups and clonal vs. non-clonal growth. We gathered meta-data from 28 studies on 9 seagrass species distributed worldwide and demonstrated that seagrasses are limited by their own boundary line. Then, we applied a new metric - d_{grass}: each stand's perpendicular distance to the seagrass boundary – and used this parameter to review fundamental aspects such as clonal growth patterns, depth distribution, seasonality, interspecific competition, and the effects of light, temperature and nutrients. Using only biomass and density data we established a new and efficient tool to describe space occupation by seagrasses. This was used with success to evaluate their meadows as an ecological indicator for the health of coastal ecosystems.

ISBW084: Spatial Distribution Patterns of Submerged Aquatic Vegetation in The Biosphere “Los Petenes” in Campeche, Mexico detected by Remote Sensing

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Seagrasses are globally recognized for their environmental services. Of special relevance are their carbon storage and sequestration capabilities through their roots and soils, estimated to be up to two to four times higher than terrestrial forests. This carbon is denominated as “blue carbon”. Currently most countries can’t report accurately on blue carbon due to the of information. In that context, baseline information on national seagrass distribution and extension, are essential for Mexico to document solid information and promote their conservation. One is the cartography, our project applies remote sensing techniques to delineate major seagrass extensions.
We used hydroacoustic echosounder and satellite images of Sentinel 2A to derive a distribution map of the submerged aquatic vegetation (SAV) applying a supervised maximum likelihood classification. Additionally, we used video transects and in-situ verification data to generate five classes of SAV in the biosphere reserve of “Los Petenes” in Campeche, dominated principally by *Thalassia testudinum* (Tt). The results show continuous distribution patterns of SAV extending south-north, parallel to the shore. The occupied area is 1,512 km^2 corresponding to 83% of the marine zone. The Kappa coefficient during accuracy assessment resulted in 77%. The best differentiation classes we observed between Tt and *Syringodium filiforme* (Sf). A principal component analysis of the collected environmental data demonstrated that water depth is the determining variable for the presence of Tt and Sf, while *Halodule wrightii* presence is mainly related to salinity. Our results show that combined remote sensing techniques together with biochemical/physical data offer great potential for mapping seagrass distribution in shallow waters in México.

ISBW085: Contrasting thermal tolerance of two Mediterranean seagrass species (*Posidonia oceanica* and *Cymodocea nodosa*) to warming

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Mediterranean Sea is currently experiencing the impact of global warming. The frequency and duration of heat waves have increased in the last decades, and a number of key marine ecosystems, including seagrass meadows, are considered at risk. However, to obtain more accurate predictions about global warming impact on seagrasses, interspecific variability (e.g. biological traits, biogeographical affinities…) among seagrass species should be taken into account.
The aim of this study is thus to evaluate the thermal tolerance of two Mediterranean seagrass species (*Posidonia oceanica* and *Cymodocea nodosa*) of contrasting ecological strategies and biogeographical affinities, identifying plant responses to warming.
An indoor mesocosm experiment was conducted to assess plant response to increasing temperature. After an acclimation period, plants were exposed to a thermal gradient (20ºC, 24ºC, 28ºC and 32ºC) for a one-month period. After exposure, photosynthetic and respiratory rates, photochemical variables, growth and survival were measured.
C. nodosa performs better at high temperatures, showing maximum values at 28ºC and 32ºC in all variables. In contrast, *P. oceanica* is highly sensitive to warming, showing a severe decline in its performances as temperature increases, with a clear reduction in survival beyond 24-28ºC. Our results suggest that, in the context of global warming, seagrass thermal sensitivity is highly species-specific, leading to winners and losers in such future scenarios. For the Mediterranean, it would seem that warming can favour the small, fast-growing *Cymodocea nodosa*, while the slow-growing *Posidonia oceanica* will suffer, for the most, negative effects. Since these two species provides different ecosystem services, the possible shift in dominance from one species to the other driven by warming can have dramatic ecological consequences.

ISBW087: Quantification of the fate of sequestered carbon: from seagrass meadows to the deep-sea

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The processes by which carbon is sequestered in eelgrass beds and transported from shallow coastal waters to the deep sea were demonstrated. A part of the carbon uptake by eelgrass is decomposed and returned to the biological production or the water column's dissolved inorganic carbon pool, a part is stored by accumulating in the shallow sea bottom, and a part flows out into the deep sea. Here we described the growth of eelgrasses and the processes of decomposition, sedimentation, and transportation of eelgrass-derived organic carbon using the Seto Inland Sea as a model site. We estimated the amount of carbon sequestered and stored in eelgrass beds, the fate of eelgrass-derived organic carbon by a numerical model, and the amounts accumulated in the shallow coastal water and transported to the deep sea. It was estimated that of the annual carbon sequestration amount (73,000 tons) in the Seto Inland Sea, 40.9% accumulated in the Seto Inland Sea and 8.3% flowed out to the deep sea, which was based on calculations from tracking carbon over a one-year period. In other words, the eelgrass beds in the Seto Inland Sea have an annual potential of 36,000 tons of carbon storage capacity. In addition, most of the organic carbon was accumulated in the shallow coastal waters rather than in the deep-sea.

ISBW089: Demography of *Thalassia testudinum* in the Reserve of the Biosphere "Los Petenes", Campeche, Mexico.

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Seagrasses are angiosperms with a great ecological and economical importance. The register of the plastochrone index (Pi) and the register of biomass is relevant for estimated the status of the population. Although these registers help us to stablish the status of the seagrasses in terms of age and structures, these studies can´t evaluate the fitness of the population. The objective of the study was to describe the poblacional structure and the finite rate growth (λ) of *Thalassia testudinum* in the Reserve of the Biosphere "Los Petenes". It was extracted 5 samples of biomass, with a 0.25cm^2 area in 6 different areas in the 2013 and 2014. It was calculated the Pi of each vertical shot; with that data it was made the population structure. With the biomass data it was calculated an ANOVA for finding significative differences, also with this data it was calculate the λ for each area and for the population in general. It was obtain significative differences in the years, being higher in 2014. The λ was 1.12 for the population in general and for all the areas was higher than 1. In general terms, the population of *Thalassia testudinum* in the Reserve of the Biosphere "Los Petenes" is growing and is healthy. It can be assumed that the conditions in the area are appropriated for its establishment and grow and the population can resist the natural impacts like hurricanes. It is suggested to continue these studies and with this data proposed management and conservation plans.

ISBW091: Broad-scale estimation of distribution and biomass of tropical seagrass beds covering the whole coastlines of Southeast Asia

Kenji Sudo, Masahiro Nakaoka

Although Southeast Asia is the hotspot of the global seagrass diversity, fine scale data on species distribution and biomass of tropical seagrasses were not available due to large gap in spatial information of each species. In this study, we aim to analyze spatial patterns of species distribution and biomass of seagrass covering the whole coastlines of 6 ASEAN countries (plus southern China, south Japan, northern Australia) at fine resolution (4 km grid). Available data on species occurrence and biomass collected over 20 years were stored and analysed on a GIS-based platform. Distribution of 7 tropical species, estimated using the maximum entropy model (MaxEnt), showed that depth, steepness of slope, sea surface temperature and salinity were among the best predictors explaining the distribution of each species. The combination of best predictor variables differed among species; for example, the distribution of *Enhalus acoroides* is better predicted by geographical factors such as slope steepness and depth, whereas that of *Cymodocea serrulata* related more with variation in sea surface temperature. Spatial variability of seagrass biomass, analysed using general additive model (GAM), did not correlated well with any environmental predictors collected at broad-spatial scale, suggesting that local variability in environmental factors, including those related to human-induced stressors, is more important for determining the biomass variation. Our models on species distribution and biomass can be utilized as a baseline for better conservation and management of coastal seagrass beds in this region which is still under great threats by multiple human activities.

ISBW096: A Preliminary Study of the Seagrasses in Miyajima Island and Surrounds: Ecology & Genetics

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Miyajima (Itsukushima) Island is one of the sacred islands for Japanese people, and well-known as a World Heritage site for the shrine and the forests on the mountain. Since it has become famous, damage to the coastal ecosystem by garbage has been significant. Fishing activities have also had a significant impact. Some of the seagrass areas have declined but there is still little information about the seagrass beds on this island. This research began by surveying the existence and extent of seagrass beds at low tide. Surveys were conducted by circling the island by boat and at each sampling location photographs were taken and the site location accurately recorded. At each location point, seagrass samples for *Zostera marina, Z. japonica* and *Halophila nipponica* were taken to for voucher specimens and to for DNA sequencing. The protocol of the DNA extraction, PCR amplification and DNA sequencing followed Suzuki et al. (2013) and Inoue & Tsubota (2014). Sequences for chloroplast *rbcL* gene, *trnT-trnL-trnF* region and nuclear ITS region were newly obtained. Sequencing alignments were performed by MAFFT and phylogenetic analysis were constructed by RAxML. Haplotype variations were confirmed among Japanese populations of *Z. marina*. Haplotype variations in each species still need to be obtained from other localities in Seto Inland Sea.

