

Reef Conservation UK

Saturday 14th December 2019

#RCUK2019



09:00 Registration opens

09:30 Welcome address

09:35 Plenary speaker I

09:35	Johann Mourier	The behavioural ecology and role of reef sharks on healthy reefs	UMR MARBEC
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Johann Mourier is a marine behavioural ecologist at the Marine Biodiversity Exploitation and Conservation lab (MARBEC) in France. His research has focused for the last 15 years on the ecology and conservation of marine predators, primarily sharks. He has been studying the behavioural ecology, trophic ecology, movement ecology and conservation biology of sharks using multiple advanced and non-invasive approaches including underwater observations, biologging, genetics, stable isotope analyses and network theory. Much of his research has been focused around the remote and healthy coral reefs of French Polynesia (Pacific Ocean) where he has also been involved in an elasmobranch citizen science program for the past 8 years. In the last 5 years, he has been leading a research project in the atoll of Fakarava in one of the largest aggregations of reef sharks with the objective to better understand the role these predators have in the coral reef ecosystem.

10:05 Session I: Reef ecology

	Speaker	Presentation title	Institution
10:05	Christina Skinner	Carbon isotopes of essential amino acids highlight pelagic subsidies to predators on oceanic coral reefs	Newcastle University

*Predators on reefs play an important role linking and stabilising ecosystems and are key components of the reef fishery. Increasing evidence suggests that their biomass is substantially sustained by oceanic production sources, but the mechanisms through which this occurs remain poorly understood. Most studies exploring these reef-pelagic linkages have used bulk stable isotopes; one of the major limitations being that co-occurring sources may overlap, which can preclude accurate identification of source origin. We used $\delta^{13}C$ values of essential amino acids ($\delta^{13}CEAA$), which act as unique fingerprints revealing the mode of carbon acquisition, to trace the origin of the carbon sources sustaining predator biomass on inner lagoonal and outer edge reefs in the Maldives. White dorsal muscle tissue was taken from four key fishery target groupers (*Aethaloperca rogaa*, *Anypserodon leucogrammicus*, *Cephalopholis argus* and *Cephalopholis miniata*), and eight primary consumer species sampled to represent six energy pathways. Primary consumer $\delta^{13}CEAA$ values showed excellent discrimination and separated in to four distinct clusters broadly representing: 1) benthic algae/detritus, 2) coral, 3) reef plankton (diurnal and nocturnal) and 4) pelagic plankton. Bayesian stable isotope mixing models determined that pelagic plankton primarily sustained all four groupers on both inner and outer reefs. A combination of enhanced mesopelagic prey around oceanic atolls and consistently available small benthic reef fish larvae suggest these reefs may be a sink of pelagic energy. Furthermore, the consistently high pelagic reliance across the atoll indicates a well-mixed system with oceanic nutrients available throughout. Reefs that rely on pelagic subsidies for sustaining fish productivity may be more resilient to coral bleaching than previously thought. Furthermore, the exceptionally high pelagic reliance of the groupers, a fundamental component of the reef fishery, suggests that fishery predictions based solely on habitat loss may not be accurate.*

10:20	Melita Samoily	Predicting responses of fish assemblages to coral reef condition in the Indian Ocean	CORDIO & University of Oxford
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Tracking climate change impacts on corals affect fish populations is challenging due to the complex dynamics of reef fish assemblages, poor consensus on which fish indicators to measure and gaps in our understanding of the functional role of different taxa. We measured the density and size of >150 fish species in Comoros, Madagascar, Mozambique, Tanzania, Chagos and Djibouti, and 16 bio-physical variables, to develop a model that tests the sensitivity of aggregate fish indicators to coral reef health. We first analysed species' density and biomass and bio-physical variables and found geographic location and reef geomorphology were the most significant drivers of fish assemblage structure. Fishing effects only became significant at smaller spatial scales. Only in Chagos, with negligible fishing pressure and relatively homogeneous geomorphology, did live coral cover

