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School of Natural Sciences

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Centre for Marine Ecosystems Research

RESEARCH HIGHLIGHTS 2015

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DIRECTOR'S REPORT

Glenn Hyndes and Paul Lavery
Co-Directors, Centre for Marine Ecosystems Research

It is a pleasure to present the 2015 Research highlights for CMER. It was a year in which fledgling areas of research initiated through our Collaborative Research Network become major themes within the Centre: blue carbon; paleo-ecological reconstruction; and marine microbial ecology. This year's report showcases several projects from each of these themes, which complement our ongoing research in coastal connectivity and human impacts.

In 2015 we welcomed our newest staff member with the appointment of Pere Masqué as Research Professor in Environmental Radionuclides. Pere's appointment is a boon not just for CMER but for the State as a whole. His expertise in using radionuclides as tracers of environmental processes brings a capability to study a marine process that has not previously existed in WA. Already Pere has been forging excellent links with other organisations, throughout the country and internationally.

While we welcomed Pere, we said farewell to two of our PhD students. Andrew Mackey completed his PhD, on the use of stable isotopes to understand coastal foodwebs, an outstanding piece of research that received the Faculty Research Medal. Andrew is now working as an environmental consultant in QLD. Mohammad Rozaimi, gained his Ph.D. for his research on carbon preservation in seagrass ecosystems and has since taken up an academic position at UKM in Malaysia.

Particularly pleasing to CMER were the outcomes of the Australian Government's Excellence in Research Assessment, which was released during the year. ECU was ranked as 'Well above world average' in Ecology and 'Above world average' in Environmental Science. While CMER was by no means the only contributor to those excellent outcomes, we played a significant role in both, reflecting positively on the excellent research that continues to undertaken by our students and staff. A small reflection of this was the doubling of our research outputs in 2015compared with 2014, and in some of the highest ranked ecology and environmental science journals. While these metrics are nice though, one of the most pleasing things about 2015 was the impact that our research is having in our community. As you read through the report you will notice the range of partners we are working with to translate our research into better marine management, be this for dredging, fisheries, marine park management or the impacts of the catastrophic nuclear accident at Fukashima.

Best wishes and thanks for your interest

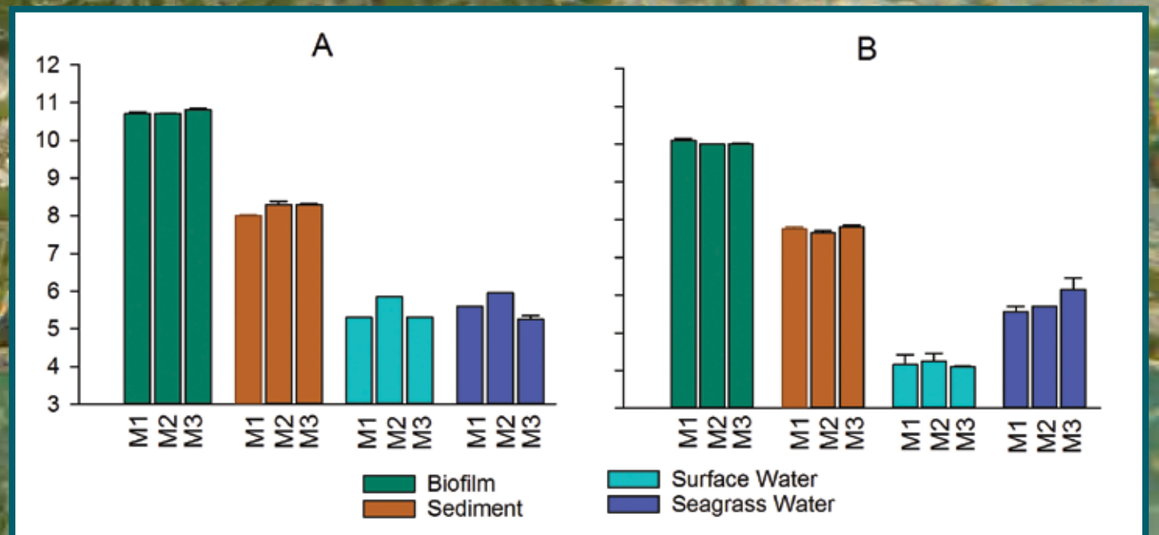


Figure 2: Quantitative Polimerase Chain Reaction (q-PCR) on bacterial 16S rRNA (A) and archaeal 16S rRNA (B) from three meadows (M1, M2,M3) of Posidonia sinuosa in Marmion Marine Park, and four habitats: biofilm, sediment, surface and seagrass water. Benthic primary ecosystems are key energy sources in coastal marine environments and understanding the movement of material and sources among habitats is of critical importance for the management of marine environments. Although we tend to have a simplistic vision of the food chain, most food webs are the results of complex interactions and connections among different habitats.

HIGHLIGHTS IN HABITAT CONNECTIVITY AND TROPHIC INTERACTIONS

Habitat connectivity and trophic interactions form one of the main focal topics of research in CMER. The two projects outlined here focus on genetic connectivity of seagrass across the Indonesian Archipelago and Australia, and research helping us to understand the vital role prokaryotes play in aiding nitrogen uptake in seagrass.

GENETIC CONNECTIVITY OF SEAGRASSES ACROSS INDONESIA AND WESTERN AUSTRALIA

PhD student Mr Udhi Hernawan, supervised by Kathryn McMahon and Paul Lavery in CMER, as well as Gary Kendrick from UWA and Kor-Jent van Dijk from the University of Adelaide has been studying the patterns of genetic connectivity among population of the seagrass *Thalassia hemprichii* across the Indonesian Archipelago and into Australia. His research is exploring the patterns of genetic connectivity among seagrass populations and the factors, both contemporary such as ocean currents, and historical such as sea level changes during the Pleistocene period that influence population connectivity. The greatest genetic diversity was found in eastern Indonesia around the Coral Triangle. The Sunda area was exposed during the Pleistocene period when sea levels were very low. Following sea level rises, seagrass likely recolonized this area and the genetic data supports that the eastern clade was the source (Figure 1). This work has been funded through the Collaborative Research Network, Western Australian Marine Science Institution and the Indonesia Endowment Fund for Education – LPDP.

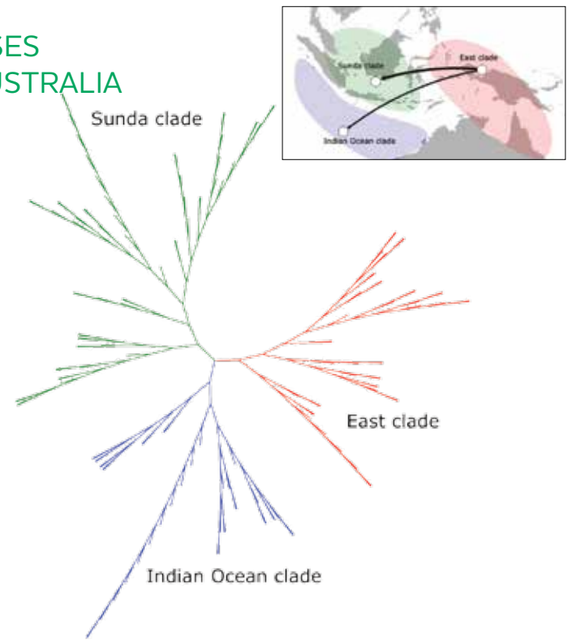


Figure 1: A consensus tree showing three distinct genetic groups determined from SNP genetic data across Indonesia and Northern Australia, the Eastern clade, the Sunda clade and the Indian Ocean clade. The lines one the map show the direction and strength (based on thickness) of migration among the clades, highlighting the significance of the eastern clade for supporting populations to the west.