ISBW111: Preliminary assessment of the seagrass habitat associated with the sea cucumbers *H. scabra* and *H. atra* in a highly disturbed site of Libong Island, Southern Thailand

Adonis S. Floren, Anchana Prathep

The seagrass habitat preference of the two sea cucumber species, *H. scabra* and *H. atra,* were assessed using the sediment properties in an attempt to rehabilitate the wild population of sea cucumbers in Libong Island, Southeastern Thailand. This preliminary study was conducted in the seagrass meadow known by the locals to have abundant sea cucumbers in the past but is now facing depletion due to over harvesting. The sea cucumber *H. scabra* is considered as an “Endangered” species on the IUCN Red List of threatened Species while *H. atra* is under the “Least concerned” category. Result of the study revealed that the sediment properties Chlorophyll-*a*, Chlorophyll:Phaeopigment ratio, dry bulk density, organic matter, inorganic carbon, and sediment grain sizes (i.e. ≥2000 µm, 2000 µm, 1000 µm, 500 µm, 250 µm, 125 µm, and < 63 µm) did not significantly vary ($P > 0.05$) between the habitats occupied by *H. scabra* and *H. stra*. The only exception to this is the 63 µm which showed significantly variation ($P = 0.006$, $F= 10.494$) between the habitats occupied by *H. scabra* and *H. Atra,* with the former preferring this grain size over the larger grain size categories. Examination of the gut content of *H. scabra* also confirmed the preferential ingestion of 63 µm sand while *H. atra* showed preference for the coarse 125 µm sand. This contrasting preference on certain sediment grain size clearly indicates the partitioning of ecological niche for each cucumber species. Assimilation of seagrasses in the sea cucumber’s diet requires investigation.

ISBW121: Evaluation of the function of seagrass to stabilize sediments

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Seagrass rhizome and root systems trap organic matter, thereby stabilizing the sediments. Research on the strength of seagrass body against external forces in the laboratory has been carried out so far. However, the measurement *in situ* have not been conducted to the best of our knowledge. This study compared the resistance *in situ* against pulling up forces among four seagrass species, *Halophila ovalis, Cymodocea rotundata, Thalassia hemprichii* and *Enhalus acoroides*. Experiments were conducted at Tantangon Island, Busuanga, the Philippines from 13 to 14 September 2017. Dual steel wires (diameter, 1.5mm) were inserted below the rhizome and connected to Digital hanging scale by polyethylene line. After setting the wire the scale was pulled up and force (kg) for the rhizomes to be lifted up or broken were recorded. The largest species, *Enhalus acoroides*, showed the highest resistance with the values diminishing as plant size decreased. The results have some significant implications to the plants' ability to stabilize sediments, store blue carbon and resist the impacts of strong waves brought about by climate change. Additional survey to evaluate the relationship between the resistance of each species and sediment grain size are scheduled. The biomass and reached depth of below ground part of each species would be also measured.

ISBW122: Photosynthesis Performance and Response of Tropical Seagrass, *Halophila ovalis* (R. Br) Hook. f During Low Tide Exposure

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Seagrass in Pulau Gazumbo, Penang survived wide ranges of environmental conditions in intertidal habitats through various adaptations. To ensure continuous existence, seagrass health status should be monitored with the environmental conditions continuously. Therefore, the aim of this study is to monitor and examine the influence of environmental conditions on the photosynthesis performance of Halophila ovalis. Five sampling sites were studied and pulse amplitude modulated (PAM) fluorometry (Pocket PAM with modified leaf clips) was used to generate rapid light curves (RLCs) to derive maximal electron transport rate (ETRmax), photosynthetic efficiency (α), saturating photon flux (Ek) and effective quantum yield (ΔFv/Fm'). Throughout the monitoring months (n=6) and sampling sites, temperature (24.0–33.0°C) and light (PAR) (1974.0–113.1µmol $m^{-2}s^{-1}$) were the most influential parameters affecting the photosynthetic variables. In all sampling sites, there were significant differences in light ($F_{4,85}=5.787, P<0.05$) and temperature ($F_{4,85}=1.105, P=0.359$) while in monthly observations, only temperature showed significant changes ($F_{5,84}=1.105, P<0.001$). Based on linear regression analysis, temperature have significant positive effect on ETRmax ($r^2=0.096, P=0.003$) and Ek ($r^2=0.072, P=0.011$) while light showed significant positive effect on α ($r^2=0.218, P<0.001$) and negative effect on ΔFv/Fm' ($r^2=0.164, P<0.001$). In-situ PAR is mostly higher than Ek, which indicate light saturation in seagrass. ΔFv/Fm' in this study does not limited nitrite, nitrate and ammonia, except phosphate ($r= -0.300$, $P=0.004$). Finding shows that photoinhibition by non-photochemical quenching (NPQ) mechanism and closure of photosystem II reaction centres are possibly the response of seagrass to excess light that could cause photoinhibitory damage. Moreover, response suggest that seagrass at Pulau Gazumbo showed sign of stress characterized by low quantum yields and low rates of electron transport.

ISBW125: First step towards a Western Indian Ocean Seagrass Network

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The Western Indian Ocean (WIO) region is one of the world's most species-rich areas for seagrass. Seagrass meadows form remarkable and diverse habitats and provide a wide range of ecosystem services, including habitats for endangered species, particularly green turtles (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*) and dugongs (*Dugong dugon*). In the context of global change, and following the first observations of seagrass decline in the region, obtaining an overall understanding of seagrass trends is key to provide an early warning of major changes.
Supported by a newly EU funded project to reinforce seagrass conservation in the Western Indian Ocean, a regional seagrass advisory and monitoring network is being set up. It aims to i) highlight local initiatives involving mapping, monitoring, research and conservation of seagrass, ii) facilitate regional cooperation between researchers, scientists and managers actively involved in seagrass-related works, and iii) standardize protocols for monitoring and baseline assessment to provide a regional overview of the status of seagrass habitats that is consistent with worldwide seagrass networks and reporting. The first regional meeting was held in November 2017 at Reunion Island, where focal points from each geographic area gathered to establish the current state of knowledge and define common monitoring methods for seagrass mapping and sampling stations. Furthermore, the WIO Seagrass Network intends to foster discussions and provide guidance on other emerging regional management issues pertaining to seagrass ecosystems as well as facilitate exchange with the wider seagrass community.

ISBW126: Monitoring ecosystem services of coral reef associated seagrass communities at Samui Island, the Gulf of Thailand

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Coral reefs are characterized by high biodiversity and high abundance of marine organisms and provide significant economic values in tourism and fishery sectors. Several coral reefs in the Western Gulf of Thailand are associated with high productive seagrass communities. Ecosystem services of coral reef associated seagrass communities have been less studied in most Southeast Asian countries although seagrass communities cover the sediments of the shallow reefs. Ecosystem services of both seagrass and coral reef communities are threatened by several human and natural disturbances, particularly coral bleaching events and impacts from tourism, coastal development and illegal fishing. We examined some coral reefs at Ko Samui, Surat Thani Province, the Western Gulf of Thailand under a long-term monitoring program for assessing seagrass and coral reef ecosystem services. The study emphasized on linking seagrass and coral reef conditions with various types of ecosystem services. The coral reef associated seagrass communities in the Western Gulf of Thailand were categorized into several groups depending on their threats and utilization types. We found that growing of tourism development at Ko Samui led to high demand of local food consumption by tourists. Artisanal fishing on a wing shell (*Strombus camarium*) and a sea anemone (*Stichodactyla haddoni*) by using some destructive fishing practices caused severe damages in some seagrass communities at Ko Samui. The ongoing research has concentrated on management strategies and assessing economic values of fisheries, bioactive compounds, coastal protection and carbon capture and storage from coral reef associated seagrass communities in the Western Gulf of Thailand.

ISBW128: Methodology Development for utilizing Planet Satellite Imagery in Seagrass Mapping

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Compared to mangroves and coral reefs, studies on seagrass are relatively few. Previous researches in seagrass mapping usually involves classification using LandSat and Worldview satellite images, and common software built-in algorithms such as Isodata. Exploring new methodologies and data resources can greatly contribute in increasing awareness and appreciation of the seagrass ecosystem. Planet Labs Inc. has made available new remote sensing products from archived images since 2009, including satellite imageries from their Dove satellite constellation which is a constellation of more than 175 satellites that provide medium resolution monitoring with spatial resolutions of 3 to 5 meters and covering more than 300 million square kilometers of the Earth's surface. In this study, a methodology is developed for utilizing the Dove satellite imagery in seagrass mapping for Bolinao, Pangasinan covering the years 2011 to 2012. Available field points were used as training and validation samples in implementing three (3) algorithms, namely Support Vector Machines (SVM), Mixture Tuned Matched Filtering (MTMF) and Maximum Likelihood. The outputs are compared and assessed to come up with a summary of their advantages and disadvantages in relation to significant processing considerations, such as accuracy of results, appropriateness for a particular purpose, and processing requirements.

