Reef Conservation UK
Saturday 1st December 2018

09:00 Registration opens

09:30 Welcome address

09:35 Plenary speaker I

09:35	*Christina Hicks*	Coral reef conservation for peopled seas	*Lancaster University*

The social sciences have been largely absent in coral reef conservation and management, yet they have a lot to offer. Societies and the environments in which they co-exist are inextricably linked and the relationships people form with nature are complex, dynamic, and contextual. Understanding and managing these relationships requires sustained engagement with the depth and breadth of the social sciences. Here I present work that draws on the social sciences to understand marine ecosystem changes. I highlight how rapid changes in underlying social drivers, such as markets, technological innovations, and polices often precede ecosystem shifts. However, managing social drivers requires an understanding that the benefits people gain from nature are socially differentiated, and dependent on a range of social and political mechanisms, such as wealth, knowledge, and status, rather than the underlying ecology. Sustaining coral reefs in this changing environmental and economic climate will involve moving towards a deeper engagement with the social sciences. Such progress will reveal that many of our greatest environmental challenges are exacerbated by the ways in which we have viewed human environment relationships, and sought to address emerging environmental challenges. For example, when we view fish as a source of income or protein, we fail to distinguish characteristics and focus on limitless benefits. However, when we view fish as contributing to social, cultural, or nutritional status, a far more nuanced picture emerges, that is focused on satisfying needs. Here I suggest that developing socially and nutritionally sensitive fisheries has the potential to satisfy needs while reducing effort.

10:05 Session I: Ecosystem function on reefs

	Speaker	***Presentation title***	***Institution***
10:05	*Holly East*	Reef Ecology – Reef island connectivity on Huvadhu Atoll Rim, Maldives	*Northumbria University*

Coral reef islands are regarded among the world's most vulnerable environments to climate change as they are low-lying (typically <3 m above mean sea level) and formed entirely of sediment produced by organisms in the adjacent reef communities. Understanding the links between reef ecology and reef island building is therefore crucial for assessing future island resilience. This is a particular priority for atoll nations where reef islands provide the only habitable land. Here, we present a holistic study of reef ecology-reef island linkages within a section of Huvadhu Atoll rim. This is the first study of reef-to-island connectivity to be undertaken on a Maldivian atoll rim, despite the fact that the rim island settings host the majority of the nation's population (89%). Detailed ecological surveys were undertaken to quantify rates of sediment production, and connectivity was assessed by examining links with island building processes (using island cores, Ground Penetrating Radar and radiometric dating). Estimated annual sediment production was 382,000 kg yr-1 across an area of 1.3 km2. Sediment production rates ranged from 0.05 kg m-2 yr-1 in the oceanward sand zone to 0.84 kg m-2 yr-1 on the lagoonward reef crest. Marine, beach and island sediments were dominated by sand-grade coral with excavating parrotfish identified as the dominant sediment producers, accounting for 79.4% of the total annual production. We therefore highlight the role of excavator parrotfish as major biophysical engineers in the formation and maintenance of Maldivian reef islands. In addition, we find links between the spatial distribution of excavator parrotfish and the long-term patterns of reef island accretion. Any shifts in excavator parrotfish abundance and spatial distribution could thus have a critical impact upon reef island resilience in the face of future environmental change.

10:20	*Rebecca Daniel/Jessica Kalisiak*	Transfer of a microplastic-associated pesticide (DCMU) in the marine food web	*University of Essex*

The ingestion of microplastics (MPs) has adverse effects on the health of many marine organisms. Recent studies demonstrate that MPs adsorb pollutants from the environment, exacerbating the risk to organisms by increasing pollutant bioavailability. The herbicide DCMU was sorbed onto polystyrene MPs (~2mm2 or 40-48 µm) and the effect of their ingestion was quantified using

imaging fluorometry with the tropical sea anemone Aiptasia cf. pallida *or grazing experiments with nauplii of the brine shrimp* Artemia salina*, feeding on* Thalassiosira weissflogii *phytoplankton.* A. salina *containing ingested DCMU-MPs were repeatedly offered to Aiptasia anemones over four days to determine the potential for MPs to transfer to and biomagnify sorbed pollutants in higher trophic levels. Photosynthetic efficiency (Fv/Fm) of anemones that directly ingested DCMU-sorbed MPs significantly decreased by 29% from 0.67 to 0.47 1-h post ingestion. Ingestion rate of* A. salina *decreased by 59% with untreated, and 38% with DCMU-treated microplastics. The lesser effect on grazing of DCMU-treated MPs may result from the effects of DCMU on algal prey. Over the 4-d biomagnification experiment, Fv/Fm significantly declined by 14% on the second day, however, anemones returned to normal photosynthetic efficiency 24-h later. This study demonstrates the direct effect of MPs on A. salina, and highlights the detrimental effects MP-associated pesticides can have on both algae and anemones. It suggests that MPs enhance the transfer of pollutants in marine food webs, which may act as an additional stressor on already fragile reef systems. These results call for further research on the current concentrations of both MPs and pesticides in tropical reef environments, particularly as coral reefs are a major contributor to the economy of coastal countries in some of the most economically deprived areas in the world.*

10:35	*Katie Dunkley*	Within and between species diversity influences the dynamics of cleaner-client interactions in the Caribbean	*Cardiff University*

*Through the removal of parasites, dead skin and mucus from the bodies of visiting reef fish (clients), cleaner fish provide a significant ecosystem function on coral reefs. What regulates and maintains these between species beneficial interactions is however poorly understood, as cleaning interactions are inherently complex and dynamic. On a reef, different species can act as cleaners and many fish species can interact as clients. Therefore, this means that cleaner-client interactions often involve multiple asymmetric partners, and what is not clear, is how this diversity influences cleaning outcomes. By comparing the cleaning behaviours of the predominant Caribbean cleaner, the sharknose goby (*Elacatinus evelynae*), to the part-time cleaner fish, the blueheaded wrasse (*Thalassoma bifasciatum*), we found that the part-time cleaners were more selective and opportunistic in their cleaning behaviour than the full-time sharknose goby cleaners; bluehead wrasse predominantly cleaned selected individuals within three surgeonfish species. In addition to between species differences, individuals within species can also consistently vary in their behaviour, and by quantifying sharknose goby personality traits (activity, boldness and exploration) in the field, we also found that these within species variations were associated with cleaner-client interactions; boldness and activity behaviour were significantly related to posing by clients and cleaning, respectively. Within species differences of cleaners also influenced cleaning and posing of particular client types (functional group, body size and trophic level). Together, we show that within and between species diversity can influence who interacts with who and how, suggesting that partner diversity can have strong consequences on cleaning interaction outcomes. This work is uniquely placed within a long-term 8 year data set on cleaner-client interactions, collected from a coral reef in Tobago and aids in determining factors that can influence the dynamics and pervasiveness of cleaning interactions.*

10:50 Speed talk	*Robert Semmler*	Dietary flexibility of generalist and specialist corallivores following coral bleaching	*Lancaster University*

With large-scale bleaching events becoming more frequent, the future state of the world's coral reefs will be characterized by coral mortality, and a shift to slower growing, thermally-tolerant coral species. For corallivorous fish like butterflyfishes (Chaetodon sp.), these changes mean both an overall reduction in food availability, and a change in the specific food items available. In response, butterflyfish may show significant foraging plasticity, expanding their dietary breadth to include other food items. Though not always co-occurring, there is thought to be a connection between plasticity exhibited in a particular behaviour and generalism within that aspect of an animal's niche. While plasticity in diet choice can be difficult to observe in the natural world, and doing so can rely on being in the right place at the right time, dietary generalism is much more readily seen. This research seeks to estimate the level of dietary flexibility exhibited by different species of butterflyfish, and to test the extent to which dietary generalism predicts plasticity in diet choice. This is done with a large dataset of butterflyfish foraging behaviour collected in Iriomote Japan, observed before a bleaching event, and at one and two years following. This work sheds further insight on the worldwide decline of specialist species. Specialist species, through still debated means, are less capable of withstanding disturbance events. It is possible that one reason for this is pattern is behavioural inflexibility. If a disturbance causes habitat or food conditions change rapidly, such as coral-bleaching, then specialist species may be less likely to alter their behaviour to better suit new conditions.