THE ROLE OF EPIPHYTIC PROKARYOTES IN FACILITATING SPATIAL SUBSIDIES IN SEAGRASS MEADOWS

The important function of prokaryotes associated with seagrass leaves in enhancing nitrogen availability for uptake by seagrasses.

It is estimated microbes comprise 98 % of the biomass within the marine environment and, among other functions, these tiny microorganisms play a vital role in facilitating the cycling of several elements, including nitrogen. Seagrass are important primary producers, they provide a complex ecosystem and a source of nutrients for many organisms such as crabs, turtles, dugongs, and manatees. Although a key component in maintaining high seagrass productivity, nitrogen can be limited in marine environments. Dissolved Organic Nitrogen (DON) represents the most abundant form of nitrogen in coastal habitats and in Western Australia two important sources of DON are represented by phytoplankton and kelps. A small number of studies have suggested that seagrass may be able to directly uptake organic nitrogen through their leaves, however, these studies did not consider the prospect that seagrass organic nitrogen uptake may be microbial-mediated.

PhD student Flavia Tarquinio, supervised by Glenn Hyndes of CMER, and Annette Koenders with the School of Science at ECU has been researching the function of epiphytic prokaryotes on seagrass leaves in regard to the nitrogen cycling within seagrass meadows. The aim of the study was to determine the importance of the prokaryote-seagrass association in enhancing nitrogen availability for uptake by seagrasses, with a focus the role of prokaryote in processing allochthonous (namely phytoplanktonic and kelp) sources of nutrients in seagrass meadows. Nutrients can flow from most productive ecosystems, known as 'donor ecosystems', to less productive ones, the recipients. Once the allochthonous material is deposited within a recipient habitat, it may have substantial implications on the productivity and food web structure.

Results found *Posidonia sinuosa* leaves hosted a significantly higher microbial abundance than the surrounding habitats with some microbes undetected in surrounding water or sediment suggesting colonisation to be plant specific. This implies the microbial mineralization of organic nitrogen may be of pivotal importance in plant nitrogen uptake and thus essentially influencing the ecological success of these valuable communities. This research is part of the Collaborative Research Network between Edith Cowan University and the Department of Parks and Wildlife.

Photograph: Seagrass *Thalassia hemprichii* growing in coral sands in Northern Australia

Figure 5: Percentage contribution of green, red and brown algal species to the stomach content of the two life stages of temperate *Kyphosus* species. The findings show difference in the proportion of different types of food (algae) consumed by the different species and also between adults and juveniles of the same species.

HIGHLIGHTS IN CONSERVATION AND FISHERIES BIOLOGY

This wide-ranging research theme covers a diversity of projects in CMER with a focus on integrating marine ecology with coastal planning and management through improved understanding of ecosystem processes. As we continue to explore fisheries biology, this year's highlights examines the important function of herbivorous fish species, *Kyphosus*, essential to understanding and managing the complexity of marine ecosystems.

THE ROLE OF KYPHOSUS SPP. IN REEF ECOSYSTEMS

It is well known that herbivory greatly influences the ecological processes that regulate the biodiversity in marine environments, and therefore evaluating herbivory becomes an essential step in understanding and managing the complexity of marine ecosystems. The herbivorous fish Kyphosids, commonly found in both temperate and tropical waters all over the world, are recognized as a key group for many reef habitats. Despite their importance as algal consumers and their wide distribution, basic ecological information about the diet, abundance, and distribution of Kyphosids is scarce. PhD student Aldo Turco is exploring the main habitat features and species morphology of the Kyphosid particular to Western Australia, in order to increase the basic ecological data of this herbivore and to better understand their significance to our reef environments.

The study has focussed on two marine protected areas of Western Australia; Marmion Marine Park (Perth's city marine reserve) and Ningaloo Marine Park (the iconic North West coral reef). In a collaboration with the Department of Parks and Wildlife the study has assessed the relative abundance of the various species of *Kyphosus* together with a biological and physical reef variables such as algal cover reef form across different sites.

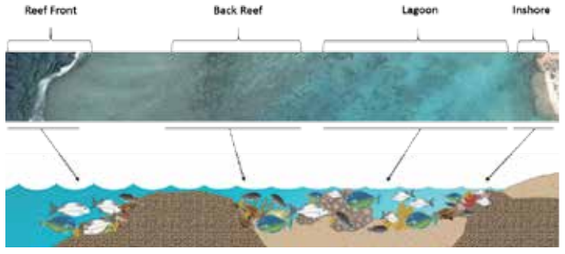


Figure 3: Main habitat types at Ningaloo reef.

A multivariate statistical approach was used to explore the relationship between fish numbers and environmental variables providing essential information on which habitat features can affect species distribution and abundances. Six species were included in the study, three temperate (*K. sydneyanus, K. cornelii* and *K. gladius*) and three tropical (*K. bigibbus, K. cinerascens* and *K. vaigiensis*). All six species exhibited a strong relationship to specific structural elements of high-relief reef habitats – be it caves, boulders or crevices – in both the temperate and the tropical regions.

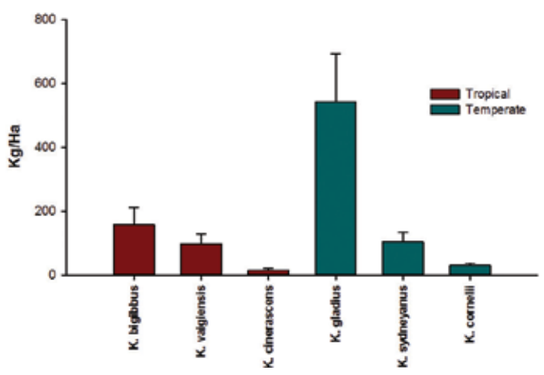


Figure 4: Average biomass values of tropical (red) and temperate (blue) kyphosids.

The analysis of stomach content implied that algal composition has a moderate influence with the correlation, generally weak, found only in algae representing the Kysophus spp. main food sources. The diet analysis also confirmed Kyphosids role as relatively exclusive herbivores but unveiled crucial differences in their functional role.

The research has indicated a dominant role of kyphosids as herbivores across reef habitats in both temperate and tropical regions with surprisingly higher abundance and biomass for temperate species. There were also differences in the diet between species and life stages; adults of big-bodied fish (K. *sydneyanus, K. gladius* and *K. bigibbus*) were "Browsers" feeding on brown algae (Ochrophyta) while juveniles and smaller species (*K. cornelii* and *K. cinerascens*) were "Grazers", feeding mainly on smaller red and green algae (Rhodophyta and Chlorophyta). These results may have major implications for the way these species need to be considered in general reef ecology across different latitudes and will be essential to the marine park authorities for more accurate management of resources within and outside the marine protected areas.