ISBW130: Restoration of a fragmented seagrass habitat in Mannar, Sri Lanka

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Existing seagrass beds in Sri Lanka are highly fragmented and greatly diminished in their ecological structure, functions and services. More than 73% of the seagrass beds in the Gulf of Mannar have been removed by activities ranging from destructive fishing such as trawling, blast fishing, bottom set nets and pollution. To rehabilitate what has been lost, a restoration effort was initiated in January 2016 in Mannar, with the objective of using short-term efforts to project long-term outcomes of seagrass transplanting. Three species of seagrasses were selected for transplanting; *Halodule uninervis*, *Halophila ovalis* and *Cymodocea serrulata*. Donor plugs were extracted at no less than 25 cm distances to minimize any effects on the donor community. Water parameters were measured at the transplanting site and 800 seagrass plugs were transplanted at 1.0 m intervals covering approximately an area of 1000 m^2 using peat pot method. 93.26% of transplanted *Cymodocea serrulata,* 38% of *Halophila ovalis* and none of the *Halodule uninervis* plugs survived at the end of the first three months of the project. Average temperature, pH and salinity of the restoration site were 29.2 °C, 7.10 ppm and 34 ppt respectively. However, about 27% of *Cymodocea serrulata* survived by the end of 16 months while other two species indicated no signs of survival. Difficulties, failures an advantages of using peat pot method for restoration were recognized and the attention will be given on using hessian bags for future transplantations. Interviews with fishermen showed a positive attitude towards seagrass restoration. Awareness programmes and costal clean-ups were conducted on the importance of seagrasses and to reduce the pressure of pollution to ensure the long-term survival of seagrsss habitats which allows to bring back the fauna associated with it through natural recruitment.

The project was funded by the Rufford small grants programme.

ISBW135: Citizen Science: A meaningful application to seagrass and endangered species conservation in Busuanga, Palawan, Philippines

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Seagrass meadows are often undervalued and overlooked as a marine resource, but their importance to the marine ecosystem is undeniable. In the Philippines dugongs and sea turtles are threatened with bycatch and habitat loss; however, assessment of their primary food source, seagrass, is a challenge due to remote island locations. A rapid assessment of existing seagrass habitats was conducted around a dugong hotspot: Busuanga, Palawan Province with the participation of trained community members using a Rapid Assessment Protocol (RAP) at various sites within the study area. RAP site methodology differed due to the need to assess multiple sites under a short timescale, some of which were remote and costly to access. In both training and test data collection, community observers snorkeled to examine a variety of criteria such a seagrass percentage cover, species and sediment type. Surveys adopted Seagrass-Watch protocol in order to standardize results and maintain objective estimations of percentage cover within quadrats. However, the model produced does provide an insight into potential areas for further *in situ* surveys to be carried out in certain areas of Busuanga. The model is also very cost effective. There is the chance for application to other nearby islands and remote sites, which enables sites to be chosen with prior knowledge of expected seagrass presence and potential dugong and sea turtle presence. This study offers evidence towards the need to introduce conservation measures in some areas around Busuanga Island. Dugongs inhabit waters up to 21 m deep and dugongs, particularly around Busuanga Island, priority conservation areas include Barangays Buluang, New Quezon and Calauit Island.

ISBW136: Intertidal seagrass monitoring using UAV

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For scientific as well as management purposes spatial information on the distribution of seagrass is essential. Seagrass meadows are traditionally mapped using an array of techniques e.g. satellite/aerial and video imagery, grab samples & visual monitoring by diving or walking. The preferred method depends on scale, depth (intertidal, shallow subtidal, deep water), turbidity and species. Up till now methods for mapping intertidal, low density meadows are limited and time consuming. We compared a physical disturbing technique (walking using the nearest neighbour method) with a novel technique, aerial imagery using an UAV (unmanned aerial vehicle) i.e. drone, for mapping *Zostera marina* in two sparse, recently restored, intertidal meadows in the Dutch Wadden Sea. Machine learning image analysis software was developed to identify individual *Z. marina* plants. This enabled us accurate plant counts and surface coverage. The study identified the pros and cons of this new techniques.
Seagrass monitoring by drones has many advantages over traditional methods in intertidal areas. The usefulness of this technique for shallow subtidal seagrass meadows is currently studied.

ISBW139: One-decade spatial variability of seagrass meadows and Blue carbon: Ria de Aveiro (Portugal)

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Seagrass meadows play a major role on Blue carbon (C) storage through their ability to sequester C both in biomass and in the rhizosphere; consequently, providing important ecological functions and services. Ria de Aveiro is a temperate coastal lagoon, wherein seagrass meadows diversity and coverage started declining in the 1980's, due to anthropogenic drivers and pressures. This work assessed the current extent and Blue C in seagrass meadows at Ria and estimated its spatial variability in the last decade. *Zostera noltei* spatial distribution, currently restricted to intertidal areas, was mapped by remote sensing using an unmanned aerial vehicle (UAV) and aerial photography. Biomass and C was monitored for *Zostera* and Blue C-stock assessed. By 2014, seagrass monitored areas at Ria showed an extent of 232 ha, with Blue C-stock ranging from 146 to 585 MgC (considering 25% and 100% cover, respectively; 10 cm depth). An increase in the spatial extent was recorded from 2005 to 2014, when comparing meadows monitored in both dates. Overall, contrary to the worldwide decline trend, intertidal *Zostera* meadows in Ria have increased its extent in the last decade, which might be related to the natural adjustment to past human intervention in the system, combined with a more accurate assessment due to the use of UAV. This recovery contributes to an effective increase of Blue C stock in the seagrass meadows at Ria de Aveiro, however its further recovery and contribution to climate regulation and ecosystem health is still threatened by anthropogenic drivers and pressures.

ISBW141: Innovative techniques in seagrass restoration

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The seagrass meadows (*Zostera marina* & *Zostera noltii*) of the Dutch Wadden Sea have been in declining since the 1930s and haven't shown any natural recovery up to date. Due to the international importance of the Wadden Sea as a World Heritage site several seagrass restoration efforts have been undertaken to reverse the loss of the critically important seagrass meadows. The latest restoration efforts (2015-2017) have focused on studying bottlenecks for seagrass restoration success of intertidal, annual *Zostera marina*.

We here present an overview of recently developed seagrass restoration techniques that have yielded promising results for reducing seed loss over winter. Through innovative methods in seed harvesting, seed processing, storage and broadcasting, we managed to produce up to 180 times higher plant densities in the field within a 2-year period. Ongoing research and development will very likely produce even more promising results with regard to intertidal seagrass restoration, contributing to high quality nature management.

ISBW143: Dredging, port- and waterway construction near coastal plant habitats

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Marine and intertidal (coastal) plant habitats, such as seagrass beds, mangroves, saltmarshes and attached seaweed communities provide a huge range of ecosystem services, including protection of shorelines from storm surges and waves, prevention of coastal erosion, sequestering of carbon, climate regulation, sustaining fisheries production, supporting coastal livelihoods and providing a bio-geophysical framework for navigation. Dredging, port- and waterway construction in the vicinity of these coastal plant habitats may have adverse impacts on these environments and their functions. A good understanding of the involved processes is required to improve the planning and management of construction activities to avoid or compensate environmental impacts.
An international PIANC working group composed of experienced engineers and ecologists alike has drafted a guideline on this topic, meant to inform contractors, authorities and NGO's on relevant processes, frameworks and mitigation options, which can support them in choosing the best solutions. This guideline comprises a review of existing literature on impacts and dredging techniques as well as lessons learnt from dredging and construction near coastal plant habitats. Methods and techniques for the management of dredging and port construction around coastal plant habitats are presented and discussed with a view to derive best management practice guidelines to avoid or minimize impacts on these valuable habitats.

ISBW144: “Seagrass ID” App: Information technology for spreading knowledge

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Every day more people acquire or carry with them mobile technology for their daily activities, which becomes more indispensable day by day. The mobile technology also has a strong impact on the type of information from the Internet and its use by people. Persons mainly use smartphones for entertainment and communication; however, there much fewer applications focused on thematic learning or dissemination of knowledge.

The “Seagrass ID” application for smartphones was designed, based on the book “A guide to the tropical seagrasses of the Western Atlantic”, which contains information on the seagrasses from the Caribbean Sea. This App, includes a simple method to identify a seagrass species based on unique characteristics, presenting at the end relevant information on this species. In addition, it contains information about the fauna inhabiting the place, that together with the seagrasses, form the ecosystem. The goal of the “Seagrass ID” App, is spread the knowledge among students and the general public from the region, who often confuse seagrasses and algae, and raise awareness of the importance of marine ecosystems in general, and seagrass meadows in particular.

ISBW145: Aassessment of carbon stocks of *Enhalus acoroides* (L.f) Royle in Pujada Bay, Philippines

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The study aimed to obtain carbon concentrations of different parts of *Enhalus acoroides* (L.f) Royle which were found to store huge amounts of carbon in their biomass and its final blue carbon content and gradients that may affect the sequestration of the element. By using the methods of Fourqurean (2012) and Yamamuro (2004; pers.com.2015), carbon stock and other parameters that might affect the process of storing the carbon in the seagrass species was assessed.
Results revealed that carbon concentration per seagrass part highly emphasizes the rhizomes to have the largest amount of blue carbon, containing a total of 129 g/m^2 for all sites against the leaves' total of 92 g/m^2 and the roots' 64 g/m^2. Total blue carbon concentration showed largest at Gregorio, with a total of 145.0 g/m^2 followed by Irish, Badas with 72.0 g/m^2 and Guang-guang with 68.0 g/m^2. The results showed that the assessment was similar to dry/wet ratios from the nearby Thailand areas (Yamamuro, 2004) and previous nutrient assessments by Yamamuro and King (2011).
Gradients taken and observed during the sampling periods were found to be of no significance to the carbon sequestration except depth and substrate which proved to be primary factors in the development, storage and well-preservation of the samples coming from each site. The study showed how rich the *Enhalus acoroides* species is in storing natural Carbons and are very good Carbon pools for efficient climate change mitigation.