10:55 Morning break & poster session (see below for poster abstracts)

11:40 Session II: Climate change and reefs

Speaker	*Presentation title*	*Institution*
11:40 *Sebastian Hennige*	Will we lose the reefs of the deep (and how will we know)?	*University of Edinburgh*

Cold-water coral reefs, such as those found off the west coast of the UK, are at threat from ocean acidification, increases in temperature and deoxygenation. While tools are well developed for predicting the risk of tropical coral bleaching, there is no

similar tool, or even routine measurements, that currently exist to assess cold-water coral reef health or degradation. Of the 'triple stressors', CWCs are at particular risk from ocean acidification due to their depth range and their proximity to the aragonite (calcium carbonate) saturation horizon (ASH). While previous studies have focussed on how the live coral will fare in projected future conditions, the structural integrity of the dead coral, which makes up the majority of CWC reef habitat and provides habitat for secondary biodiversity, is key when considering the future biodiversity provision of CWC reefs. If reef habitat complexity decreases, both the high biodiversity and carbon sequestration potential of the ecosystem will significantly decline. Currently, environmental impacts on habitat structure are not understood to an extent that allows risk analysis of CWC habitat degradation in a changing ocean. Here we present research on the skeletal mechanical properties of CWCs, including microindentation and synchrotron radiation computed tomography data, and consider how this may be integrated into autonomous characterisation of deep-sea reef structures and site biogeochemistry, to shape a metric through which we can assess CWC reef health of the future.

11:55	*Heather Baxter*	Global trends in coral bleaching over the past four centuries	*University of Glasgow*

Regular observational monitoring of coral bleaching events began in the late 1970s, prior to which very little is known about their prevalence and frequency. The first observed global mass bleaching event occurred in 1998; 20 years on there have been two more, causing major concern over the survival of coral reefs. To understand the future of coral reefs under different climate scenarios, historical records of bleaching, both pre- and post-industrialisation are needed. Here, we use skeletal extension rates of 258 coral cores from 17 countries and 4 realms (Tropical Atlantic, Western, Central and Eastern Indo-Pacific) and sea surface temperature, to extend the observational bleaching record by reconstructing bleaching events and patterns over four centuries. The earliest evidence of bleaching, based on available skeletal extension rates from each realm, occurred in 1647 (Central Indo-Pacific), 1783 (Tropical Atlantic) and 1906 (Western Indo-Pacific). Research on spatial and temporal patterns of mass bleaching in the Anthropocene has shown that 75% of 100 globally distributed reefs were affected by the 2015-6 bleaching event. Here we demonstrate that globally there has been a decrease in bleaching events from 6% to 4%, between 1837 – 1964. However, between 1964 – 2012 bleaching has increased from 4% to 7%. . Our results also show species-level variation in bleaching impact, for example the percentage of Porites sp. that bleached during 1998 varied from 26 % (Tropical Northwestern Pacific) to 43% (Northeast Australian Shelf). Spatial scales and distribution, as well as local adaptation and acclimatisation could be responsible for the differences in recorded bleaching prevalence presented in this study. More frequent and intense mass bleaching events are predicted in the future. Here we present coral bleaching trajectories utilising the reconstructed bleaching history from each ecoregion, to establish whether corals will be able to survive in a warmer world.

12:10	*Adele Dixon*	Combining climate change and ecological response to assess local reef vulnerability	*University of Leeds*

Ocean warming is causing worldwide deterioration of coral reef ecosystems but there is uncertainty regarding the local-scale spatial variation in climate change and the differences in the ecological response to rising temperatures between reef sites. This study uses statistical downscaling at 0.01° resolution to convert the coarse-scale sea surface temperature data simulated by general circulation models to reef site scale in the Coral Triangle. The high resolution projections are used to calculate a thermal stress index, which is input to the first model in coral reef research to predict local-scale changes in hard coral cover based on historical responses to site-specific thermal stress. Combining the level of climate exposure with the ecological response demonstrates considerable small-scale spatial variation in coral reef vulnerability that cannot be attributed to differences in thermal stress alone. The time taken for hard coral cover to decline to 0% with increasing thermal stress differs between reef sites. Highly vulnerable sites suffer rapid declines but are not always those that experience the highest thermal stress. Many sites in the North Sabah region of Malaysia decline to 0% before those in North Sarawak, despite experiencing only 75% of the thermal stress. Vulnerability at these sites can be underestimated where vulnerability is determined only by climate exposure, resulting in large investments in reefs that are unlikely to survive. While assessments of coral reef futures must consider the small-scale spatial variation in climate change, the results cannot inform conservation strategies without the consideration of ecological sensitivity. The identification of high and low vulnerability sites provides a foundation for further research into the varying factors affecting vulnerability under changing conditions at closely located coral reefs.

12:25	*Casey Benkwitt*	Seabird nutrient subsidies alter response of coral reefs to bleaching events	*Lancaster University*

Nutrients from seabirds nesting on oceanic islands enhance the productivity and functioning of adjacent coral reefs. However, coral bleaching events are increasing in frequency and intensity, and it is unknown whether these nutrient subsidies affect the response of coral reefs to mass bleaching events or whether the benefits of these nutrients persist following bleaching. To answer these questions, we surveyed benthic organisms and fishes around islands with seabirds and nearby islands without seabirds due to the presence of invasive rats. Surveys were conducted in the Chagos Archipelago, Indian Ocean immediately before the 2015-2016 mass bleaching event and in 2018, two years following the bleaching event. Regardless of the presence of seabirds, relative coral cover declined by 32%. However, there was a post-bleaching shift in benthic community structure around islands with seabirds that did not occur around islands with invasive rats. This shift was characterised by increases in two types of calcareous algae (crustose coralline algae [CCA] and Halimeda spp.) around islands with seabirds. All feeding groups of fishes had higher starting biomass around islands with seabirds, but only herbivores and piscivores sustained this higher biomass following the bleaching event. Coral-dependent fishes experienced the greatest losses, such that following bleaching there was no longer a difference in biomass of corallivores and planktivores between island types. Even though seabird nutrients did not enhance

community-wide resistance to bleaching, they may still promote recovery of these reefs through their positive influence on CCA and herbivorous fishes.