influence fish assemblages. The second analysis found key benthic attributes delineated clearly across two primary PCA axes: i) from high turf algal cover to exposed sites with high CCA cover; ii) from high coral cover and rugosity to high fleshy algal cover and rubble. This provided a matrix for testing the response of different aggregate fish indicators to these spectra of reef condition and anthropogenic pressure. Indicators included family, trophic group, and functional traits. Families such as Scarinae and Chaetodontidae were poor predictors of declining coral cover and rugosity. But certain trophic group parrotfish responded positively to high levels of macro-algae. Small schooling planktivorous Caesionidae responded positively to coral cover / rugosity, while grazer and detritivore acanthurids showed the opposite relationship. The addition of functional traits, such as schooling/solitary and fish size, enhances the ability to detect responses in fish assemblages to changes in reef health. The study provides insights into how declining reef condition affects fish assemblages and proposes fish indicators for predicting trends of coral reefs in the 21st century.

10:35	Benjamin Cowburn	Uncovering the reef life of subtropical central Atlantic: A first comprehensive assessment of the shallow marine habitats of St Helena	CEFAS
<p><i>St Helena is a remote volcanic island in the mid-South Atlantic that is administered as an Overseas Territory of the UK. Its Exclusive Economic Zone was declared an IUCN category VI Marine Protected Area (MPA) in 2016. There is a limited but growing body of information about local marine habitats and species to inform MPA objectives and management. The first regular monitoring of habitats and biodiversity in St Helena began in 2013 that collected data on shallow water (<25m) benthos, mobile invertebrates and fish communities. We analysed photo-quadrats of the benthic community, classifying sessile organisms and substrates to reveal spatial and temporal variation in community composition. Distinct habitat types are present in the shallow water environment including rocky reefs, boulder beds, rhodolith beds and sandy substrates, each associated with unique faunal assemblages. Unlike many locations at this latitude (15°S), the hard-substrate habitats are not dominated by corals, but by filter-feeding crinoids, sponges and zoanths. Extensive rhodolith/maerl beds form semi-consolidated substrates over sand that allow a range of other organisms (including ascidians, annelids and hydroids) to exist in these areas. These data reveal, for the first time, detailed information about the species and habitats of the inshore environments of St Helena add significantly to our understanding of the unusual marine ecology of the central Atlantic. In the long-term, the findings provide important baseline and monitoring information for use in MPA and fisheries management.</i></p>			

10:50 Speed talk	Amanda Ford	Characterising the impacts of benthic cyanobacterial mats on coral reefs in Fiji	University of the South Pacific
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Benthic cyanobacterial mats are becoming increasingly common around tropical coastlines to the detriment of marine ecosystems. In Fiji, blooms can occur annually in nearshore reef areas during warm months, but in recent years some mats have begun to prevail through the cold season as well. Little is known about how these mats influence underlying reef processes and functions, and many fundamental knowledge gaps remain including mat composition, characteristics, and dynamics. This study focuses on a cyanobacteria bloom at an inshore protected area on Fiji's Coral Coast in February 2019. Benthic surveys quantified the types and extent of mats on reef substrate, and stationary point counts measured the biomass and species diversity of key functional groups of herbivorous fish communities. Samples of different mat morphologies were analysed using a combination of microscopy and genetics. Using remote video observations, we also assessed fish grazing functions (bite rates and functional diversity) on hard substrate covered primarily by cyanobacterial mats (> 50%) compared to hard substrate lacking cyanobacterial mats (< 10%) and looked for indications of any fish species that (opportunistically) consume mats. Cyanobacterial mats covered 51 ± 4 % (mean ± SE) of the benthos, and seven different mat morphologies were identified. Most mats contained a complex consortium of cyanobacteria. Herbivorous fish biomass was relatively high (212 ± 36 kg ha⁻²) with good representation of species across all main functional groups. Preliminary video observations indicate that bite rates on the substratum were several-fold lower when mats dominated, and no fish seemed to specifically consume the mats. These results provide insight into the most common cyanobacterial mats proliferating on inshore Pacific reefs and the effect that they have on herbivorous fish function. Further work directed at supporting management to reduce the continued expansion of mats is urgent to avoid potential long-lasting ecosystem-wide changes.