ISBW148: Dispersal and establishment potential of seagrass vegetative fragments

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Seagrass meadows are undergoing dramatic declines due to human activities. Knowledge regarding landscape meadow connectivity is essential to understanding seagrass habitat persistence. Seagrasses produce both sexual and asexual propagules that disperse beyond home meadows, however, the role of asexual propagules, i.e. vegetative fragments, is poorly understood. As part of the effort to generate a bio-physical model modelling seagrass habitat connectivity and resilience in the region, fragments were examined undergoing either decay, settlement or sediment burial using mesocosm experiments. Two seagrass species with contrasting life histories, *Halophila ovalis* and *Thalassia hemprichii*, were used. The experiments tested (i) the effect of light levels on floating fragment viability, (ii) fragment settlement under a tidal regime, and (iii) fragment establishment after sediment burial (<5 mm depth). Floating fragments remained viable and positively buoyant over 28 days, indicating a large dispersal potential. Lack of self-driven settlement and establishment events suggested a short “window of opportunity” for fragments to establish during low/mid tides. Instead, experimental sediment burial was required to promote fragment establishment. Seagrass life history influences overall survivorship and establishment rates, potentially shaping the emergence of meadows along Singapore’s coasts. Sheltered areas facilitate the re-emergence of climax species, potentially allowing establishment of multi-specific meadows that provide better ecological services, contributing to local meadow connectivity and landscape habitat resilience.

ISBW152: Citizen science mapping of the seagrass of Merambong Island, Johor, Malaysia

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Merambong Island lies in the Tebrau Straits between Malaysia and Singapore and is at the mouth of the Sungai Pulai estuary. Positioned closer to Singapore than Malaysia, it is a small island with multiple coastal habitats: mangroves, rocky shore and coral reef. With increasing coastal development and reclamation in the surrounding area affecting nearby seagrass meadows, the local community has observed increased patches of seagrass on the island. This poster will present the results of a 5 month mapping, documentation and monitoring exercise of seagrass patches around Merambong Island. The work was done at 2-4 week intervals during the 5 month sampling period (dependent upon a suitable tide). While the nearby Tanjung Adang and Tanjung Kupang seagrass meadows have been extensively studied, there is little information on the seagrass of Merambong Island. This study was carried out by members of a community group, Kelab Alami, that works closely with a network of scientists to document and monitor marine habitats in the area. This study will provide baseline information that can be examined in further detail by marine scientists for more expansive analyses, and is part of an overall effort by Kelab Alami to document its surrounding marine and cultural habitats.

ISBW157: Indo-Pacific Seagrass Network (IPSN) – collaborative research highlighting linkages between seagrass ecosystems, biodiversity and fisheries

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The Indo-Pacific region is home to diverse and productive seagrass beds that support key ecosystem services including fisheries. Yet, there is lack of understanding about the linkages between seagrass ecosystem structure, human activities and well-being. IPSN is a new research network focused on capacity building and knowledge exchange to investigate social-ecological linkages through coordinated and collaborative research. Inspired by the success of similar networks (e.g. the Zostera Experiment Network; zenscience.org), IPSN builds on the idea that bite-sized standardized research carried out by multiple groups can be brought together to generate a large database covering multiple sites across a wide spatial scale. This data can be used to address pertinent questions across scales.
We invite Indo-Pacific researchers and practitioners to become IPSN members and conduct collaborative seagrass research on a volunteer basis. IPSN will facilitate standardized data collection (including ecological surveys, fishery assessments, and market analysis) and help build capacity, so that stakeholders can increase local knowledge and also support local seagrass management and decision-making. Site-level data will be shared within IPSN to facilitate large-scale analyses, but participating groups are encouraged (and will be supported) to publish their own findings. In its first year IPSN will target “seagrass gleaning”: fishing/collection of invertebrates and/or fish with no or very basic gear in water where it is possible to stand (research to be conducted July 2018-June 2019). Please contact IPSN and/or attend the IPSN training workshop during ISBW to learn more about the network.

ISBW160: Epiphyte diatom community effects on *Thalassia testudinum* in La Reserva de la Biosfera los Petenes, Campeche, Mexico.

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Universidad Autonóma Metropolitana Unidad Iztapalapa

Seagrass physiological damage can be caused by excessive colonization by epiphyte community whereas diatoms are an essential component which can reach up to a third of benthic primary producer's biomass. Diatom 4% formaldehyde samples taxonomic composition on *Thalassia testudinum* leaves was analyzed by phase contrast microscopy. Environmental factors, epiphyte biomass, water column nutrients concentrations and *T. testudinum* beyond ground biomass relationship were tested during "nortes", dry and rainy 2016 and 2017 seasons. 41 taxa were identified belonged to 27 genera, 25 families and 19 orders, being the highest richness by *Mastogloia* (6 species) and *Cocconeis* (4 species) genres. Epiphyte biomass significant differences between seasons were presented where "nortes" had the lowest biomass (average = 0.003 ± 0.002 µg cm^{-2}) and the highest in rainy season (average = 0.196 ± 0.110 µg cm^{-2}). *T. testudinum* beyond ground biomass were homogeneous between seasons ($biomass_{average}$ = 580.38 ± 75.69 g m^{-2}). Epiphyte biomass, total phosphorus and silicates correlations (ρ = -0.675 y 0.602) were found which the highest concentrations were in nortes and rainy season (TP_{nortes} = 11.92 y $SiO2_{rainy}$ = 12.11 µM). Epiphyte diatoms were affected by abiotic factors and not by substrate availability due to the stability of the *T. testudinum* community in Petenes. However, negative health effects were found to *T. testudinum* community by nekrosis leaves evidence.

ISBW161: Response to stress and indicators of resilience, from theory to seagrass conservation measures: the HEALSEA project

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The documented and worldwide loss of seagrasses calls for effective measures to anticipate their decline and improve conservation. It has been suggested that seagrass response to increasing stress can be often nonlinear and show sudden decline. Ecological theory also proposes that systems close to decline become more stochastic and slow in recovering from disturbance, a phenomenon known as critical slowing down. Based on this phenomenon, some indicators of resilience have been proposed, including the measure of a slower recovery rate following a disturbance. Using such indicators could provide appropriate experimental tests and anticipate seagrass loss. Here, we show preliminary results on the trajectory of response of the eelgrass *Zostera noltei* (Horneman) to increasing intensity of herbivory that confirm a potential sudden decline of seagrasses under increasing stress. We also present the objectives of a funded Marie Curie individual fellowship (the HEALSEA project) which will focus on (1) identifying what are the response patterns of seagrass traits to gradients of stress; and (2) testing for the existence of indicators of resilience in seagrasses, particularly the change of recovery rate. Ultimately, the project will aim at (3) implementing the results into a protocol of action to be used by practitioners as innovative tools to anticipate potential changes in seagrass resilience. Our goal with the HEALSEA project is to contribute significantly to seagrass conservation using an innovative approach that combines experimental work with ecological theories.

ISBW164: Exploring the role of citizen science to translate science into action: a focus on SeagrassSpotter

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Seagrass meadows are complex social-ecological systems that provide ecosystem services supporting human wellbeing. Yet seagrass globally is suffering from degradation and loss, with a general downward trend, increasing intensity of threats, and significant lack of data to support management action. The role of citizen science in data collection for terrestrial ecological monitoring is widely acknowledged as providing significant contributions to science, education, society, and policy. Although the uptake of citizen science in the marine sector has been slower than in the terrestrial sector, the situation is improving particularly with the help of citizen friendly research tools and technologies. Seagrass meadows are easy to access and so lend themselves well to the engagement of citizen scientists, and indeed the growth of seagrass citizen science projects in recent years reflects this. Methodological and technological developments have been critical to such expansion, providing a myriad of opportunities for citizens to engage with seagrass. Moreover, the increasing use of online tools has created opportunities to collect and submit as well as help process and analyse data. Here we present Seagrass Spotter, a phone application that is working towards supporting the collection of global data on the distribution, health and status of seagrass meadows. Citizen science has helped researchers integrate scientific and local knowledge and engage communities to implement conservation measures that would usually not be economically viable. Here we use Seagrass Spotter as an example to demonstrate how citizen science can contribute to both science and action.

ISBW166: Establishing a baseline for seagrass species across different natural light environments in Singapore using PAM Fluorometry.