12:40 Speed talk	*James Guest*	CORALASSIST: Assisting coral reef survival in the face of climate change.	*Newcastle University*

Dramatic changes to coral reefs are inevitable in the face of climate change because corals are highly vulnerable to changes in temperature. Corals have the capacity to adapt, but it is unclear whether rates of adaptation are sufficient to cope with current rates of change. As a result, innovative approaches to conservation of corals are now being seriously considered. These include generation of coral genotypes preadapted to higher temperatures via selective breeding and assisted gene flow (AGF), i.e., deliberate movement of individuals or gametes within and between populations. Corals reefs provide an excellent model for testing the feasibility of selective breeding and AGF because reef building corals: i) provide much of the habitat complexity on reefs; and ii) show considerable variation in thermal tolerance, even within populations. Selective breeding and AGF involve certain risks for the fitness of recipient populations. For example, there may be resource trade-offs between adaptive traits, furthermore, it is not known if selected traits are heritable over multiple generations. Therefore, considerable research is still needed before selective breeding and AGF can be implemented as conservation tools. CORALASSIST is a 5-year, European Research Council funded project that spans the disciplines of evolutionary biology, restoration ecology, microbiology and proteomics to examine the role that selective breeding and AGF can play in sustaining biodiversity and ecosystem services in the face of climate change. During 2017 and 2018, the CORALASSIST team began work at the Palau International Coral Reef Center (PICRC). Our main aims were to examine the extent of trade-offs between thermal tolerance and the potential for long-term heritability of thermal tolerance in a range of coral species with different life-history strategies. During this talk we will introduce this ground breaking project, discuss the rationale for our research and present results from field work carried out during 2017-2018.

12:45 Speed talk	*Philippe Laissue*	Symbiont expulsion and polyp contraction: Light-induced stress reactions in reef-building corals	*University of Essex*

Reef-building corals are the key ecosystem architects of the most biodiverse marine ecosystem. Despite their importance and much research effort, there are wide gaps in our understanding of their fundamental biology. We need a better understanding of larval settlement and development, skeletogenesis, interactions with pathogens and symbionts, and how this biology interacts with environmental change such as elevated temperatures and ocean acidification.

Live fluorescence microscopy is a potent approach to investigate the behaviour and development of corals at high resolution. It can reveal the dynamic interaction of a reef-building coral's three main components – coral tissue, symbiotic algae and calcified skeleton However, live imaging has been little explored to date, as it comes with several challenges: Reef-building corals grow as large colonies, have a hard, opaque skeleton with complex three-dimensional architecture, and are not genetically tractable, while strong autofluorescence often precludes the use of live dyes. Crucially, many species are highly photosensitive and require a low-light imaging approach. Imaging such processes and interactions in the same coral sample requires very low phototoxicity, if they are to be followed over long time periods, at high spatial, spectral and temporal resolution, and in three spatial dimensions.

We here show light-dependent behaviour in the reef-building coral Acropora muricata *by using a custom-made light-sheet fluorescence microscope for large, photosensitive samples. The emergence of* Acropora muricata *polyps depends on the power and intensity of the light. We quantify polyp emergence in different conditions, and show how this demarcates a 'safe' imaging range with minimal to non-measurable phototoxic effects. Exceeding this range results in changes in fluorescence intensity of two fluorophores: endogenous GFP in the coral tissue, and chlorophyll in the endosymbiotic algae. For the first time, we report how increased exposure leads to the expulsion of the coral's endosymbiontic algae, a fundamental process of coral bleaching. Finally, we demonstrate the complete loss of tissue integrity at high exposure levels.*

12:50 Speed talk	*Alice Tagliati*	Ecotoxicology of mineral-based sunscreen on corals in a changing ocean	*Heriot-Watt University*

While several studies have recently demonstrated the toxicity of chemical sunscreen compounds on tropical corals, the impacts of mineral sunscreens (which form the basis of many 'reef-safe' formulas) and how any detected impacts may change under projected future warming, has not yet been studied. Here we present an integrated view of the effects of a custom-made sunscreen lotion containing titanium dioxide nanoparticles (nTiO2) as a UV-filter on two coral species (one heat tolerant and one heat sensitive) and the sea anemone Exaiptasia pallida*, under present and projected future ocean warming conditions. Respiration, photosynthetic efficiency, symbiont density, chlorophyll a concentrations and HSP70 and HSP90 gene expression were evaluated at multiple timepoints under both ambient and elevated temperature conditions. Our previous work on isolated Symbiodinium indicated that toxicity of mineral sunscreens are likely driven by the oil ingredients in the cream, which are used to disperse the nanoparticles. We therefore conducted additional studies of nTiO2-sunscreen and filter-free formulations of sunscreen on the coral model* Exaiptasia pallida*. Formulations lacking nTiO2 caused a concentration-dependent inhibition of photosynthetic efficiency comparable to sunscreen with the same composition but with nTiO2 as UV-filters. The mineral sunscreen ingredients induced stress in both corals and sea anemones, and this was worsened by elevated temperatures. This indicates that sunscreen exposure may exacerbate the bleaching response of corals at higher temperatures, potentially leading to higher instances of bleaching at tourist coral reef locations. Our results indicate that sunscreen toxicity is not due to UV-filters alone, and highlights the importance of taking into account the emollient and emulsifier ingredients in addition to UV filters when developing environmentally friendly sunscreens.*

12:55 Lunch break & poster session

14:15 Plenary speaker II

14:15	*Cecilia Guerrero*	Women entrepreneurs in conservation: lionfish jewellery as an alternative livelihood in Belize	*Blue Ventures*

*First sighted on an offshore reef in 2008, invasive Indo-Pacific lionfish (*Pterois volitans*) are now found throughout Belize's waters. As voracious predators that feed on juvenile fish and small invertebrates, uncontrolled populations of invasive lionfish threaten Belize's fisheries productivity, and in turn coastal fishing communities and their livelihoods. Recognising the opportunity to marry invasive lionfish control with community development and gender empowerment, in 2015, marine conservation organisation Blue Ventures provided training to nineteen Belizean women, and subsequently supported the establishment of the Belize Lionfish Jewellery Group "Belioness". Structured as a member-owned social enterprise, Belioness aims to collectively address the environmental and economic impacts of the lionfish invasion, while building the capacity of its members in business management, improving the livelihoods of their families, and increasing the resilience of their communities to environmental change. Interviews conducted in 2017 with members showed that financial independence was the most frequently cited benefit of participation in the group, as well as gaining the respect of their families and peers. However, the group faces many challenges, including limited financial resources, varying educational backgrounds, and limited computer and business experience. Further development of their professional skills, along with exchange workshops with other successful women's groups, will help to address these barriers.*

14:35 Session III: Reef management approaches

	Speaker	***Presentation title***	***Institution***
14:35	*Dan Exton*	Artisanal fish fences pose a unique threat to coral reef and seagrass fisheries	*Operation Wallacea*