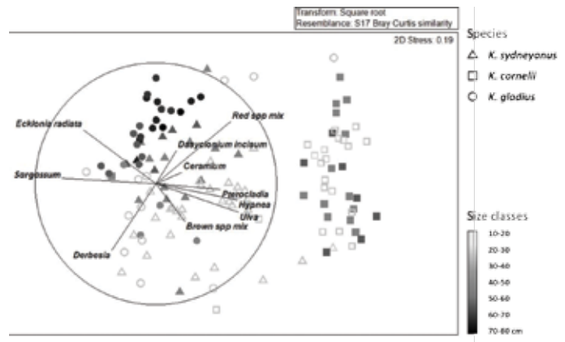
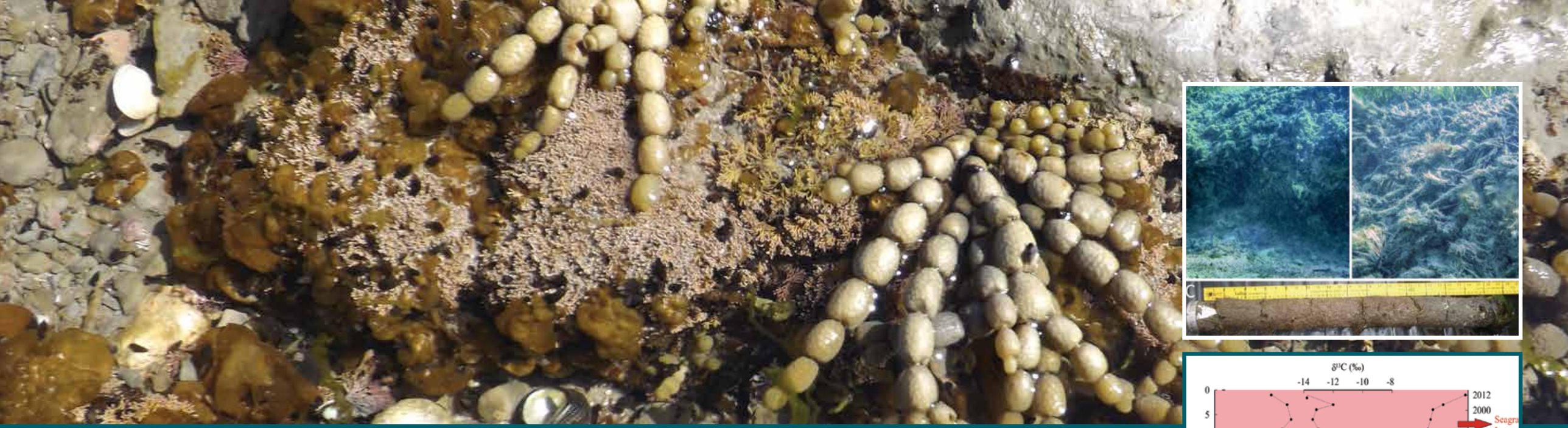
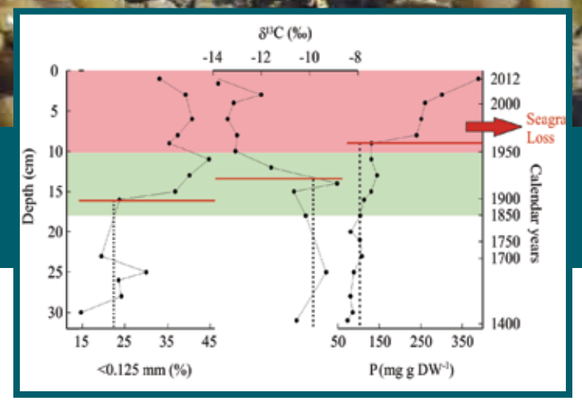


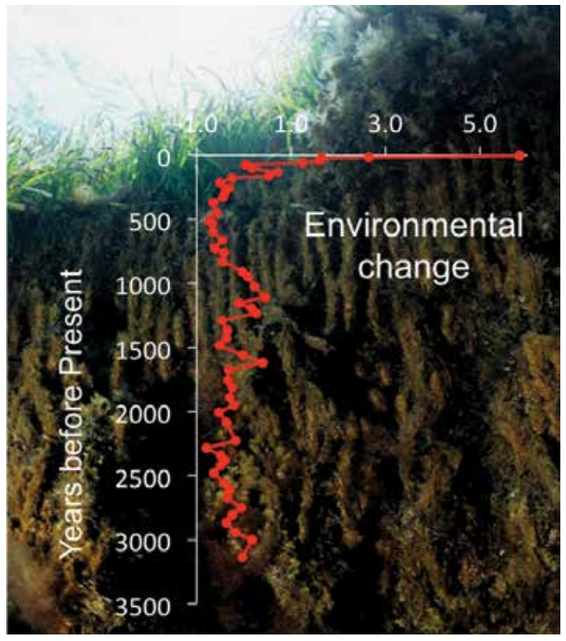
Figure 6: Multi-Dimensional Scaling (MDS) of the main algal species contributing to the differentiation of size classes and species of temperate kyphosids.





HIGHLIGHTS IN HUMAN IMPACTS OF ECOSYSTEMS PROCESSES

Western Australia's growing population and the massive development of infrastructure to support mineral exports are putting significant pressure onto the coastal environment. CMER has continued to lead research into the increasing range of human impacts in coastal marine systems. Research in this theme stress the importance of not only understanding coastal ecosystems' responses to human impacts, but also drawing on the immense value these systems offer to mitigate those impacts. Research into the damage to seagrass along Western Australia's coast with increasing human development are highlighted in this year's report.



A seagrass bank, with super-imposed profile of environmental change at different depths (= ages) in the seagrass sediment. The largest change occurred in the last 50 years.

SEAGRASS ARCHIVES REVEAL THE LONG-TERM DETERIORATION OF COASTAL ECOSYSTEMS

Seagrasses along Australia's coast have been devastated by human development but new research is shedding light on how and when that damage occurred. In a study recently published in the journal Global Change Biology, sediment cores taken from within seagrass meadows were used to reveal the loss of 80 per cent of the seagrass in one area in less than 30 years. From the 1960s until 1980s the seagrass meadows in Oyster Harbour, near Albany, Western Australia were decimated as a result of increased nutrients and deposited sediments associated with agricultural development and land clearing.

Researchers took core samples from seagrass meadows at Oyster Harbour by sinking two metre long pipes into the seafloor before extracting the core. The cores were taken back to the lab and analysed and provide a glimpse at more than 600 years of the meadows' history. The cores provide a detailed history of the seagrass meadows,including the cause of the massive loss of seagrass; huge increases in phosphorus entering the ecosystem from the 1960s onwards. Increases in nutrients in the marine environment can cause algal blooms, which soak up the light needed by seagrass and other marine organisms to survive. However this damage is not unique to Oyster Harbour; the loss of seagrass in Oyster Harbour reflects similar damage to marine ecosystems all around Australia's coast.

In Australia more than 80 per cent of the population lives along the coast and that's placed enormous stress on our coastal marine ecosystems, particularly from extensive land clearing, agriculture and coastal development. This has led to the death of seagrass, hampering their capacity to sequester CO2 and mitigate climate change. This research is providing insights to properly manage further environmental change, including from climate change.

The results from the study demonstrate the power of seagrass cores to show timelines of man-made pressures on estuaries and changes in the environment's condition. This information can be used to improve the capacity of scientists and environmental managers to understand, predict, and better manage ecological change in estuarine ecosystems. For example, in this case we were able to identify the level of phosphorus accumulation that was associated with large-scale damage during the 1960s, 70s and 80s. We will now be able to use that information as a guideline for future management of estuaries.

Figure 7: The ancient sediments under seagrass meadows act as an archive, revealing past environmental histories. a,b) Exposed seagrass reef (3 m high) showing the archive in the Mediterranean and Australia; c) Seagrass peat-like archive revealed in a core.

Figure 8: Temporal trends revealed in a *Posidonia australis* seagrass core from Albany (modified from 5). The vertical dotted lines indicate baseline conditions. The horizontal red lines indicate ecological regime shifts. The time course of ecological changes over the last 600 year shows two major phases of change compared to the baseline conditions (green and red shaded areas). In the first shift (green area) the seagrasses were still resilient but land clearing, agriculture and run-off led to higher fine sediments <0.125 mm and algal productivity (lower 13C values), as shown in the left and centre panels. In the second phase, from about 1950 onwards (pink area), cumulative stresses overcame the resilience of the seagrasses, resulting in 80% seagrass area loss. A threshold value of 150 mg g DW-1 of Phosphorous in sediments at the seagrass study site (i.e. target level) could be critical for the persistence of seagrasses.