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Singapore has different seagrass habitats, from estuarine to reef-associated seagrass meadows, with naturally varying light regimes, from turbid and eutrophic environments associated with estuarine habitats in the Straits of Johor, to relatively clearer, oligotrophic conditions found at reef-associated meadows in the Straits of Singapore. To understand how seagrass adapt to the natural light conditions, we targeted three sites with different light profiles (high (CR), moderate (TM), and low (CJ) light environment based on existing literature), and measured photosynthetic performance of a single species, *Cymodocea rotundata*, using PAM (Pulse Amplitude Modulated) Fluorometry. PAM Fluorometry a common tool for measuring photosynthetic performance, but this technique hasn't been applied to habitat monitoring in Singapore, and information on the photosynthetic efficiency of seagrass in Singapore is limited. A Diving-PAM was employed to obtain rapid light curves (RLC), and 5 parameters – maximal quantum yield (F_v/F_m), electron transport rates (ETR), alpha (α), onset of light saturation (I_k) and light saturation (P_{max}), were estimated. Significant differences were found for F_v/F_m, α and P_{max} across all sites, but there was no significant difference for I_k between two of the sites. Post-hoc comparisons showed that TM stood out as being the most different from the other sites, which suggests that seagrass there received even lower light than previously thought. Further investigations revealed ongoing construction at TM which might be affecting the photosynthetic performance of seagrass. This study is part of an ongoing baseline development project, and aims to include other seagrass species to the collection.

ISBW167: Is credit given where credit is due? Pivotal role of seagrass beds as fishery habitats

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Coastal fisheries support millions of people in the tropics, but are threatened by degradation of fish habitats. Coral reefs and mangroves are often described as key habitats, but increasing evidence suggest that seagrass beds play a critical role. Here, we assessed the relative importance of seagrass beds and coral reefs as fish habitats in fished and no-take areas along the Kenyan coast, using field surveys and a literature review. Based on visual fish census, the total fish biomass per hectare was 2-4 times higher on coral reefs than in seagrass beds, and ca. 50% lower in fished than protected areas. In contrast, the pooled biomass of the 15 most important fishery species (>90% of sold fish, based on 10 years of fish market surveys) was as high in seagrass as coral habitats. Furthermore, the proportion of total fish biomass made up by the 15 fishery species was four times higher in seagrass beds than in coral reefs, and only impacted by fishing in seagrass beds. Consequently, seagrass fish appear to be important for, by also impacted by, coastal fisheries. A systematic review of the scientific literature on coastal fisheries in Kenya showed that while many studies also suggest seagrass beds are important fishery habitats, most studies erroneously label these as ‘coral reef fisheries’. Consequently, we must work to acknowledge the key role of seagrass as fishery habitats and the impacts of fishing, to help safeguard the future of seagrass ecosystems and associated services.

ISBW170: Does microbe-particle association influence the health of seagrasses?

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The soil rhizosphere is recognised in terrestrial ecosystems as an essential contributor to plant health, driven largely by the microbial community (bacteria and fungi) and soil particle size. In comparison, little information is available on the microbe-particle association in the seagrass rhizosphere and its influence on seagrass health. Knowledge of the microorganisms associated with the rhizosphere sediment of seagrasses represents an initial step toward understanding the physiological and ecological interactions between microorganisms, the rhizosphere soil, and the seagrass itself. In this study, we determine if the rhizobiome community structure associated with seagrasses (*Zostera muelleri*) is affected by sediment particle size and whether microbe-association has an influence on the health of seagrasses. ITS region and 16s RNA were employed as phylogenetic markers to describe microbial diversity sediment samples from a natural seagrass meadow and sediment translocated into CQUniversity's Tidal Mesocosm facility. The results are discussed as a first step in understanding how the rhizobacterial community responds to transplantation and how that may influence seagrass survival.

ISBW171: Connectivity and dispersal of knobbly sea stars (*Protoreaster nodosus*) in an urban marine environment

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Protoreaster nodosus is a sea star species common to shallow coastal waters of the Indo-West Pacific. In Singapore, *P. nodosus* is listed as 'Endangered', but little is known about its local ecology or distribution. This study examined the distribution, age structure, genetic diversity and larval dispersal potential of *P. nodosus* populations in Singapore through field surveys, desktop predictive modelling and the mitochondrial COI genetic marker. Of the five sites sampled, the largest population was found in the south of Singapore on Terumbu Pandan and Pulau Semakau, whereas northern populations were much smaller. Of the 386 individuals recorded at Terumbu Pandan over an eight month monitoring period, 96% were adults (R_{max}≥11 cm). Using a coupled hydrodynamic and agent-based model, a high level of connectivity between seagrass sites was predicted, with good transport of larvae across the southern waters of Singapore and some settlement reaching the northern parts. Conversely, larvae from the north-eastern sites oscillated and remained within the eastern straits of Johor, with a relatively higher level of self-recruitment. These predictions of strong larval dispersal were supported by the lack of genetic structure between populations. An unexpectedly high genetic diversity was found amongst the 78 sampled individuals (22 haplotypes, of which, 18 are unique to particular sites). Terumbu Pandan and Pulau Semakau are potential source sites for this species and haplotypes unique.

ISBW172: Carbon Stock Assessment in Seagrass Meadow In Penang, Malaysia.

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Seagrass meadows provide important carbon storage services known as coastal blue carbon and recognized as an intense carbon sink ecosystem. Middle Bank Seagrass (MBS) meadow (Penang, Malaysia) supports mixed-species of seagrass and hold carbon stock accumulated over the past years. However, MBS is projected for a reclamation project for the proposed Penang Transport Master Plan and reliable data needed by the state council to protect the area. In this study, we provide baseline estimates for carbon stock analysed from seagrass and sediment cores. Cores were collected from *Enhalus acoroides*, *Thalassia hemprichii* and *Halophila ovalis* patches. The carbon stock in belowground seagrass biomass was higher than aboveground seagrass biomass. Carbon stock across soil depth interval were statistically significant different. Carbon stock in soil dominated the total carbon storage constituting more than 99%. In both seagrass biomass and 100 cm soil depth, the ecosystem carbon stock averaged at 253 Mg C/ha. This study shows the importance of MBS in carbon storage.

ISBW173: Seagrass Oasis in Natural Analogues of Warm and Acidic Oceans in Mabini, Philippines

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Shallow coastal hydrothermal vents in Batangas, Philippines, emit hot (30-50 °C), acidic waters that create seawater conditions analogous to forecasted global warming scenarios this century. In an area with gaseous emissions, about 90% of the bubbles is CO_2. Carbon sequestered in seagrasses *Halophila ovalis* and *Syringodium isoetifolium* and microbial mats, as well as oceanographic processes, likely mitigated the pH to 8.04 in the bubble field close to buffered seawater conditions that otherwise would have been harsh conditions. This ecosystem service is undervalued in most areas prone to acidification, but in this specific environment the seagrass meadow served as oasis for fishes and turtles that often feed in the site, despite the high pCO_2, depressed dissolved oxygen and slightly warmer ambient temperature. Two factors limit the proliferation of seagrasses. In deeper areas (>15 m), photosynthetic activity is compromised by the amount of light able to penetrate and also likely exacerbated by hydrothermal vents that emits saltwater with 6.99 pH at 15m. Only up to 14 shoots per m^2 of monospecific *H. ovalis* were counted. In shallower areas, seagrasses are depauperate where sulfides precipitate. Without the sulfides, up to 34 shoots per m^2 of combined *S. isoetifolium and H. ovalis* were counted with latter as the predominant specie. Environmental control on ecology is strong and the feedback of the biological community to its environment is equally perceptible. The biogeochemical structure, survival and adaptation of species in areas that are natural analogues to warm and less alkaline waters are important to study.

ISBW182: A simple method for conducting habitat surveys using a camera-attached Unmanned Aerial Vehicle.

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DHI Water & Environment (Singapore)

Unmanned Aerial Vehicles (UAV) have gained traction in ecological studies as it reduces the time required to obtain data. While the use of UAVs in habitat mapping is well-established, it is used less often for collecting monitoring and percent cover information, probably due to issues with scaling photographs in post-processing. We use a simple and easily replicable method for using UAVs in habitat monitoring. A remote controlled drone was flown over suitably distributed transect lines predetermined using the DJI GS Pro application and capturing an image of a reef top mixed coral and seagrass environment at 20m intervals. Images captured were cropped to the equivalent of a 1 m^2 quadrat, which was done by determining pixel size for a 1 m^2 quadrat based on the calculation of Ground Sampling Distance (GSD), from focal length, sensor width and the estimated flying height of the drone mounted camera. Images were geotagged onto Google map and used for *ex-situ* quantitative image analysis using the Coral Point Count with Excel extension software (CPCe). Following a stratified random distribution, 100 points were randomly assigned to each cell of a 10 by 10 grid superimposed on the image. Each random point was assigned a benthic substrate category (e.g. seagrass, hard corals, sand) commonly used in intertidal surveys, and percent cover was quantitatively computed in CPCe. Results were comparable to live visual observations, with UAV surveys having the added advantage of allowing qualitative biodiversity assessment by reducing disruption caused by human presence to sensitive fauna.

ISBW184: SAV spatial-temporal variations and environmental relationship in different localities in the Gulf of Mexico.