There is widespread urgency to achieve sustainability in small-scale tropical coastal fisheries. The multi-gear nature of these fisheries means restrictions on gear usage, particularly those deemed most damaging, are considered an important management tool. Yet individual gear types express characteristics that span ecology, economics and the social sciences, and to fully understand their true impact they should be viewed beyond the narrow perspective of being visibly destructive. Here, we apply this thinking to artisanal fish fences, and argue that their underpinning mechanisms demonstrate a highly impacting nature that requires urgent management attention. Despite being largely unstudied, we demonstrate their widespread use over two ocean basins, before presenting a 15-year case study from Kaledupa Island (Wakatobi National Park, Indonesia). Local fish fence effort was shown to increase significantly, culminating in a combined fence length of 27km around the island's 60km coastline. Fish fences are designed to take advantage of natural fish movements, and a semi-permanent barrier encompassing ca. 50% of an island's coast will severely disrupt vital ecological connectivity. Monitoring of catches revealed not only a 70% decrease in catch per unit effort (CPUE) and the exploitation of 251 fish species (44% of all species recorded locally), but also a 400% increase in the proportion of juveniles, reaching 36% of total catches and 90% for species that mature >20cm. Locally, fence owners remove surrounding seagrass beds by cutting or using poison, creating an ecological edge effect, while the fences themselves are typically constructed using mangrove wood. Socially, fish fences assume property rights in an otherwise open access fishery, while the bioeconomics of their high-investment but low-effort nature could exacerbate overfishing. We therefore call on managers to target gear restrictions towards artisanal fish fences, as this will likely lead to significant benefits to both small-scale fisheries sustainability and ecosystem resilience.

14:50	*Rebecca Short*	Disentangling the net: The socio-ecological dynamics of mosquito net fishing	*Imperial College London*

Recognition that mosquito nets, largely handed out for free in efforts to control malaria, are increasingly used as fishing gear is widespread in the media. Mosquito net fishing (MNF) has been condemned as an unsustainable threat to food security and biodiversity due to its indiscriminate nature. However, despite a number of countries banning the activity, there has been almost no empirical investigation of the impacts or drivers of MNF. In this study I conduct the first holistic investigation in to MNF, using a socio-ecological systems approach to characterise MNF as it relates to relevant Sustainable Development Goals.

I will review the relevant theories underpinning assumptions of negative social, ecological and health impacts of MNF in a conceptual framework, discussing potential for significant positive impacts in terms of food and nutrition security, livelihoods and social equity. I also present the first global assessment of the prevalence and characteristics of MNF, which highlights the widespread nature of the issue before focusing on a case study in Cabo Delgado, Mozambique to test both entrenched and newly presented theories on the drivers and impacts of MNF in a coral reef fishery.

Using a rapid assessment of fish landings I broadly assess the likely impact of MNF on catches of other gears and potential for biodiversity impacts. A distinct gender divide is discovered in MNF deployment methods, whereby a predominantly androcentric method shows potential for negative impacts on other gears but a predominantly gynocentric method shows little resource overlap. I then use a household survey to investigate the food security and livelihoods contributions of MNF in light of these

contradictory impacts. MNF is shown to be an important part of household livelihood profiles and multiple adaptive strategies, but particularly for weathering starvation periods in these mixed agriculture and fishing communities.

The research presented legitimises concern over MNF sustainability but highlights the recklessness of basing management on broad, unsubstantiated assumptions of both drivers and impacts. I also demonstrate opportunities for MNF to enhance wellbeing and discuss consequent implications for international policy and local management, suggesting that enforcement policies are ineffective.

15:05	*Laura La Beur*	Baseline assessment of marine debris and microplastics in the East Mingulay MPA to determine good environmental status	*University of Edinburgh*

As public awareness around the issue of marine litter and microplastics increases, so do public and private sector measures to reduce waste in the ocean. However, the extent of marine litter and microplastic (ranging from 0.2 mm to 0.5 mm) occurrence across ocean biomes and species remains poorly characterized, particularly in remote difficult to access places such as the deep ocean, making it challenging to assess where spatial management is needed and what measures would help achieve this. For example, the United Kingdom declared large knowledge gaps for the seafloor environment and a lack of baseline values to help set targets towards implementing the European Union's Marine Strategy Framework Directive (MFSD) that sets out to ensure Good Environmental Status (GES) of European waters by 2020. The MFSD establishes 11 descriptors to assess GES, this study focuses on Descriptor 10: that marine litter does not cause harm. The present study is the first assessment of marine litter and microplastics in a continental shelf marine protected area (MPA) in UK waters. Extent of marine litter was quantified at two (Mingulay and Banana) cold-water coral reefs in the East Mingulay MPA (Sea of the Hebrides) through systematic reviews of seven research expedition reports from 2003 to 2012 and annotating 41 hours of video surveys conducted in 2012. Reviews of expedition reports resulted in 6 recorded instances of litter out of 217 benthic stations. In every case the litter was fishing related; nets, rope, gear and plastic tarpaulin. Microscopic analysis of trypsin-digested gut contents from benthic reef macrofauna (n=112) showed 9% had ingested microplastics, all within the 0.2 - 0.5mm size fraction. Ingestion differences in microplastic occurrence were observed across feeding guilds, with microplastics observed more frequently in suspension and filter-feeders. Besides establishing a baseline assessment of marine litter and microplastics in this MPA, the approach demonstrates the utility of using historic data and specimens collected for other purposes to expand the geographic and ecosystem coverage for GES assessments.

15:20	*Max Bodmer*	Restoration of the long-spined sea urchin, *Diadema antillarum*, to Caribbean coral reefs	*Operation Wallacea*

Diadema antillarum *is a keystone herbivore on Caribbean coral reefs. When at densities >1m-2 they remove the entire daily net growth of macroalgae and bias the outcome of space competition in favour of hard coral. In January 1983, an unknown water-borne pathogen spread throughout the Caribbean and reduced populations by 95-99%. Mass-mortality is associated with the onset of macroalgae phase-shifts that drastically reduced hard coral cover and structural complexity. Today, mean* D. antillarum *population densities of 0.01m-2 remain two orders of magnitude lower than prior to mass-mortality, and* D. antillarum *restoration remains a priority. We studied the ecology of* D. antillarum *at reefs off the north coast of Honduras. With hard coral cover of ca. 62% and D. antillarum densities >2m-2, Banco Capiro may be one of the healthiest reefs in the Caribbean. Comparison of Banco Capiro to nearby 'typical' reefs around the island of Utila, has shown that populations remain supressed because processes of reef flattening have created a dearth of predation refugia. We provide experimental evidence that artificial reefs facilitate a doubling of* D. antillarum *populations on a degraded Caribbean reef within just 24 months, and increases in urchin populations suppress macroalgal growth and encourage hard coral expansion.*

15:35 Speed talk	*Chloe Shute*	Positive effects of long term, large-scale coral reef restoration prevails beyond natural disturbances	*Nature Seychelles*