Photo: A sea-snake swimming through a sparse seagrass meadow in the Exmouth Gulf.

POPULATION DYNAMICS OF TROPICAL SEAGRASS MEADOWS

The Pilbara region of Western Australia is a hub for industrial activity, particularly ports and infrastructure servicing the oil and gas and mining sector. Seagrasses are susceptible to dredging pressures but there is very limited information on the population dynamics of seagrasses in the region. Paul Lavery, Kathryn McMahon and Rosh McCallum from CMER, in collaboration with a team of CSIRO scientists led by Dr Mat Vanderklift, have been studying the seagrass meadows in the Pilbara over the last two years. The research has shown that the seagrass meadows of the Pilbara are far more variable than those in the neighbouring Gascoyne and the Kimberley regions. We have found that there is significant variation between sites in the amount of seagrass and the species present. Usually one to two species were present, but in some cases mixed meadows of up to six species were observed. In shallow meadows <5m deep, where we see changes over the year, the peak abundance occurs from November to February, and one species, *Halophila ovalis*, flowers at this time as well. We are using this information to propose the time of year when dredging will have the least impact on seagrass meadows.

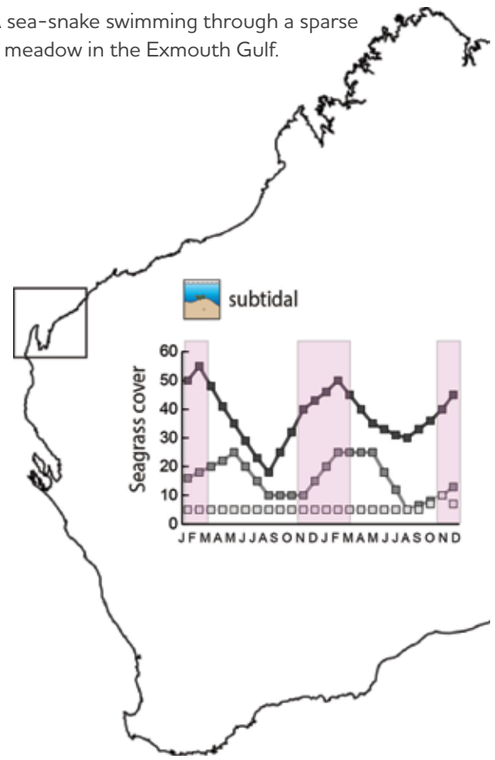


Figure 9: Patterns in seagrass cover at 3 sites in the Pilbara over two years from January to December. Pink bars indicate the time that flowering was observed for *Halophila ovalis*.

HIGHLIGHTS IN MARINE MICROBIAL ECOLOGY

While less visible than larger marine organisms, microbes compose between 50 and 90% of the biomass of oceans, and they are now recognised as key players within marine ecosystems. Current research on marine microbes within CMER is expanding rapidly and focusses on the role of prokaryotes in nitrogen cycling in seagrass meadows; biogeographical associations of microbes with seaweeds, corals and sponges; the role of microbes in inland saline wetlands and the diversity and function of microbial assemblages in the guts of herbivorous.

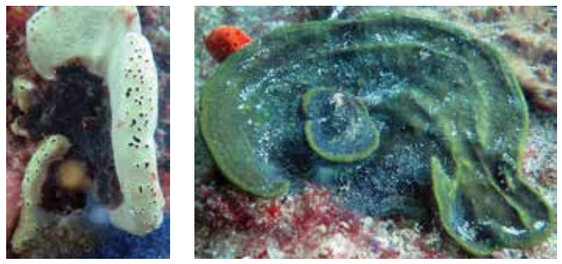
THE IMPACT OF RANGE SHIFTS ON THE STABILITY OF THE GASTROINTESTINAL MICROBIAL COMMUNITY OF THE TROPICAL HERBIVOROUS FISH SIGANUS FUSCECENS

Honours student, Ms Jackie Jones, together with Dr Megan Huggett and Dr Joey DiBattista (Curtin University) is involved in new research aimed at understanding the role of microbes in range-shifting herbivourous fish along the WA coastline. Climate-change has allowed the rabbitfish *Siganus fuscescens*, to expand its distribution from coral reefs in the north to macroalgal reefs in the south, where it has a different diet. The assemblage of microbes in a fishes gut (the gut microbiome) is essential to the health of herbivorous fish. Diet is a major factor determining the structure of the gut microbiome of vertebrates, and if this is also the case for rabbitfish it will impact individuals now living at the southern edge of the specie's range. Sequencing of the 16S rRNA gene has revealed different midgut and hindgut communities, dominated by Proteobacteria and an unclassified phyla in the midgut, and Fusobacteria, Proteobacteria and Firmicutes in the hindgut. Subsequent studies of *S. fuscescens* along West Australia showed that the gut microbiome changed with latitude, with a corresponding shift in the fatty acids found in the hindgut. The study is continuing with final results expected in 2016.

Dive officer Mr Rob Czarnik in ECU's research vessel, the Mistral, while supporting field work for the rabbitfish project in Coral Bay, Western Australia.

SPONGE MICROBIAL ASSOCIATIONS

Sponges are ecologically important and are a rich source of novel, biotechnologically relevant natural products with powerful biological activity. In some hard-substrate communities sponges dominate in terms of biomass and abundance and they stand out among organisms that are known to form close associations with marine microbes as they host extremely dense and diverse populations of microorganisms; up to 40% of sponge biomass is comprised of microbial cells. Dr Megan Huggett, in collaboration with Dr Jane Fromont (Western Australian Museum) and Dr Nicole Webster (Australian Institute of Marine Sciences) has been investigating the role of microbes in sponges along the West Australian Coast. They have discovered that the common calcareous sponge, *Leucetta prolifera*, is dominated by the cyanobacteria *Hormoscilla spongeliae*, which is likely to play a role in transfer of organic compounds to the sponge host. Their research has also revealed a strong influence of latitude on the common sponge *Cymbastela marshae*, with populations from Jurien Bay, Marmion Marine Park and Busselton comprised of distinct microbial assemblages.



The calcarean cyanosponge *Leucetta prolifera* (left) and the demosponge *Cymbastela marshae* (right) in Marmion Marine Park

The coralline algae *Amphiroa* in Marmion Marine Park, below the canopy forming seaweeds *Ecklonia* and *Sargassum*.

MICROBIAL COMMUNITIES ON CORALLINE ALGAE SHIFT UNDER FUTURE CLIMATE CHANGE REDUCING THEIR FACILITATION OF SEA URCHIN LARVAL SETTLEMENT

Settlement of larvae is a key life history stage for marine invertebrate, impacting reef structure and dynamics. Microbial communities associated with coralline algae are important in facilitating settlement of larvae of a range of organisms including corals, sea urchins and abalone. Despite this, few studies have addressed the impact that future environmental conditions on interactions between larvae of marine invertebrates and reef microbes, and none in temperate ecosystems. CMER researchers Dr Megan Huggett, Dr Kathryn McMahon and postgraduate student Ms Rachele Bernasconi exposed the temperate coralline alga *Amphiroa gracilis* to treatments representing future climate change scenarios. The algae became bleached and their photosynthesis were affected. At the same time, the microbial assemblage on the algae changed and settlement by larvae of the abundant sea urchin *Heliocidaris erythrogramma* was reduced. The experiments indicate that future environmental conditions will not only have a direct impact on algal physiology but will also reduce the ability of temperate reef microbes to facilitate settlement of some invertebrate larvae, with significant implications for reef biodiversity and function.