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The submerged aquatic vegetation (SAV) is constituted by seagrasses species and benthic macroalgae. SAV is influenced by environmental, physicochemical and biological factors as in sediments and the water column nutrients concentrations are being absorbed by roots and leaves. SAV biomass samples spatial-temporal variations collected with a 0.02 m^2 cores were investigated. Linear regressions analysis between beyond ground and underground biomass were tested; also correlation between SAV biomass and environmental factor, water column and sediments nutrients concentrations and phytoplankton biomass were examined in 63 stations in three different coastal environments in the Gulf of Mexico during three climatic seasons. Significant differences between zones were presented by *Thalassia testudinum* ($Yalahau_{biomass}$ = 393.4 and $Cabo\ Catoche_{biomass}$ = 695.8 g m^{-2}) and *Halodule wrightii* ($Petenes_{biomass}$ = 110.5 and $Dzilam\ de\ Bravo_{biomass}$ = 259.7 g m^{-2}). The highest macroalgae biomass were located in San Felipe (mean = 348.6 g m^{-2}) and Cabo Catoche (mean = 361.7 g m^{-2}). The positive relationship between beyond ground and underground biomass were observed in all seagrasses species, but significant differences (p = 0.008) were presented only in H. wrightii between dry and rainy seasons. Correlation between physicochemical parameters, T. testudinum and *H. wrightii* while water column soluble reactive phosphorus and *S. filiforme* (ρ = 0.25) were presented. The lack of significant correlation between SAV and sediments nutrients concentrations showed that there were not nutrient limitation; nevertheless, SAV distributions were influenced by physicochemical parameters.

ISBW185: Characterisation of the lonely *Zostera marina* meadows in North Africa and the deeper one of the Mediterranean (south to the strait of Gibraltar, Morocco)

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Seagrass meadows are considered among the most productive and valuable marine habitat types, for biodiversity, ecological goods and benefits services they provide. *Zostera marina* is one of the world's most widespread marine macrophytes distributed in the northern hemisphere. In the Mediterranean, the species is present in coastal lagoons and the innermost part of very sheltered bays. Its alarming abundance regression requires a good knowledge of the dynamics and functioning of these ecosystems for regular monitoring and effective conservation actions.
In Morocco, there is knowledge gaps related to marine vascular plants and extensive studies are strongly needed into the conservation ecology of these species. Especially since the *Zostera marina* meadows has disappeared from many localities where it was historically reported. The only one which still exist in Morocco, seeing in North Africa, are those of Belyounech and Ouad El Marsa bays at the marine part of the site ‘Jbel Moussa’ (southern the Strait of Gibraltar).
The present study aimed to provide baseline quantitative data on these two deeper eelgrass meadows in Mediterranean (lower limit at -17 m in depth). The Belyounech meadow has a wide continuous distribution whereas that of Oued El Mersa is very fragmented. Shoot density and aboveground biomass were consequently higher in Belyounech with 745 shoots.m^{-2} and 272.94 g.DW.m^{-2} respectively. Roots were more developed in Ouad El mersa and accounted for 82% of the belowground biomass. Seagrass cover (%) showed significant differences only between the border (80%) and the central parts (100%) while it remained comparable between both sites. The percentage cover of *Caulerpa cylindracea* algae was higher throughout the margins parts and especially in Ouad El Mersa bay where the meadow is fragmented. Roots serve as the main bioaccumulator organ of 28 chemical elements with low translocation to rhizomes and leaves. %C was higher in leaves while $\delta^{13}C$ in sediment. Leaf %N reached 2% while belowground parts did not exceed 1%. The results obtained were compared to other regions in the Mediterranean to assess the quality and the health of the deep eelgrass meadows of Jbel Moussa.

ISBW194: Burial of Organic Carbon, Heavy Metals and Polycyclic Aromatic Hydrocarbons in seagrass sediments of the Arabian Gulf

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Vegetated coastal ecosystems such as seagrass meadows can promote the accumulation of organic material and pollutants in their sediments. As a result of the anoxic conditions and high rate of vertical particle accretion, these habitats can preserve substantial levels of organic carbon (C_{org}) and pollutants, effectively removing them from the environment. The high sedimentation rate typical of such habitats helps to preserve a historic record of fluxes of C_{org} and pollutants over a long period of time. Moreover, destruction or disturbance of these habitats could result in large-scale release of the stored carbon and contaminants to the surrounding environment.
The Arabian Gulf contains the world's largest exploited oil deposits, resulting in significant coastal and off-shore infrastructure and development since the emergence of intensive oil consumption over the last century. As well as the global implications of increasing fossil fuel consumption such as climate change and sea level rise, there have been substantial local and regional impacts from the oil industry such as pollutant emissions, oil spills and habitat destruction.
In this study we present results on the capacity of Arabian Gulf seagrass habitats to remove C_{org}, heavy metals and Polycyclic Aromatic Hydrocarbons (PAHs). We show how inputs of C_{org} and pollutants have varied over time through the analysis of sediment cores collected in seagrass meadows along the Saudi Arabian coastline. We outline the importance of the role of seagrass meadows on a local scale as a pollutant sink, and in global terms as an effective carbon sink and therefore their role in climate change mitigation.

ISBW195: The influence of substrate temperature on intertidal seagrasses

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The influence of soil-temperature on rhizome depths of four intertidal seagrass species in central Queensland, Australia, was investigated. We postulated that certain intertidal seagrass species are soil-temperature sensitive and vertically stratify rhizome depths. Below-ground vertical stratification of intertidal seagrass rhizome depths was analysed based upon microclimate (soil-temperature) and microhabitat (soil type). Soil-temperature profiles exhibited heat transfer from surface layers to depth that varied by microhabitat, with vertical stratification of rhizome depths between species. *Halodule uninervis* rhizomes maintain a narrow median soil-temperature envelope; compensating for high surface temperatures by occupying deeper, cooler soil substrates. *Halophila decipiens. Halophila ovalis* and *Zostera muelleri* rhizomes are shallow rooted and exposed to fluctuating temperatures, with broader median temperature envelopes. *Halodule uninervis* appears to be a niche specialist, with the two *Halophila* species considered as generalist niche usage species. The implications of niche use based upon soil-temperature profiles and rhizome rooting depths are discussed in the context of species' thermal tolerances and below-ground biomass O_2 demand associated with respiration and maintenance of oxic microshields. This preliminary evidence suggests that soil-temperature interaction with rhizome rooting depths may be a factor that influences the distribution of intertidal seagrasses.

ISBW196: Effect of light availability changes on seagrasses and macroalgae absorption to different forms of nitrogen

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Seagrasses can provide important ecological services for the marine environment. Eutrophication caused by an excess of nutrients is one of the most important threats to seagrasses. Nutrient enrichment can accelerate seagrass loss through algal proliferation that could cause shading and/or smothering. In some areas of the north coast of China, seagrass meadows have disappeared and been replaced by macroalgae mats due to increasing nutrient load. We carried out a mesocosm experiment to study the effects of light availability changes on seagrass *Zostera japonica* and macroalgae *Ulva pertusa* absorption to inorganic (i.e. nitrate, ammonium) and organic nitrogen (i.e. urea, glycine) forms nitrogen using ^{15}N isotope techniques. Our results showed that after low light effect *Ulva pertusa* decreased capacity to take up nitrate, ammonium and urea. After the same light effect, *Ulva pertusa* can absorb more ammonium and glycine than nitrate and urea. *Zostera japonica* leaves can absorb more ammonium than other forms nitrogen after the same light effect. But after high (100% natural), medium (45% natural) and low (10% natural) light effect, seagrass belowground part can take up more organic forms nitrogen (glycine and urea) than inorganic forms nitrogen (nitrate and ammonium), separately. Our results indicated that monitoring different forms nitrogen in eutrophication areas may provide management advice to avert phase shifts from seagrasses to macroalgae ecosystem.

ISBW197: *Ruppia* in China: population crisis, seeds researches, and consevation prospects.

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After a few investigations along the coastal area of four provinces, we find *Ruppia* species are facing serious population reductions due to anthropogenic impacts in China. Because of its significant role in coastal ecosystems, it is very essential to recover amounts of *Ruppia* populations. Seeds are important materials for the restoration of globally-threatened marine angiosperm (seagrass) populations. We have carried out a series of researches on the seed ecology of the Chinese native *Ruppia* species, *Ruppia sinensis*. We investigated the effects of temperature and salinity on its seed germination and seedling establishment, and found its optimum seed germination conditions was salinity 5 at 30 °C;. Then we have studied the tolerance abilities of *R. sinensis* seeds to desiccation, low temperature, and high salinity, and make sure that it is better to storage them in seawater of salinity 30-40 psu and 0°C. Meanwhile, we have found there are two typical *Ruppia* seed types Shape L and Shape S, whose weight, seed curvature, and endocarp thickness were significantly different. These findings provided basic seed-related ecological information for R. sinensis and serve as useful information for *Ruppia sinensis* habitat establishment and restoration programs. In fact, we are promoting a program in which *R. sinensis* meadows will be established to purify the sewage from shrimp culture ponds in the Yellow river estuary. In future, *Ruppia* may play more important roles in coastal environment improving practices with the increasing interests of China society in ecology and environment protection.