The widespread bleaching event in 1998 caused significant disturbance to coral reefs within the Western Indian Ocean, resulting in up to 98 % coral mortality within the Seychelles. In 2011, a large-scale coral reef restoration project was implemented to facilitate reef recovery and enhance ecosystem services within the Cousin Island Special Reserve. Between November 2011 and June 2014, a total of 24,431 nursery-grown coral colonies from 9 different species were transplanted in 5,225 m2 (0.52 ha) of degraded reef, at the no-take marine reserve. Coral nubbins, collected from survivors of the 1998 event and corals of opportunity, were raised in in-situ midwater nurseries. To measure the effects of restoration on natural recovery, ecological monitoring was completed before and after initial transplantation, at the transplanted site and at the adjacent control sites ('degraded' and 'healthy'). In 2012, before intervention, live coral cover, juvenile coral density (< 5 cm in diameter) and fish density at the transplanted and degraded sites were similar. By 2014, live coral cover, juvenile coral density and fish density at the transplanted site were 5, 1.6 and 1.9 times higher than at the degraded control site, respectively. Following a series of natural disturbances throughout 2015 and 2016, live coral cover decreased dramatically across all sites. Surviving corals (i.e. thermally resilient) were identified, stocked and transplanted (1,837 colonies 2017 - 2018) in an ongoing effort to repopulate the reef. Preliminary results from ongoing monitoring show significant signs of reef recovery and the positive effects of transplantation are still apparent, whereby juvenile coral density and fish density at the transplantation site remain higher than at the degraded control site. This work highlights that the positive effects of large-scale reef restoration continue even after the occurrence of natural disturbances, which may be related to prevailing structural complexity following coral mortality.

15:40 Afternoon break & poster session

16:25 Session IV: New tools and approaches to coral reefs

	Speaker	*Presentation title*	*Institution*
16:25	*Gareth Williams*	Coral reef ecology in the Anthropocene	*Bangor University*

Natural environmental gradients act as a filter for coral reef ecosystem structure and function across multiple trophic levels and scales, from microbes and plankton, to corals and fishes. However, local direct human impacts, such as the fishing of herbivores, nearshore nutrient enrichment and sedimentation, are often overwhelming part of this filter on many coral reefs globally. Furthermore, underlying socioeconomic dynamics underlying these local impacts, such as trade, consumer demands, carbon dioxide emissions and human migration, are predicted to increase in the future. We argue this presents a new reality and means that coral reefs will increasingly reflect rapid human-induced, socioeconomic selection rather than being a product of natural environmental selection. In order to understand these changes now and in to the future, this presentation will argue that human social and economic processes must become an integral part of coral reef ecological theory and practice as much as biological and geophysical processes are today. This warrants a revisiting of traditional ecological paradigms and theories and either adapting them so that they capture contemporary dynamics of intertwined social-ecological systems, or developing novel social-ecological theories. This will likely influence the way we identify drivers of coral reef ecosystem structure and function and ultimately the way in which we study, describe, predict and manage their fundamental ecology.

16:40	*Sidhant Gupta*	Autonomous coral reef mapping robot with laser quadrat	*The University of Hong Kong*

Coral reef ecosystems are some of the most diverse and valuable ecosystems on the earth, supporting more species per unit area than any other marine environment (Costanza et al., 1997). However, due to climate change, only about 46% of the world's coral were considered healthy in 2008 (Wilkinson, Clive, 2008). Further, the years 2014-2017 experienced the world's largest coral bleaching event yet (Ruben van Hooidonk 2016). One of the biggest challenges in coral conservation is that reef mapping is currently carried out manually, with a group of divers manually placing a large PVC quadrat and then photographing the area (U.S. Geological Survey Fact Sheet 084-01). This process is time-consuming, dangerous and expensive, resulting in an unfavourable coral monitoring process. Our solution is to develop a reef-mapping drone robot which can sail on water and map the reef autonomously, at a low cost. This robot updates the physical quadrat, which is used today, to a projected laser quadrat - eliminating the need to dive to the bottom of the sea. We use existing waypoint navigation and GPS stabilization systems from airborne drones and adapt it to handle the needs of a water borne robot. On-board processing then extracts the parameters required to create the map. To further streamline the process of mapping, the robot uploads the photographs into a cloud based photogrammetry suite where computer vision algorithms transform the robot's multispectral images into 3D maps and models. Successive maps can then be compared to understand the extent of bleaching of the reef at different points and dates. Currently experimental, this technology could prove to be a leap forward in the world of ocean based instrumentation and has the potential to create far-reaching impact to coral reefs around the world.

16:55	*Emily Husband*	Coral colony-scale rugosity metrics and applications for assessing temporal trends in structural complexity of coral reefs	*University of Exeter*

Coral reefs worldwide are experiencing reductions in structural complexity, primarily due to a loss of key reef building taxa. Monitoring these changes is difficult due to the time-consuming nature of in-situ measurements and lack of data concerning coral genera-specific contributions to reef structure. This study aimed to develop a new technique that uses coral colony level data to quantify reef rugosity (a 3-dimensional measure of reef structure) from 2D video footage and UAV imagery. A database of coral colony rugosity data comparing coral colony planar and contour length for 66 coral genera and 9 abiotic reef substrates was created using measurements from the Great Barrier Reef and Natural History Museum. Linear regression analyses (y=mx) revealed statistically significant ($p<0.05$) relationships between the two variables for every genus. The gradient governing this relationship was unique for each genus, ranging from m=1.23, for (encrusting) Acanthastrea, to m=3.84, for (vase-shape) Merulina. These gradients were used as conversion factors to calculate reef rugosity from linear distances measured in video transects using Kinovea software. This calculated, 'virtual' rugosity had a strong, positive relationship with in-situ rugosity ($r2=0.96$), showing that the technique can provide accurate colony level rugosity information. The conversion factors were also applied to historic line intercept data from the Seychelles, where temporal changes in calculated rugosity were consistent with changes in coral cover between 2005 and 2017. Finally, on application to 1,736 corals digitised from UAV imagery of the Maldives, the conversion factors enabled calculation of rugosity for three 100m2 reef areas and prediction of how the rugosity will decrease during two future scenarios of coral degradation and community change. The study highlights that the application of genera-specific coral rugosity data to both new and existing coral reef survey datasets could be a valuable tool for monitoring reef structural complexity over large spatial scales.

17:05 Speed talk	*Sue Wells*	Improving management of marine protected areas for coral reefs – the IUCN Green List	*IUCN World Commission on Protected Areas*

Marine Protected Areas (MPAs) are one of the main tools used in the conservation of coral reefs. However, in many cases, reefs that an MPA has been designed to protect have deteriorated. Although there are significant factors external to the MPA that often contribute to this, notably climate change, failure to undertake effective management is also a known cause of declining reef health.

As in any business, undertaking an assessment of performance is a good way to identify shortcomings and problems. Assessing the effectiveness of a protected area is now a well-recognised tool for taking the necessary steps towards improving management, with a number of methodologies in use, some of which have been designed specifically for MPAs.

As an incentive to encourage protected areas to improve their performance, IUCN – The World Conservation Union has established the Green List of Protected and Conserved Areas ('IUCN Green List') programme. This allows identification of protected areas that are delivering successful nature conservation outcomes and associated cultural, ecosystem services and social benefits. The Green List Standard covers four aspects of management: good governance, sound design and planning, effective management, and the achievement of successful conservation outcomes. The Standard is accompanied by 17 criteria that are globally consistent requirements collectively describing the efforts needed to achieve successful conservation; each criterion has generic indicators and suggested means of verification which can be adapted to suit the local context.