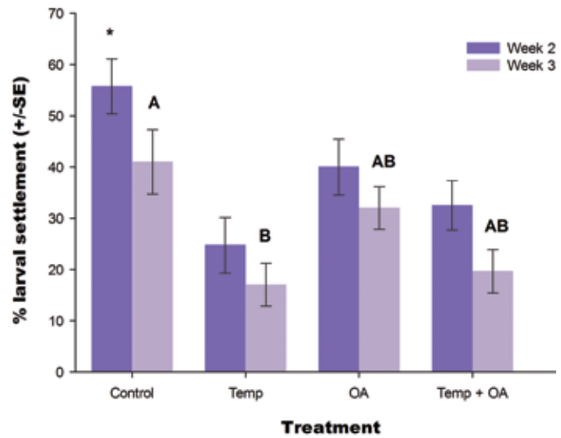


Figure 10: Settlement by larvae of the sea urchin *Heliocidaris erythrogramma* in response to coralline algae treated with increased temperature (Temp), ocean acidification (OA) or a combination of both (Temp + OA) in comparison to controls.

Edu, Oscar, Paul, and Miguel, ready to core the seagrass archives in the shallow areas of the Cabrera Island, Balearic Archipelago. Source: GAME

NEW PROJECTS

VASSE-WONNERUP INVESTIGATION NODE

Coastal wetland systems are highly susceptible to human disturbance particularly through nutrient inputs for agriculture in their catchments, loss of fringing vegetation, and changes to flow rates from the catchments and ocean. Understanding how these disturbances impact the environmental, social and economic values of coastal wetlands such as Ramsar values, natural coastal amenities and fisheries is critical for for designing management measures to mediate such impacts.

The Vasse-Wonnerup Wetland System is an important waterbird site in south-western Australia, supporting over 37,500 water birds, and has the largest regular breeding colony of Black Swan in the region. The system is recognized as a wetland of international importance under the Ramsar convention. Unfortunately, this important wetland still periodically receives high nutrient input from the surrounding catchment, made more problematic by limited exchange with the ocean due to the barriers at the entrance channels. The high nutrient loads and reduced flushing have stimulated extensive phytoplankton and macroalgal blooms resulting in large accumulations of detrital material in the sediments, which are likely to be contributing to fish kills, and other harmful environmental effects.

Understanding the main sources of nutrients and their influence on the overall functioning of the ecosystem is the primary aim of this research. Over the next 4 years the project will identify the different sources and sinks of nutrients and organic matter in the Vasse-Wonnerup Wetland System using a variety of approaches, such as biomarkers assessment and field-based experimental manipulations. The project aims to provide recommendations leading to water quality improvement in this important recreational region of south-western Western Australia. Specific aims are to identify the flow of nutrients and carbon between the potential sources of nutrients and the pool of nutrients in the wetland system; and identify the proportion of the allochthonous and autochthonous sources of carbon and nutrients (N and P) contributing to the wetland system's primary productivity.

The project is being carried out by CMER members in collaboration with the South West Catchments Council and researchers at Murdoch University and Southern Cross University as part of a larger multi-institutional and disciplinary program.

PALEOPARK: "MILLENARY CHANGES IN THE INSULAR SPANISH NATIONAL PARKS: PERTURBATIONS, RESILIENCE AND TRENDS AFTER THE SEAGRASS ARCHIVES"

PALEOPARK expands the very fruitful collaboration between CMER and the GAME (Group of Aquatic Macrophyte Ecology) team at the Spanish Research Council laboratory in Blanes. Globally, increasing urbanisation of coasts is resulting in disturbances and impacts. Conventional monitoring often fails to provide managers with the information they need to understand these impacts. Paleo-reconstructions offer an alternative approach, providing insights into the impacts and the ecosystem responses.

PALEOPARK is using seagrass sediment cores as paleo-archives, to reconstruct the dynamics of coastal and terrestrial ecosystems in two Spanish National Parks, highlighting interactions with natural and human disturbances. The information derived from the project will serve two main objectives: (i) providing the National Park managers with long data series of ecosystem condition over the last few thousands of years; and (ii) estimating the size and the dynamics of the massive carbon deposits under the *Posidonia oceanica* seagrass meadows. The objectives are being be achieved through the efforts of an international consortium of 25 researchers studying geological, chemical, micro-paleontological, molecular, genetic, palynological, and isotopic proxies, together with archaeological and historical information available on the Spanish Insular National Parks.

This research will help to highlight the amazing benefits that Mediterranean countries derive from this marine grass that only occurs in the coasts of the Mare Nostrum, and to reinforce the urgent need to establish management programs that will ensure its presence for future generations. The project will help to differentiate between human and natural impacts on these valuable ecosystems and will reveal how seagrasses respond to these changes, so that managers can develop appropriate strategies.

In June 2015 an enthusiastic international team of 12 researchers, post-docs, PhD students, and engineers worked side by side with the crew of the R/V García del Cid for ten days in the coves of Santa María and Es Port, in the Archipelago of Cabrera. Prof. Paul Lavery and Dr Oscar Serrano from CMER participated in the field trip. The research team performed multiple coring operations trying different techniques, both from the oceanographic vessel García del Cid and on SCUBA, to obtain long, continuous sediment cores of the seagrass bed. The R/V García del Cid and its experienced crew, were our home and our family for about a week, a warm group of people always ready to go beyond their duties. We came back with a valuable load of samples from the *Posidonia* meadows of the Cabrera National Park, with lots of lessons learned, and with our hearts full of the warmth of an unforgettable human experience. The sediment cores are being processed in Spain, and the ECU researchers are responsible for analysing some of the cores to decipher past, present and future change in coastal ecosystems.

An enthusiastic team of 12 people integrated by international researchers, post-docs, PhD students, and engineers has been working really hard, side by side with the crew of the R/V García del Cid, during ten days in the coves of Santa María and Es Port, in the Archipelago of Cabrera. Prof. Paul Lavery and Dr Oscar Serrano from the Centre for Marine Ecosystems Research at ECU participated in the field trip. The research team have performed multiple coring operations trying different techniques, both from the oceanographic vessel García del Cid and in SCUBA diving, to obtain long-continuous sediment cores of the seagrass bed. The R/V García del Cid and its experienced crew, has been our home and our family for about a week. They are not just a crew. They are a warm group of people always ready to go beyond their duties. We came back with a valuable load of samples from the *Posidonia* meadows of the Cabrera National Park, with lots of lessons learned, and with our hearts full of the warmth of an unforgettable human experience. The sediment cores are being processed in Spain, and the ECU researchers are responsible to analyse some of the cores to decipher past, present and future change in coastal ecosystems.

Celebrating the success of the PALEOPARK mission in the Cabrera Island. (From left to right) Paul Lavery, Oscar Serrano, Edu Serrano, Anna Thoran (behind), Ambra Milani (front), Nerea Piñeiro, Carmen Leiva, Miguel A. Mateo. Source: GAME

Some of the crew members before departure in the oceanographic vessel Garcia del Cid. Source: GAME

CARBON PRESERVATION IN SEAGRASS MEADOWS. MOHAMMAD ROZAIMI (PHD)

Seagrass meadows play an important role in the global carbon cycle by storing large amounts of carbon in their sediments. Recent scientific efforts have focused on valuing the carbon storage capacity of seagrass ecosystems. However, the robustness of these valuations can be questioned since there are still major knowledge gaps regarding the factors that influence the carbon storage capacity of seagrass meadows. We still do not fully understand how the species of seagrass or the nature of the environment in which they occur affect carbon accumulation in seagrass meadows. To address some of these information gaps, Rozaimi's PhD research aimed to: 1) provide new perspectives into the variability in carbon accumulation among seagrass meadows, with particular reference to *Posidonia australis* and *Halophila ovalis* meadows; and 2) understand the roles of sediment characteristics in controlling carbon preservation in seagrass ecosystems. To achieve these objectives, Rozaimi sampled sediment cores in estuarine and oceanic seagrass meadows around Australia. Detailed analyses of the cores mainly revolved around the determination of sedimentary organic carbon content. Other aspects of the sediments were analysed to account for variations in carbon content, including organic matter content, inorganic carbon content, stable carbon isotope composition of the organic matter, sediment dry bulk density and sediment grain-size composition. Selected cores were further analysed to determine their age, biochemical characteristics and microbial metabolism. Consequently, Rozaimi's thesis serves to bridge the fields of seagrass ecology and marine biogeochemistry. Rozaimi's thesis explores how the stocks of carbon preserved in seagrass sediments is affected by the seagrass species and by the habitat in which it occurs, thus exploring the role of species and habitat in the preservation and accumulation of organic carbon. Indeed, he characterised the forms of carbon that are preserved in seagrass sediments using NMR analysis,

Mohammad Rozaimi sampling seagrass sediment cores at Oyster Harbour (Albany, Western Australia) to examine their carbon sequestration capacity.