ISBW198: Different population recruitment strategies of the threatened seagrass *Zostera japonica* in different habitats of temperate China

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The seagrass *Zostera japonica* is being widely and severely threatened in its native range - Northwestern Pacific Coast, especially in China, though it has been introduced to the North America and expanding its colonization. However, data related to its population recruitment, especially through sexual reproduction, are absent for its native range. This study aimed to understand sexual reproduction and its role in population recruitment of *Z. japonica* for three seagrass meadows in different geographic habitats, the marine lagoon Swan Lake (SLL) , Huiquan Bay (HQB) and Yellow River estuary (YRE) . At SLL, mixed annual *Z. japonica* had a high yield of seeds throughout a long flowering period (5 months), and a relatively stable sediment seed bank (1460 ± 417 seeds m^{-2}). Population recruitment from seedlings accounted for 41.16 ± 24.49% of the total population size at SLL. By comparison, the perennial *Z. japonica* at HQB had a lower seed reproduction, and thus an extremely small seed bank (9.63 ± 6.34 seeds m^{-2}), hence seedlings were absent in the spring. At YRE, the reproductive efforts and the sexual recruitment ratios can be comparable with or higher than those of SLL, but showed larger annual variations. The microsatellite analysis verified the observations above and indicated an important role of sexual reproduction in the population recruitment at SLL & YRE and the maintaining of genetic diversity at HQB although at a very low frequency.

ISBW200: Enhancing inorganic nitrogen loading to coastal waters by leaching and photodegradation of CDOM released from seagrasses detritus

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Seagrass detritus has been proved to be one of the main sources of CDOM in coastal waters. Photodegradation of CDOM released by seagrasses detritus could be a pattern enhancing nitrogen loading of coastal waters. In this study, indoor cultivation experiments were conducted to illustrate the characteristics, releasing and photodegradation patterns of CDOM released by seagrasses detritus (*Enhalus acoroides* and *Thalassia hemprichii*). The results showed that four components, including three protein-like substances and one humic-like substance, of CDOM released by seagrass detritus were determined. During the CDOM release experiment for 7 days, protein-like and humic-like substances released both from *E. acoroides* and *T. hemprichii* first increased and then decreased along the leaching days. CDOM derived from seagrass detritus rapidly degraded after exposure to UV-B for 5 days. The absorption coefficience, DOC and UV-B absorbance performance of CDOM significantly decreased during photodegradation. The component of CDOM (protein-like and humic-like substances) decreased obviously as well. In the photodegradation process of CDOM, dissolved organic nitrogen (DON) was decomposed to dissolved inorganic nitrogen (DIN). 79% of the DON that has been UV-B decomposed was converted to NH_4^+ and NO_3^-. It can provide obvious evidence that CDOM released by seagrasses detritus would influence the nitrogen cycle by its photodegradation process and contribute significant inorganic nitrogen to coastal waters.

ISBW201: Effects of seagrass leaf litter decomposition on sediment organic carbon composition and the key transformation processes

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Seagrass leaf litters are an important source to sediment organic carbon (SOC). However, the influencing mechanisms of the decomposition of seagrass leaf litters on SOC composition and the key transformation processes are still unknown. To address this gap, we carried out a laboratory chamber experiment to compare the labile organic carbon composition and the enzyme activities governing SOC transformation between the seagrass leaf litter addition group and control group. The results showed that the decomposition of seagrass leaf litters significantly elevated the salt-extractable carbon (SEC) content and the SEC/SOC. Additionally, the invertase, polyphenol oxidase and cellulase in seagrass leaf litters addition group were generally higher than control group, which could elevate the decomposition of recalcitrant organic carbon. After 24 days incubation, the addition of seagrass leaf litter increased the releasing amount of CO_2 but decreased the SOC content. Therefore, the decomposition of seagrass leaf litter leached abundant leaching dissolved organic carbon, which enhanced the activity and transformation of SOC.

ISBW202: Effect of sediment type on photosynthesis and biochemical composition of seagrass *Thalassia hemprichii* (Ehrenb.) Aschers

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Sediment type is very vital for seagrass growth and successful rate in seagrass restoration, but little is available on the photosynthetic and biochemical response of seagrass to sediment type. *Thalassia hemprichii*, collected from a eutrophicated seagrass bed in Xincun Bay, Hainan Island of Southern China, was cultured at three types of sediment (in-situ sediment combined with different ratio of sand) in flow through seawater. Higher Eh was found in the sediment type with higher sand composition. Higher sand composition didn't change the effective quantum yield, but significantly enhanced the relative maximum electron transport rate and minimum saturating irradiance. Lower C content but higher N content were observed in the aboveground tissue of seagrass growed in higher sand composition. Furthermore, sediment with higher sand composition significantly reduced the total amino acid, sarcosine, proline and alanine in the both aboveground and belowground tissues. Therefore, these results indicated that *T. hemprichii* may respond positively to sediment type with higher sand composition. This may be the reason for that *T. hemprichii* often grows in coarse sand substrate. It is also very important to change the sediment type to improve the growth condition for seagrass and to enhance the successful rate in transplanting seagrass shoots in the euthropicated ecosystem.

ISBW204: Leaching of dissolved organic matter from seagrass leaf litter and its biogeochemical implications

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To study how the various fractions of dissolved organic matter (DOM) from seagrass leaves contributed to the coastal biogeochemical cycles, we carried out a 30-day laboratory chamber experiment on tropical seagrasses *Thalassia hemprichii* and *Enhalus acoroides*. After 30 days of incubation, on average 22% C, 70% N and 38% P of these two species of seagrass leaf litter was released. The average leached DOC, DON and DOP of these two species of seagrass leaf litter accounted for 55%, 95% and 65% of the total C, N and P lost, respectively. In the absence of microbes, about 75% of the total amount of DOC, monosaccharides (MCHO), DON and DOP were quickly released via leaching from both seagrass species in the first 9 days. Subsequently, little DOM was released during the remainder of the experiment. The leaching rates of DOC, DON and DOP were approximately 110, 40 and 0.70 μmol g^{-1} DW d^{-1}. According to the logarithmic model for DOM release and the *in situ* leaf litter production (Xincun Bay, South China Sea), the seagrass leaf litter of these two seagrass species could release approximately 4×10^3 mol d^{-1} DOC, 1.4×10^3 mol d^{-1} DON and 25 mol d^{-1} DOP into the seawater. In addition to providing readily available nutrients for the microbial food web, the remaining particulate organic matter (POM) from the litter would also enter microbial remineralization processes. What is not remineralized from either DOM or POM fractions has potential to contribute to the permanent carbon stocks.

ISBW205: Rhizosphere microbial community structure in two tropical seagrass beds: importance of patch types

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Rhizosphere bacterial community structure and their determining drivers have been studied in a variety of marine and freshwater ecosystems and covered across a range of plant species. This study aimed to determine which factor (habitats, patch types and plant species) have crucial role on the rhizospheric bacteria in seagrass beds containing mixed plant communities (*Thalassia hemprichii* and *Enhalus acoroides*) or independent populations. Using Illumina Miseq sequencing technique, we observed substantial distinction in rhizospheric bacterial richness, diversity, and relative abundances of taxa between two habitats, which were characterized differently in sediment conditions. In mixed patches with two coexisting species at Xincun and Tanmen, the rhizosphere microbiota was clustered tightly may probably owing to the entangled root systems of two neighboring plants. As for independent patches with single seagrass population (*T. hemprichii* or *E. acoroides*) at Xincun, the rhizosphere microbial communities were distinct from that of the mixed patches. Therefore, after between-habitat variation, the contrast between patch types, which was mediated by the root exudates, was the next most significant source of variation in rhizosphere compartments in one small-scaled location. Although the ANOSIM analysis did not detect significant difference between two species crossing two habitats, we observed two types of rhizospheric sediment harboring different community composition when seagrass grew in separated patch. Overall, plant roots selectively stimulated the relative abundance of *Proteobacteria*, which involved in diverse sulfide, carbon and nitrogen cycling; while reduced the abundance of spore-forming *Firmicutes* when compared with bulk sediment.

ISBW207: Marine citizen science in action: seagrass monitoring within Rottnest Island Marine Reserve, south-west Australia

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West Australian Divers for Diversity Inc.

Rottnest Island is located in the warm temperate waters of south-west Australia (32°S, 115.30°E) and is surrounded by extensive seagrass meadows containing eleven different species. Since the establishment of the Rottnest Island Authority Act 1987, there has been no comprehensive baseline study of the seagrass meadows within the marine reserve that can be used to inform current or future management of this important habitat. Volunteer divers from the citizen science community organisation, West Australian Divers for Diversity Inc. (WADDI), were trained in seagrass monitoring methods and have been monitoring the seagrass in the Reserve since 2015. A five-year seagrass monitoring program was established in 2016, and includes the annual monitoring of 10 separate meadows around the Island during the austral summer months, primarily targeting *Posidonia* and *Amphibolis* species. Not all meadows are dominated by the same species, and preliminary data from two years of monitoring shows high variability of shoot counts within meadows, as well as between meadows. Interestingly, the morphology of *Amphibolis antarctica* also varies between meadows at different locations around the Island, and this is most likely due to the differing oceanographic conditions influencing each of these locations. After five years of monitoring, baselines for seagrass viability indicators will be established and used to assess future changes in the meadows, which is not just important for an Island that is a popular tourist destination year-round, but more importantly, because seagrass habitat acts as a nursery, refuge and food source for a high diversity of tropical and temperate marine life.