To date, few MPAs, and even fewer coral reef sites, are involved in the Green List programme, but this will change as the programme is further trialled and expanded. The IUCN Green List and other management effectiveness assessment programmes provide an important opportunity to improve the management of MPAs for the conservation of coral reefs, and both scientists and conservationists can play important roles in their development.

17:10 Speed talk	*Jamie Craggs*	Ex-situ co-culturing of the sea urchin, *Mespilia globulus* and the coral *Acropora millepora* enhances early post-settlement survivorship: implications for large scale coral propagation	*Horniman Museum*

Anthropogenic driven climate change is causing significant loss of associated biodiversity in coral reef habitats and a global decline of these ecosystems. This has led some researchers to suggest that human intervention through active restoration is of increasing importance. However restoration efforts, particularly those involving coral sexual propagation, are in need of upscaling if they are to reverse this decline. One of the biggest barriers to successful upscaling is the fact that scleractinia reef building corals undergo a survival bottleneck during early ontogeny, partly due to competition with faster growing algal species. Here we conduct a co-culturing experiment to assess if coral survivorship post settlement can be enhanced by rearing the reef grazing sea urchin Mespilia globulus *at different densities alongside the coral* Acropora millepora*.*

All grazing treatments [low (treatment 2 - 4 urchins), medium (treatment 3 - 9 urchins) and high density (treatment 4 - 18 urchins)] significantly (P=<0.001) increased coral survival compared to ungrazed control (treatment 1). In addition the sizes of coral spat surviving at 180 days was significantly affected by presence or absence of grazing urchins. Corals in treatment 2, 3, 4 were 12.67mm2 (P=<0.001), 17.82 mm2 (P=<0.001) and 17.50mm2 (P=<0.001) larger respectively than corals in the un-grazed control (treatment 1). Grazing density also had a significant influence on sea urchin growth (P= <0.001), with urchins in treatment 2 having a mean value of 3.32mm and 5.65 mm larger body diameter than treatment 3 and 4 respectfully. Urchin size was therefore significantly affected by density, we suggest as a result of food availability and resource partitioning.

Our results illustrate that a more holistic approach of multi taxa co-culturing can increase the production of sexually diverse coral spat and that if applied to restoration practises, could in part help to address the challenge of successfully up-scaling efforts.

17:15 Remembering Dr. Ruth Gates

17:20 Student prizes & closing remarks

17:30 Drinks reception in the Aquarium (BYO receptacle)

19:30 Aquarium closes

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Poster abstracts

Louise Anderson: Spatial variability in the functional community structure of coral reef fisheries and implications for management planning.

Coral reef fisheries in Chuuk, Federated States of Micronesia, are threatened by climate change and the consequent decreasing time between disturbance events. These changes are occurring in the context of growing human populations, increasing commercial exploitation and an erosion of traditional governance systems. Coral reef fisheries represent a key source of economic and food security for the 60% of Chuuk's inhabitants that maintain subsistence livelihoods. This study examines the influence of management and fishing pressure gradients on the spatial variability of food-fish functional community structure, and explores how these findings can be used to support targeted management actions that complement existing governance. Fishing pressure and management interventions are known to be an important predictor of overall reef condition, but their impact on the food-fish community is less clear. Stationary point count surveys of food-fish size and abundance were collected across 64 sites representing major reef habitats, management regimes and geographic areas throughout Chuuk. Combined with detailed information on fishing activity, and refined through discussion with local fishers and conservation organisations, this work explores whether functional community structure can support future management decision-making.

Preliminary results from this on-going analysis indicate that reef habitat type, levels of fishing pressure and existing management shape the functional community structure of food-fish populations in Chuuk. These results will be discussed in the context of targeted management applications and the role of community action planning in identifying and responding to changes in these fisheries. The scope for a functional understanding of Chuuk's food-fish communities to inform local decision-making means that this study offers a useful perspective for management and conservation of this important resource.

Alex Bartlett: Local and regional drivers of the trophic structuring of fish assemblages associated to seagrass in the Caribbean following varying levels of protection.

Marine protected areas (MPAs) are being increasingly adopted as the primary management tool across the world's coastal habitats and fisheries, specifically tropical marine ecosystems (TMEs).
MPAs are known to increase fish size, biodiversity and the monetary value of fish, however in TMEs they tend to be focussed predominantly on coral reefs, and their efficacy to protect soft bottom habitats such as seagrass meadows has been questioned.
We currently possess little knowledge on how MPAs affect seagrass associated fish biodiversity and community structure on a regional scale.
We studied 12 sites in the Caribbean and 18 in the Indo-pacific, across 11 countries, with varying levels of protection.
Here I show MPAs increase fish biodiversity and trophic complexity in Caribbean seagrass meadows, yet land use and social compliance with MPA legislation are more influential in maintaining healthy faunal communities than protection status.
We found that unprotected seagrass meadows in south east Asia were considerably less diverse than east Africa and the Caribbean, using a new baseline formula to assess trophic score of individual seagrass meadows with Baited Remote Underwater Video Stations (BRUVS).
We anticipate this study will act as a starting point for future research and guidance for designing effective MPAs. The development of the site trophic score formula, enables anybody with internet access to be able to assess the health of their seagrass meadow within a global database, where required we believe this will act as a vital tool in guiding decision making.

Maria Beger: Are trait combinations of reef fishes preserved along tropical to temperate biogeographical gradients?

Understanding the drivers of fish community assembly on subtropical reefs is a prerequisite to predict how temperate and subtropical reef ecosystems may be affected by climate change. High relative reef integrity should be ensured by maintaining ecosystem functions along the gradient, but it is unclear how changes in the abundances and biomass of fishes with different trait-combinations reflect this hypothesis. Here we compare drivers of fish community assembly along tropical-to-temperate transition zones in eastern Australia and Japan through the lens of functional traits. We examine patterns of trait association with latitude and environmental drivers, considering traits such as trophic group, thermal affiliation, pelagic larval duration and length. We show that the degree of overlap among fishes with different thermal affiliation varies with temperature, and distance from shore. Moreover, the proportion of fishes displaying different traits changes in the transition zone. For example, the proportion of fishes with larger maximum size and longer pelagic larval duration increases towards higher latitudes. Trophic groups, such as corallivores, predators and herbivores exhibit declines, increases and non-linear relationships with latitude, respectively. These patterns are broadly similar in both hemispheres, with differences in the spatial assembly patterns and biogeographical breaks

within the transition zone. In summary, dynamics of fish communities in transition zones respond to environmental drivers and are mediated by specific trait combinations in both the southern and northern hemispheres. This enables us to predict which types of fishes are more likely to invade north or south, and how they will be affected by tropicalisation.

Ole Brodnicke: Coral health and resilience – The influence of nutrition on the coral holobiont

Coral reefs globally have suffered substantial mortality in recent years from marine heatwaves combined with synergistic impacts from local anthropogenic stressors. Resilience to these events is linked to the health of the ecosystem and importantly coral community health. The health of any coral is dictated by a complex interaction of metabolic pathways across all partners of the holobiont and the environmental conditions surrounding these. Nutritional competence in corals is often overlooked in aspects of coral health although it's importance is well documented in many other organisms. This study describes the physiological, energetic and microbial changes in response to distinct feeding regimes during domestication of coral colonies from the Great Barrier Reef. Linking the diet of coral to its nutritional status measured as fatty acid composition, lipid stores and protein content combined with correlations to changes in the microbiome sheds light on how coral health and resilience can be enhanced. Augmenting coral health through diets, probiotics or beneficial microbes may enhance coral growth and resilience and aid development of strategies for improved coral mariculture and restoration efforts to repopulate and restore deteriorated reefs.