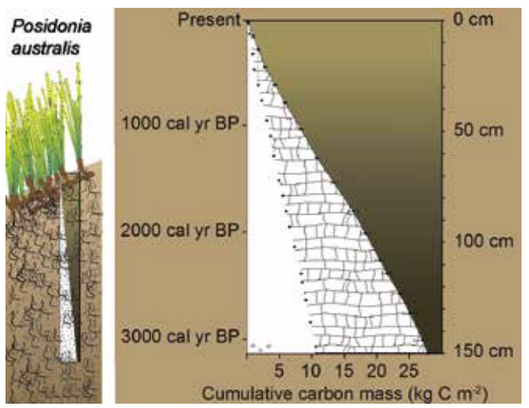


Figure 11: Accumulation of organic and inorganic carbon over 3000 years in *Posidonia australis* meadows at Botany Bay (Sydney, New South Wales).

Finally, his thesis reports on an experimental investigation which tested whether the exposure of deep sediments to oxic conditions (as occurs following disturbance) can cause the 'preserved' carbon to be remineralised. His integration presents a holistic picture of the carbon burial phenomenon in seagrass meadows and contributes to new insights in understanding the processes leading to carbon preservation in seagrass ecosystems.

Rozaimi's thesis demonstrates how the stocks of carbon preserved in seagrass sediments are affected by the seagrass species and by the degree of exposure of the meadow to wind and water movement. He characterised the forms of carbon that are preserved in seagrass sediments using NMR analysis, Finally, his thesis reports on an experimental investigation which tested whether the exposure of deep sediments to oxic conditions (as occurs following disturbance) can cause the 'preserved' carbon to be remineralised. His final dissertation presents a holistic picture of the carbon burial phenomenon in seagrass meadows and contributes new insights on the processes leading to carbon preservation in seagrass ecosystems.

HIGHLIGHTS ON STAFF

In 2015 CMER was extremely fortunate to welcome its newest Professor, Pere Masque. Pere had been working with CMER as an adjunct during late 2014 and into 2015, but in September was appointed the first of the Vice-Chancellor's new Research Professors.

PROFESSOR PERE MASQUÉ

Pere is the first of more than 20 new ECU Professorial Research Fellows to join the University and will establish Western Australia's first environmental radioactivity laboratory. Pere is a renowned expert in physics, environmental science and oceanography and his major research projects investigate environmental processes using radioactive isotopes as tracers. Among the areas of research that he applied these techniques are:

- Evaluating groundwater and associated nutrients discharge to the oceans;
- The role of the oceans in climate change as a source or sink of CO2;
- The potential for seagrass beds to offset climate change by absorbing CO2; and
- The impacts of radioactive waste materials in the environment.

The new laboratory will have the capacity to analyse radioisotopes with half-lives ranging from few days to thousands of years. It will have extensive applications in environmental, mining, agricultural and forestry industries and as well in fundamental research areas. Pere joined ECU and CMER from the Universitat Autònoma de Barcelona, where he was a Professor in the Department of Physics and the Environmental Science and Technology Institute. He is also an Adjunct Professor at the University of Western Australia's School of Physics and UWA Oceans Institute.

In welcoming Pere to ECU, Vice-Chancellor Professor Steve Chapman said he would strengthen the research capability of the University as well as benefiting the Western Australian community. Both those outcomes align perfectly with CMER's goals of undertaking relevant research for better management outcomes.

CMER MEMBERS: STAFF

ROB CZARNIK

After completion of a Post Graduate Diploma of Science (Biological Sciences) Rob was employed as a research assistant in CMER. Rob has since taken on the role of Field Safety and Support Officer where he provides expert advice and assistance to postgraduate students and staff on the preparation of Risk Analysis and Management Plans and ensures CMER operates under legislative, training and competency requirements. In addition, Rob is actively involved in the field operations of many of CMER's research projects.

MS NATASHA DUNHAM

After recently completing her Master's degree at Edith Cowan University Tash began working for the centre early this year. Her interest in coastal marine ecology focuses on research investigating the effect of climate change and increasing human activity have on these ecosystems. Tash is currently involved in the investigation on the effects of dredging specific to marine primary producers, part of a joint initiative with ECU, UWA and WAMSI.

DR MEGAN HUGGET

With more than a billion microorganisms per litre of seawater, the biodiversity of microbial communities and the functional roles that they play in the marine environment are enormously significant. Megan's research focuses on the function and diversity of marine microbes, and falls into two themes: prokaryote-eukaryote interactions in the marine environment and the function and diversity of bacterioplankton communities. She has been involved in studies of the genome content and architecture of bacterioplankton via whole genome sequencing projects, as well as investigating bacterioplankton diversity in response to a large storm event, and across coral atolls in the North-western Hawaiian Islands.

MS ROISIN MCCALLUMI

Roisin's role at CMER is part of a collaborative project between ECU, UWA and CSIRO, investigating the impacts of dredging on seagrasses in the north-west of Australia. Roisin joined CMER in 2013 after completing a Master's degree at Southern Cross University in Marine Science and Management. Her interest in marine ecology research encompasses the interactions between biogeochemistry of sediments and water, in particular seagrasses and macro algae. Roisin is also a representative for Work, Health and Safety at the centre and manages CMER's laboratory.

ASSOCIATE PROFESSOR GLENN HYNDES

Coastal marine and estuarine environments are highly complex systems prone to high levels of human disturbance resulting from the concentration of Australia's population along the coastal regions. It is, therefore, crucial to develop a high level of understanding of the complex ecological processes in these coastal environments. The movement of animal and plant material from one habitat to another forms an important process of habitat connectivity in the coastal, marine landscape. This forms the focus of Glenn's research activities. His studies have examined the trophic links among habitats using a combination of experimental and biomarker (stable isotopes and fatty acids) approaches to trace key food sources through the food web. Glenn's work has also examined the importance of different coastal habitats, particularly seagrasses, to fish communities, the ecosystem effects of consumers on shallow coastal biodiversity.

ASSOCIATE PROFESSOR UTE MUELLER

Geostatistical techniques were developed for the estimation and simulation of the spatial distribution of mineral reserves, but are equally applicable to other natural resources. Ute's research interests include the development and application of simulation and estimation of fisheries data.

PROFESSOR PAUL LAVERY

Paul's research focuses on benthic marine ecosystems and how they respond to human-induced pressures, particularly seagrass ecosystems. Currently, he has three major areas of research interest: (1) the use of seagrass sediments as environmental archives to reveal past environment conditions and their ability to capture and store atmospheric carbon, thereby offsetting some of the impacts of global CO2 emissions.; (2) The impact of dredging on seagrasses and other primary producer ecosystems; and (3) Connectivity and trophic subsidies among coastal marine ecosystems, using stable isotope and other biomarker techniques to understand how materials transported from one habitat support productivity in adjacent habitats of the impacts of global CO2 emissions.