ISBW209: Phenotypic plasticity in *Enhalus acoroides*: in vitro and in situ light response experiments

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Enhalus acoroides is one of the most prominent seagrass species in shallow waters of the tropical Indo-Pacific region and occupies various habitats characterised by differences in sediment composition (sandy to muddy) and/or light conditions (turbid to clear waters). Leaf morphology and reproductive traits have been observed to vary between *Enhalus* shoots occupying these contrasting habitats, suggesting phenotypic plasticity, genetic variation or both.

This study presents the results of a combination of laboratory and field experiments (common garden, shading and reciprocal transplant experiments) on different *Enhalus* “seed families”. Morphological characteristics and physiological performance were documented to assess the phenotypic plasticity components in adaptation strategies of *Enhalus* shoots to variation in light intensities.

The different “seed families” showed similar responses to variations in light intensity, indicating phenotypic plasticity in morphology (leaf surface area and root lengths) and pigment (chlorophyll *a* and *b*) concentrations. Plants grown under a range of light intensities, or at different depths, showed a variety of responses, with those grown at high light intensities, or at shallower depths, having smaller shoots, shorter roots and lower chlorophyll concentrations. Although limited in extend, these plastic responses were observed both in the developmental stage (seedlings) as well as in mature plants. These responses might be one of the mechanisms of *Enhalus* to cope with light gradients in the environment and could explain its ability to survive in various habitat types.

ISBW210: Impacts of Plastics on Seagrass and its Associated Fauna

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Plastics are carbon-based organic polymers produced from non-renewable resources leaves toxic residues. The increased production of plastics reflects the increased demand for plastics. The plastics degrade under certain pH range and ultra-violet radiation to form microplastics. The accumulation and dispersal of plastics by natural calamity and anthropogenic activities causes recurrent damage to the aquatic environment such as eutrophication and sedimentation. Seagrass referred to as grass meadows of the coastal environment, provide ecosystem services and support a diverse assemblage of fauna including recreational and commercial fishes. Seagrass and its associated fauna are vulnerable to entanglement by plastic debris. The decline in abundance and distribution of seagrass causes loss of biodiversity, habitat degradation, decrease in primary production, carbon sequestration and nutrient cycling in the marine environment. As the plastics are non-biodegradable and found to have toxic effects on living beings and their environment, the bioplastics came into existence. Bioplastics are degradable, eco-friendly, sustainable and non-toxic plastic developed using renewable resources. However, the application of bioplastic has not gained much attention, but also seaweed has been identified as the raw material for the production of bioplastic to be utilized in food and food packaging industry. Bioplastics from seaweeds are reported to be more resistant to microwave radiation, less brittle and durable due to the presence of polysaccharide complex. The technology development for seaweed-based bioplastics are still under the research phase and it is hoped that significant advancements should be made in the bioplastics industries to make seaweed bioplastics a reality in future.

ISBW211: What impact did an unusual summer flood have on seagrass cover in a Western Australian estuary?

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Estuarine seagrass distribution and cover are partly determined by the environmental conditions and the dynamic nature of the colonising species within. It can be affected by extreme climatic events like unusual rainfall events. Understanding the associated magnitude of the variation in seagrass cover may aid management. Seagrasses are surveyed in the Swan-Canning estuary (Perth, Western Australia) every summer, as part of a routine monitoring program. During the summer 2017 there was an extreme rainfall event which resulted in major floods into the estuary, approximately 270 GL of water being discharged from the catchment in a short time. This resulted in an almost instantaneous drop of salinity, and a drastic reduction in water clarity across all the estuary. At the study site, the percentage surface irradiance (measured at the seagrass canopy) dropped from approximately 45% to almost 0% and water temperature decreased for a few days. Here, we present the result of 1000 observation assessed in two occasions in HTH, one of the six sites, where seagrass percentage cover declined 31% from February to March 2017 compared to 12% and 8% seen in 2013 and 2018 respectively. The reduction of seagrass was more evident in the deeper margins in 2013 and 2018 than in 2017, likely due to the natural seasonal reduction of light reaching the seagrass canopy. This suggests that the decline of seagrass in the shallower margins in 2017 following the summer flood was due in part to fresh water exposure as well as reduction of light.

ISBW212: Drivers of methane (CH_4) and nitrous oxide (N_2O) emission rates in tropical seagrasses – ongoing studies in the Western Indian Ocean

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Methane (CH_4) and nitrous oxide (N_2O) are, apart from carbon dioxide (CO_2), the most potent greenhouse gases (GHGs) in the atmosphere. A large part of the emissions of these gases originates from wetlands and are linked to anoxic conditions of submerged sediments of high organic matter content, stimulating methanogenesis and denitrification. Seagrass meadows are particularly exposed to anthropogenic disturbances, receiving substantial amounts of nutrients from land. Their high filtering capacity causes accumulation of organic matter in their sediments, stimulating GHG emissions. In an ongoing project in Tanzania, we determine GHG fluxes in seagrass meadows, comparing emissions from the surface of seagrass sediments under high and low tides, in sheltered and exposed meadows, in areas with high and low input of pollutants, and in meadows exposed to stress, i.e. grazing, shading and high midday temperatures. So far, we have found higher emissions from polluted compared to pristine sites, indicating that eutrophication in seagrass areas may contribute to increased emissions of GHGs. Further, all stressors (grazing, shading and temperature) caused a significant increase in GHG emissions. These emissions were negatively correlated to photosynthetic rates of the seagrasses and positively correlated to their belowground biomass. It is probable that there is a link between the decrease in photosynthetic oxygen production in the seagrasses and the increases in stress related GHG emission from the sediment, and future increases in the frequency and severity of extreme weather events together with increased nutrient runoff could induce the release of larger amounts of methane to the atmosphere.

ISBW213: Land-sea connectivity: effects of mangrove degradation on carbon sequestration in nearby seagrass habitats in northeastern Madagascar

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Seagrass meadows constitute important contributors to climate change mitigation through sequestration of carbon dioxide from the atmosphere, creating long-term storage of sedimentary carbon. Although the understanding of strength and variability of sedimentary carbon sequestration and storage is of vital importance to assess coastal carbon dynamics, there is a large uncertainty on how co-existing drivers at local- and landscape scales governing carbon storage in coastal seascape environments. The main aim of this study was to understand effects of mangrove degradation on carbon sequestration in nearby seagrass habitats. The study is part of the four-year Blue Forests Project initiated by the United Nations Environment Programme (UNEP) and partly funded by the Global Environment Facility (GEF). We assessed organic- and inorganic carbon stocks, and carbon sources using isotope technique, covering a 20 km multi-species seagrass area in northeastern Madagascar. The study area encompassed seagrass meadows located nearby intact mangroves as well as those adjacent to heavily deforested mangroves. Preliminary results show that there might be an increase in sedimentary carbon content next to the deforested mangrove areas, presumably due to escalated runoff of carbon-rich mangrove soil. The findings emphasize that the carbon sink capacity of tropical seagrass beds is linked to land-sea connectivity and the configuration of the surrounding coastal landscape, and hence affected by land use changes such as habitat conversion.

ISBW214: Myanmar: Updates on the Seagrasses of the Myeik Archipelago

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Myanmar Marine Science Partners

At ISBW 12, we presented some preliminary data on the seagrasses of the Myeik Archipelago in Myanmar - the first collected in a decade. Two years later, we are excited to be able to provide an update on results from three additional successful surveying seasons, including high-resolution drone footage of the meadows, longer-term species composition data, and sediment composition gradients across the islands. We also conducted the first ecosystem service valuation of the Myeik islands, focusing on aquatic ecosystems, with plans to create more refined iterations in the next few years. Our hope is that this analysis will bridge the divide we often see between academic work and development policies in a country that is home to some of the most pristine and diverse ecosystems in the world - including seagrass - and that has shown an interest in managing them sustainably.

ISBW215: Effect of future global warming on the productivity of a widely distributed seagrass

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Seagrass meadows provide key ecosystem services but are declining worldwide. Globally, sea temperatures are rising, with sea surface temperatures in Australia projected to increase by 2°C by 2100. Knowledge of seagrass productivity across temperate and tropical locations can assist in predicting impacts under future climate change scenarios. Using oxygen evolution we generated photosynthesis-irradiance curves for whole plants of *Halophila ovalis*, a globally distributed seagrass species, across a latitudinal gradient (10°) at three temperatures (17, 23, 28°C). At all locations, temperature affected all photosynthetic parameters, but the nature of this effect varied (Temperature x Location/Site, $p < 0.05$). Net photosynthesis ranged from 1.35 ± 0.12 to 12 ± 0.68 mg O_2 g DW hr^{-1}, with a 3-fold higher mean rate at tropical compared to temperate locations. The rate of respiration ranged from -0.74 ± 0.068 to -4.4 ± 0.28 mg O_2 g DW hr^{-1} and generally increased with temperature at all locations. We conclude that there is potential for negative effects of projected temperature increases on *H. ovalis* productivity, with temperate regions more likely to be negatively affected than tropical regions. Tropicalisation of temperate west coast Australia may result in lower productivity of seagrass ecosystems, with implications for consumers and food webs.