Heidi Burdett: Environmental protection provided by fine-scale geochemistry of the *Heliopora coerulea* skeleton

The blue coral, Heliopora coerulea, is a major target for illegal trade due to its uniquely coloured skeleton. Found on coral reefs around the world, H. coerulea also appears to be particularly resilient to bleaching stressors. As a bleaching-resilient coral, H. coerulea could become ever-more prominent in coral reefs as other corals struggle in the face of a rapidly changing climate. Here, we investigated the geochemistry of the skeleton to see if this plays a role in its environmental resilience. We focused on iron distribution within the skeleton, since 'iron salts' may be the reason for the blue colouration. Using synchrotron X-ray fluorescence imaging conducted at the Diamond Light Source, we found that the outer surfaces and the surfaces of the internal lamellae were enriched in iron, suggesting a high degree of biological control. Calcium and iron content were negatively correlated, suggesting that the observed iron enrichment may occur by substituting calcium in the carbonate skeleton. Other biogenic carbonates enriched with iron (e.g. beaver teeth) are known to be highly resilient to environmental degradation, particularly low pH. Our results therefore suggest that the mineralogy of H. coerulea could provide natural resilience against environmental change, especially ocean acidification. We propose that H. coerulea could be robust to projected climate change, perhaps regaining its competitive advantage over other, more sensitive, coral species in the future and continuing with its 100 million year history.

Aaron de Verés: Herbivory Alone Can't Control Algae After a Phase Shift as High Cover of Unpalatable Species Persist

With the decreased ecosystem function associated with coral-macroalgal phase shifts, algae are condemned as a nuisance to reefs. However, algae are not uniform. Some are consumed, and others toxic. Herbivory is often explored as algal biocontrol, but incorporating dietary and biomass data of the herbivore and algal species accurately identifies which species and how much of the algae is within and beyond natural control. Consequently, this study used manual, video and photographic surveys to quantify species-specific benthic cover of the algal community on a Mexican Caribbean coral reef. Herbivorous fish families and sea urchins were surveyed with an Underwater Visual Census incorporating length estimates of encounters to calculate biomass using length-weight allometric relationships. Herbivory rate was calculated observing the number of fish bites on algae within $1m^3$ during 5-minute surveys. Feeding selectivity surveys on Surgeonfish and Damselfish, prominent herbivorous families, processed using Ivlev's Electivity Index, identified which algae were being actively consumed. Describing the diet of the fish families linked herbivorous biomass specifically to the algae it consumed, using critical mass figures from the literature to determine whether herbivorous biomass is sufficient to control the algal community. Preliminary results show high cover of algae that are not being consumed, such as Lobophora, and a very low biomass of sea urchins, a key macroalgal herbivore. Without herbivorous control these algae can persist, reducing available benthic substrate for coral and possibly impeding reversal of the phase shift. On such reefs, intervention may be necessary for ecosystem recovery. This study is the first step in a new direction, examining the structure of algal communities on coral reefs more closely. Presenting baseline data and a study model for adaptation, further studies can investigate how these relationships change over time, and whether these unpalatable species are preventing the reversal of coral-macroalgal phase shifts.

Konstantinos Georgoulas: Title?

The ecosystem services provided by coral reefs are worth over $100 billion annually and include coast line protection, tourism, food and medical derivatives. However, the health of the constituent corals can be significantly impacted by climate change. The proliferation of corals is reliant upon optimal current and light conditions. The 'Goldilocks Zone', where conditions are 'just right' will promote coral growth compared to sub-optimal zones. By creating a Computational Fluid Dynamics (CFD) model to understand coral growth in 'optimal conditions' it will be possible to simulate a variety of different future environments. Such a model would be a powerful tool for coral reef management. The Smoothed Particle Hydrodynamics (SPH) method will be used for the model as its mesh-free Lagrangian nature is ideal for simulations where the examined object (i.e. a coral) is growing dynamically. The model will be written in C++ programming language and will be parallelized with the Open Multi-Processing (OpenMP) application programming interface to allow for time-effective high-resolution simulations.

Jeneen Hadj-Hammou: Assessing the evidence base for functional response and effect traits of coral reef fish

Coral reef fish are increasingly confronted with a range of environmental disturbances. However, they also contribute to ecosystem processes in a number of ways. Functional traits and corresponding metrics of functional diversity provide a mechanistic link between species and their responses to disturbances or effects on processes. This study identifies the fish traits being used in coral reef science and determines the evidence base for linking such traits to specific responses to disturbances (climate change, pollution, and fishing pressure) or effects on ecosystem processes (bioerosion/calcium carbonate production, herbivory/primary production, predation/secondary production, and nutrient uptake/nutrient excretion). We conducted a systematic review using two databases: Web of Science and Google Scholar. A range of fish traits were identified and categorised to generate a typology of traits, modifying the trait-based "Response and Effect Framework". We then adapted the IPCC approach to estimating certainty to ascertain the different confidence levels for linking traits to either environmental disturbances or ecosystem processes. Through this procedure, we were also able to generate a schematic of evidence types, ranging from lab-based experiments to global observational studies. Additionally, a network analysis revealed which traits are most commonly used together, as well as the types of questions they are used to answer. The results clearly indicate the need for greater evidence to support the use of traits that, theoretically, should be of great importance to coral reef ecosystems. Crucially, the results show where the research gaps are in trait-based functional coral reef science and provide a foundation for the systematic selection of traits. Improving the selection of traits used in functional assessments of ecosystems has the potential to elucidate the mechanisms driving and affecting functional changes on novel coral reefs.

Christina Hunt: Habitat complexity drives aggregating behaviour in invasive lionfish

Caribbean lionfish (Pterois volitans and Pterois miles) are considered the most heavily impacting invasive marine vertebrate ever recorded. However, current management is largely inadequate, relying on opportunistic culling by recreational SCUBA divers. Culling efficiency could be greatly improved by exploiting natural aggregations, but to date this behaviour has only been recorded anecdotally, and the drivers are unknown.

This talk will summarise the work we conducted last year in the bay of Tela, Honduras. To investigate lionfish aggregation behaviour, we conducted ex-situ binary choice behaviour experiments to test lionfish attraction to conspecific visual and olfactory cues. Lionfish did not show a significant preference for visual, olfactory or visual+olfactory cues. We also investigated in-situ habitat preference by comparing the structural complexity of reef areas with and without lionfish. Habitat complexity was measured using fractal dimension, which was calculated at five spatial scales from 1-120 cm resolution.

We discovered that lionfish avoid fine-scale complexity (1-5 cm resolution) but are attracted to broad-scale complexity (30-120 cm resolution). Our findings suggest that lionfish aggregations are coincidental based on individuals' mutual attraction to similar reef structure. The knowledge we have gained on lionfish habitat preference can be used to improve culling efficiency through its application to artificial aggregation devices and traps.