CMER MEMBERS: STAFF

DR KATHRYN MCMAHON

Kathryn's main research area is coastal marine ecology, specifically focusing on seagrasses in both tropical and temperate environments following three main themes: human impacts in seagrass ecosystems; seagrass-grazing interactions; and phylogenetics. Her research into human impacts (e.g. nutrient enrichment, light reduction associated with dredging) has focused on developing ecophysiological tools to assess health or measure impacts. Secondly, with plant-grazing interactions Kathryn is interested in understanding the strategies plants use to cope with grazing, especially related to sexual reproduction. Thirdly, Kathryn's uses molecular tools to investigate the relationship of seagrass taxa.

DR OSCAR SERRANO GRAS

Oscar joined CMER in 2012 with over 7 years research expertise in marine ecology, palaeo-ecology and marine biogeochemical cycles. With a focus on carbon sequestration and paleo-ecological reconstruction from sedimentary deposits, Oscar's research includes investigating the capacity of seagrass ecosystems as a globally significant carbon sink, and the variability in carbon storage of seagrass habitats and between seagrass species. His research is largely centred on marine ecosystem response to climate change.

ADJUNCT STAFF

DR RAY MASINI

Ray is based at the Office of the Environmental Protection Authority. His research has focused on Western Australian marine ecosystems, with particular emphasis on the tropical arid ecosystems of the central- and north-west coasts. More recently this focus has moved north to the tropical Kimberley coast. His research interests include nutrient-effects, ecological modelling and environmental management strategy and policy formulation. Ray has been centrally involved in the planning and management of a range of multidisciplinary marine environmental studies around the State's 13,000 km coastline. Ray's interests also include knowledge transfer and application, particularly related to the interaction between research, environmental policy formulation and environmental management.

DR RUSS BABCOCK

Russ is based at CSIRO Marine and Atmospheric Research, and leads research to better understand how human activities influence coastal ecosystems such as kelp forests and coral reefs. Research programmes focus on issues such as fishing impacts and the effectiveness of marine reserves as conservation tools. Other projects have focused on the impacts of sedimentation on both temperate and coral reef ecosystems.

DR FERNANDO TUYA

Fernando's research is driven by the need to develop models that explain the patterns of organization of marine populations and communities from local to biogeographical scales. Fernando is particularly interested in ecological processes shaping temperate reefs, trophic linkages between reefs and adjacent seagrass meadows, effects of human perturbations on natural communities and the role of Marine Protected Areas in preserving marine biodiversity and fishery resources. He has contributed to the dissemination of the marine flora and fauna of the Atlantic Ocean through books and open-access monographs.

DR MAT VANDERKLIFT

Mat is a marine ecologist based at CSIRO Marine & Atmospheric Research. His research interests include ecological linkages between habitats, the use of stable isotopes to study trophic ecology, factors influencing the abundance of flora and fauna, the ecological importance of consumers (herbivores and carnivores) and the effects of human use of marine ecosystems

PROFESSOR DR MIGUEL-ANGEL MATEO

A lead researcher with the Spanish Council for Research (CEAB), Spain, Miguel's focus is on the ecology and biogeochemical cycles associated with seagrass-dominated ecosystems, long term carbon budgeting, palaeoecological approach to the ecosystem of *Posidonia spp* based on pluri-millenarian peat-like deposits, and aquatic macrophytes as bio-indicators for environmental assessments.

POSTGRADUATE RESEARCH STUDENTS

MARYAM ADOLAHPOUR (PhD)
Flow dynamics through seagrass meadows

ROZAIMI JAMALUDIN (PhD) COMPLETED
Flow dynamics through seagrass meadows

SIMONE STRYDOM (PhD)
Influence of light spectra (light quality) on the growth and development of seagrasses throughout their life history phases.

FLAVIA TARQUINIO (PhD)
Ecological role of prokaryotes associated to seagrass leaves and their contribution to the plant's nutrient requirement

ERIC AIDOO (PhD)
Spatial Modelling of Recreational Boat-Based Fishing in Western Australia

ANNA LAFRATTA (PhD)
Seagrass archives to reveal environmental history

NICOLE SAID (M.Sc)
The effects of temperature on photosynthesis in the seagrass *Halophila ovalis*.

JACQUELYN JONES
The impact of range shifts on the stability of the gastrointestinal microbial community of the tropical herbivorous fish *Siganus fuscecens*

RACHEL BERNASCONI (PhD)
Characterisation of coral-*Symbiodinium*-bacteria networks on different investigation levels (geographical, temporal and environmental)

ANDREW MACKEY (PhD) COMPLETED 2015
Flow Dynamics of isotopic baselines within a temperate coastal ecosyste m in relation to the surrounding biogeochemical environment.

MR ALDO TURCO (PhD)
Investigating the strength of herbivory pressure on seaweeds along a latitudinal gradient

EVA LEI (PhD)
Integrate various sources of data to assess the recreational fishery in Western Australia

PIERRE BOUVAIS (PhD)
Impact of dredging activities in north-western Australia on filter feeders assemblages.

CHARLIE PHELPS (MSc)
Determining the impact of future climate change on ecologically important macroalgae

FEDERICO VITELLI (PhD)
Causes and consequences of hybridisation of Angelfish.

PETER MALANCZAK (Masters) COMPLETED 2015
Relationships between spawning and recruitment of *Nematalosa vlaminghi* with hydrological characteristics within an estuary: can this species be used as an indicator of estuarine health?

UDHI HERNAWAN (PhD)
Genetic connectivity of the seagrass *Thalassia hemprichii* in the Indo-Australian Archipelago

CAITLIN RAE (MSc)
The role of ghost crabs (*Ocypode spp.*) as a potential vector for the trophic transfer of marine nutrients into terrestrial ecosystems in Western Australia.

CHARU LATA SINGH (PhD)
Role of microbial assemblages in affecting the nutrient cycling associated with wrack and in supporting the food webs of surf zones and sandy beaches.

CURRENT RESEARCH PROJECTS

TITLE	RESEARCHERS	FUNDING AGENCY
Resilience of seagrasses in tropical systems exposed to human impacts	McMahon	ECU Industry Collaboration Grant
Protection of coastal ecosystems and marine resource management	Lavery, Hyndes, McMahon, Kendrick, Oldham, Säwström, Ghisalberti (UWA)	Dept. of Innovation, Industry, Science and Research (DIISR)
Ecological connectivity of Kimberley marine communities - WAMSI Kimberley Research Program	McMahon	Aust. Institute of Marine Science (AIMS)
Coastal Carbon Biogeochemistry Cluster	Lavery, Serrano, Säwström	CSIRO
Effects of suspended sediment on filter feeders	Bouvais, Lavery	
Microbes, the missing link in Coastal Landscape Connectivity	Hyndes, Säwström	Dept. Parks and Wildlife (DpaW)
Sedimentation rates and history in the Vasse-Wonnerup estuaries	Serrano, Lavery	Dept. of Water
Improving the experiential design and statistical rigour for estimating state-wide recreational catch by boat based anglers	Lavery, Hyndes, Meuller, Graham	Dep. of Agriculture and Fisheries Western Australia (DAFWA)