John Rollino: A Quarter Century of Observations of Shallow Water Patch Reef Decline..... However, Low Cost Restoration Efforts May Provide a Glimmer of Hope?

In 1992, in response to the coral bleaching outbreaks of the 1980s, a long-term coral reef research project was initiated on San Salvador - a small Bahamian Island. Permanent transects were established on shallow water patch reefs (SWPRs) in less than 3M of water. SWPRs, due to their close position close to land, are often most encountered by humans for a variety of activities (e.g., recreation, fishing, etc.). These reefs are also subject to dynamic wave forces. Since 1992, we have documented three major bleaching events on San Salvador and an alarming reduction of coral coverage and diversity; especially, species that exhibit rapid

vertical growth forms that contribute to reef rugosity and habitat. After two decades of observation, we initiated low cost experiments in reef restoration geared specifically for remote communities to develop a method of replacing lost physical structure of SWPRs though means of constructed structures and coral transplants. The experiments included the construction of concrete rugosity enhancing devices to provide hard substrate for coral recruitment and the placement of coral fragments rescued after storm events. Corals along the fringing reef have been tracked for potential transplant. Colonies that have survived the past quarter century and have not exhibited die back have been targeted for transplant on to the patch reefs. Initial small scale concrete constructions and transplant efforts have provided some encouraging results.

Ana Samperiz: Stylasterids: a new paleoceanographic archive?

Stylasterids are a commonly found deep-sea coral taxon that build their skeletons from either calcite or aragonite (or both). Their potential as paleoceanographic archives remains unexplored and robust geochemical proxy data collected from modern specimens is very limited. Ninety-three stylasterids were selected from locations including the Southern Ocean, Equatorial Atlantic, North Atlantic and Galápagos Islands spanning a range of depths from 63 to 2894 m and temperatures from 0 to 17°C. Samples were identified up to species level when possible. They included 20 species belonging to 7 genera. These were Adelopora sp., Cheiloporidion sp., Conopora sp., Errina sp., Errinopsis sp., Inferiolabiata sp., and Stylaster sp. Fifty-six specimens were analysed for skeletal mineralogy. Sixteen samples were calcitic, and 40 were aragonitic. Oxygen and carbon ($\delta^{18}O$ and $\delta^{13}C$) isotopic composition was measured in all the specimens. Five specimens were sub-sampled in the main trunk, secondary branches and growing tips. All data were below equilibrium, with the tips of the colonies having the lightest values, and the trunk being the heaviest. The $\delta^{18}O$ and $\delta^{13}C$ range within a single specimen is lower compared to published values in deep-sea scleractinian corals. All the specimens were subsampled in the main trunk. Their $\delta^{18}O$ and $\delta^{13}C$ was measured and compared to local hydrographic data to gain insight into calcification mechanisms and test their use as paleotemperature archives. Different isotopic values were found between aragonitic and calcitic samples. Calcitic corals showed less depleted values from equilibrium for $\delta^{18}O$ but a higher depletion for $\delta^{13}C$. The data indicate that environmental temperature is recorded in the skeletal chemistry of stylasterid corals. A global $\delta^{18}O$:temperature calibration for aragonitic stylasterids was produced. This calibration showed a mean depletion of 0.97‰ from equilibrium. This work highlights the potential application of stylasterid coral $\delta^{18}O$ data to reconstruct ancient seawater temperature.

Amy Sing Wong: Functional role of herbivorous fish communities in driving benthic structure in coral reef systems

Marine fish play important functional roles on coral reef systems in regulating ecosystem resilience. In particular grazing behaviour of herbivorous fish are key in determining benthic community structure and thereby the ecological function and service provision of tropical reefs. The importance of understanding the functional role of key taxa in maintaining coral reef biodiversity and resilience is now more important than ever as acute and long term environmental change threatens these systems further. We aimed to enhance our understanding of the functional roles dominant herbivores play in sculpturing reef benthic community structure and to understand whether these roles are partitioned across different fish. We identified herbivore abundance and biomass and how this was partitioned across reefs zones and benthic structure over a 5 year period in the Wakatobi National Park, Indonesia. Herbivore abundance and biomass decreases within the reef from the flat to the slope, this was consistent from 2013 to 2017; however overall abundance and biomass increased overtime. We further quantified the functional role of herbivores by excluding grazing activity from 13 plots on the reef. Algal communities responded with a significant increase in benthic cover over the 12 month exclusion period. Regressions models found that abundance and biomass decreases with increased algal cover across all grazing guilds, this was best predicted by the fish abundance of guilds and particularly the secondary functional groups nested within herbivores. Secondary functional groups revealed that Acanthuridae spp. were the most abundant and contributed to the most biomass within herbivore communities and Signanidae spp. with greater mean biomass. These taxa may be key in maintaining resilience in the reef through functional processes, and vital for increased conservation and monitoring efforts against direct pressures to mitigate effects of further environmental change.

Harriet Tyley: Title?

Shallow marine water habitats provide valuable ecological and socio-economical services. The function of many shallow marine habitats has been well researched, but the role of coral bommies within these habitats is less understood. This study investigated the potential functional roles of bommies within shallow water habitats, with the aim to determine their conservation value. The biological and physical complexity of bommies in 3 different reef zones were measured on the island of Hoga, Indonesia. Physical

complexity was measured for each bommie with HAS and rugosity (RI), distance from the reef crest and substrate type. Visual fish surveys provided biological complexity metrics of abundance, species richness, community composition and residency of coral reef fish at bommies. Bommie rugosity only influenced fish abundance above a threshold of 0.626RI, whilst HAS showed a strong relationship with abundance. Abundance and developmental stage of coral reef fish at bommies was affected by reef zone environment. The seagrass environment had the highest overall abundance of coral reef fish and the near shore zone the lowest, but all 3 zones had a minimum residency of >50%, with juvenile abundances the same for bommies in the seagrass and near shore zones. These findings suggest that the functional role of bommies is dependent on their habitat and structural complexity, with bommies in seagrass and fore reef environments providing additional resources for juvenile coral reef fish species, but that all bommies play a key role for resident species.

Kathryn Whittey: The role of habitat complexity in sharknose goby (Elacatinus evelynae) cleaner-client interactions

The high levels of biodiversity found on coral reefs is largely driven by high structural complexity, but now, due to anthropogenic changes, coral reef complexity is dramatically declining. Cleaner-client interactions are a pivotal interaction observed in coral reef communities, where cleaners remove dead skin and parasites from the bodies of other reef fish (clients), influencing overall reef health. Habitat is an important driver of this interaction as many cleaners occupy stations, specific localities on the reef and clients use topological reef features to navigate to these cleaning stations. Here, we ask the questions, 'are there habitat features that are congruent across multiple cleaning stations?' and 'what is the relationship between habitat variability of cleaner stations and cleaner occupancy?'. Using a long-term (2010-2018) field site in the Caribbean, sharknose gobies (Elacatinus evelynae), and 3D constructions of cleaning stations we investigate how habitat: complexity, rugosity, height and surface area influences cleaner abundance at the station. Here we show that sharknose cleaners prefer taller and more complex stations. By understanding what features of the habitat are important to cleaners, we will gain a better understanding of how this iconic interaction will function as a result of severe reef degradation.