TITLE	RESEARCHERS	FUNDING AGENCY
Integrated state-wide survey of recreational fishing: boat and shore based activity - a long term profile	Hyndes, Graham, Mueller	Dep. of Agriculture and Fisheries Western Australia (DAFWA)
Assessing the capacity of seagrass sediments to sequester carbon dioxide and metal pollution: past, present and future scenarios	Lavery, Serrano	Edith Cowan University (ECU)
A novel approach to assess pollution in coastal ecosystems		
Insights into carbon preservation in seagrass sediments: the microbial community structure and its role in carbon degradation and remineralisation	Jamaludin	Holsworth Wildlife Research Endowment
Beach Wrack Dynamics in Geraldton	Hyndes	Northern Agricultural Catchments Council (NACC)
Vasse-Wonnerup Investigation Node	Hyndes, McMahon	South West Catchment Council (SWCC)
Ghost crabs on mid-west beaches	Hyndes, Rae	Western Australia Landskills Inc
Defining thresholds and indicators of Primary Producer response to dredging related pressures	Lavery, McMahon, Strydom	Western Australian Marine Science Institution (WAMSI)
Undertaking Geographe Bay Keep Watch Seagrass monitoring program 2014	McMahon	Geocatch
SUMILEN: Advances in sampling techniques, biogeochemical characterization, and quantification of the millenary deposits of seagrasses: critical update of their role and value as biospheric carbon sinks	Mateo, Serrano, Lavery	Spanish Government; Ministry of Economy & Competition
Millenary changes in the ecosystems of insular National Parks: perturbations, resilience, and trends after the seagrass archives (PALEOPARK).	Mateo, Serrano, Lavery	Spanish Government; Ministry of Agriculture and the Natural Environment
Benthic primary productivity: production and herbivory of seagrasses, microalgae and microalgae	Christin Säwström, Glenn Hyndes, Gary Kendrick (UWA Mat Vanderklift (CSIRO) and Bonnie Laverock (UWA)	WAMSI Kimberley Node Project 2.2.4

PUBLICATIONS

JOURNALS

Aidoo, E. N., Mueller, U., Goovaerts, P., & Hyndes, G. A. (2015). Evaluation of geostatistical estimators and their applicability to characterise the spatial patterns of recreational fishing catch rates. *Fisheries Research*, 168, 20–32. http://doi.org/10.1016/j.fishres.2015.03.013

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CONFERENCE ATTENDANCE & PRESENTATIONS

5th American-Indonesian Kavli Frontiers of Science Symposium. Makassar Indonesia, July 27- Aug 1.
INVITED ATTENDEE: MEGAN HUGGETT
2015 Kavli Fellow of the National Academy of Sciences (NAS) | Australian Delegate

Group photo of the Australian Delegation to the Kavli Frontiers of Science Symposium

52nd Annual Australian Marine Sciences Association (AMSA) Conference 2015 'Estuaries to Oceans'.
Deakin University Geelong VIC, July 4-9.

Attendees: Roisin McCallum, Charlie Phelps, Simone Strydom, Kathryn McMahon, Paul Lavery

Coastal and Estuarine Research Federation 23rd Biennial Conference. Portland USA, 8-12 November 2015
Attendee: Glenn Hyndes

SEMINAR SERIES

PROF. PAUL LAVERY
Seagrass Blue-Carbon: an update on how much is out there and factors affecting the stocks

DR LOURDES LOPEZ MERINO
Glomalin in marine sediments reflects changes in terrestrial ecosystems health

DR OSCAR SERRANO
Novel approach to understand past and future dynamics in coastal ecosystems

DR MEGAN HUGGETT
Microbes help corals find real estate
1 Minute to Pitch It Research Week Presentation

PROF. PIERRE GOOVARTS
Geostatics in Practice

ROBERT NAIMAN
Incorporating Science into Fisheries Management: Scientific Advice, Decision-making and Restoration of the Columbia River (USA)

WORKSHOPS

12TH ANNUAL AUSTRALIAN MARINE SCIENCES ASSOCIATION (AMSA) STUDENT WORKSHOP.
Rottnest Island WA, Jun 25-26.
Presentations: Simone Strydom (awarded 2nd place)

25TH ANNUAL COMBINED BIOLOGICAL SCIENCES MEETING (CBSM)
University of Western Australia, Perth WA, Aug 28th.
Presenter: Megan Huggett

TROPICALISATION EFFECTS IN TEMPERATE SEAGRASS MEADOWS: CONSEQUENCES TO ECOSYSTEM PROCESSES AND SERVICES
Attendees: Glenn Hyndes, Paul Lavery, Kathryn McMahon, Adriane Verges, Ken Heck, E Harvey, G Kendrick, R Orth, A Pearce, M Vanderklift, T Wernberg, S Whiting, S Wilson

INTERNATIONAL VISITORS

PROFESSOR THOMAS SCHLACHER from the University of the Sunshine Coast (USC). Thomas leads the research team at USC's Research Futures Project - Water Sciences, as part of the Collaborative Research Projects (CRN).

PROFESSOR MATS BJÖRK from Stockholm University. Mats is known globally for his work on marine plant photosynthesis, much of which has been done in east Africa.
ARIANE ARIAS-ORTIZ – PhD Student at the Autonomous University of Barcelona

ASSOCIATE PROFESSOR MARTIN GULLSTROM - Senior Researcher with Department of Ecology, Environment and Plant Sciences at Stockholm University.

PROFESSOR PERE MASQUÉ from the Department of Physics and the Institute of Environmental Science and Technology at the Universitat Autònoma de Barcelona (Spain). Pere's work focuses on the application of radionuclide chemistry to environmental issues, particularly in oceans. Initially a an academic visitor, Pere joined the Centre in 2015 as a Professor and lead researcher.

DR LOURDES LOPEZ-MERINO is a Postdoctoral Research Fellow with the Department of Life Sciences, Brunel University, United Kingdom. Lourdes research focuses on the reconstruction of palaeoenvironmental changes and the impact of human activities on the landscape (agriculture, pastoral activities, mining activities) through pollen analysis from a combination of Holocene bog sequences and archaeological records.

LINKS

GOVERNMENT

Australian Institute of Marine Sciences (AIMS)
Department of Parks and Wildlife (WA)
Department of Fisheries (WA)
Department of Primary Industries, Victoria
Department of Transport (WA)
Great Barrier Reef Marine Park Authority
Department of Environmental and Heritage Protection (Queensland)
Swan River Trust (WA)
Northern Agricultural Catchment Council
Environmental Protection Authority (South Australia)
WA Marine Science Institute
South Australia Water
South Western Catchment Council (SWCC)

AUSTRALIAN RESEARCH

ARC-NZ Vegetation Function Network
Fisheries Research and Development Corporation
Tasmanian Aquaculture and Fisheries Institute
Western Australian Marine Sciences Institute (WAMSI)
CSIRO Marine and Atmospheric Research

- Wealth from Oceans Flagship (Coastal Carbon Biogeochemistry Cluster)
- Strategic Research Fund for the Marine Environment (SRFME)

INTERNATIONAL

Université de Nice, France
Université P Sabatier – Toulouse III, France
Otago University, New Zealand
CIIMAR, University of Porto, Portugal
Spanish Council for Scientific Research (CISC), Spain
Department of Ecology, Environment and Plant Sciences
Dauphin Island Sea Lab, USA
University of Florida, USA
University of South Alabama, USA
University of Virginia, USA
Autonomonous University of Barcelona, Spain
University of Satiago, Spain
Helmholtz Centre for Ocean Research (Geomar) and Silversea Marine Cruises
UKM (National University of Malaysia)

INDUSTRY

Chevron
Oceanica Consulting Pty Ltd
Woodside Oil and Gas
Hydrobiology QLD Ltd Pty

AUSTRALIAN UNIVERSITIES AND SCHOOLS

Albany Senior High School
Griffith University
James Cook University
Murdoch University
The University of New South Wales
The University of Queensland
The University of Western Australia
University of Technology, Sydney
Southern Cross University, NSW
University of Queensland

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