10:55 Morning break & poster session

11:40 Session II: Reefs in a changing world

	Speaker	Presentation title	Institution
11:40	Michael Sweet	Metabolomic profiling reveals rapid juvenile plasticity in response to acute heat stress in comparison to adult coral colonies	University of Derby
<p><i>Coral reefs are suffering unprecedented declines in health on a global scale. Some researchers have responded with the suggestion that human assisted evolution (HAE) or assisted gene flow (AGF) may be necessary in order to effectively restore reefs and condition them ready for the challenges to come. Part of these approaches involves the crossing of geographically</i></p>			

distinct populations, ones which naturally experience large environmental variation, particularly in maximum sea surface temperatures. There are now proposals to extend this to the creation of hybrids (crosses between species). Here we successfully spawned (ex situ) *Acropora hyacinthus* from two distinct geographical locations (Australia and Singapore), and *A. millepora* from Australia, and reared both pure and hybrid crosses. Then the resulting juveniles and their parental colonies were subjected to an acute heat stress and their resulting metabolomic profiles quantified to assess response to the stress (using nuclear magnetic resonance and ultra-performance liquid chromatography-mass spectrometry). Regardless of profiling method, the metabolomic profiles of the adult colonies were clearly distinct between species, supporting previous work. Interestingly, this strong species-specific metabolomic signature appeared to mask any differences resulting from the heat stress. In comparison, juveniles showed clear and rapid responses to the stress, losing their species-specific differences in their metabolomic profiles immediately. Importantly for HEA studies, the juvenile metabolomic profiles showed significant similarities to those of their parents (assessed from the control group), indicating a strong component of inheritance. Contributions to this inheritance were equal between egg or sperm donors. To conclude, the metabolomic responses of adults and juveniles to heat stress differed in their timing, a result which indicates HEA experiments need to be carefully designed and further illustrates the complexity of coral responses to heat stress.

11:55 Laura Warmuth Where will Indo-Pacific corals go under climate change? Duke University

Coral reefs worldwide are facing more risks than ever before and 19% of reefs have been destroyed. A third of reef-forming coral species face extinction. These taxa are critical for reef resilience and fish communities. Coastal protection and food security under global change depend on conservation management that includes predicted coral habitat suitability. This research aimed to model the distribution of hard corals in the Coral Triangle under present conditions and under the best and worst-case climate scenarios for 2050 and 2100. We sought to identify habitats with low expected anthropogenic pressure that can act as refugia for future local threats and climate change. Machine learning and relevant environmental predictors were used to find suitable habitats for 120 coral genera. This is the first study to model distributions of all regional coral occurrences and individual ranges of functionally important taxa. The models demonstrated that ranges of all genera decrease for future scenarios and shift poleward except for the most salinity sensitive taxa. Habitat loss is predicted to be highest in the northwestern Coral Triangle. We found potential refugia in the easternmost provinces of Indonesia and the Timor Sea. Given the limited existing protection in the Timor Sea, these future habitats should be an immediate conservation priority. This study provides a transferable large-scale approach for identifying coral refugia under climate change scenarios and local stressors.

12:10 Nick Graham The changing role of coral reef marine reserves in a warming climate Lancaster University

Coral reef ecosystems are one of the first to fundamentally change in structure and function in response to climate change. A key challenge is to understand if the decades of knowledge about how reefs respond to common conservation and management tools is still applicable under these rapidly changing reef configurations. Here we assess ecological responses to no-take marine reserves over two decades, spanning a major climate-driven coral bleaching event. Coral cover was on average 15% greater in marine reserves pre-bleaching, but there was no difference post-bleaching indicating that this common benefit of marine reserves is lost on reefs that experience major coral bleaching. Species richness of the fish community was greater in marine reserves prior to the bleaching event, but benefits diminished through time post-bleaching. Biomass of the fish community was greater in marine reserves prior to the bleaching event, particularly for carnivorous fish species. Following bleaching, biomass was still greater in marine reserves, but the functional groups of fish benefiting from protection completely changed from carnivores to herbivores, particularly macroalgal browsers, and scraping and excavating parrotfish. Overall, there was a major shift in the benefits of the marine reserves from higher trophic level fish, to lower trophic level fish. These findings highlight that while marine reserves still have an important role to play on coral reefs in the face of climate change, the species and functional groups they benefit will be substantially altered.

12:25 Elena Couce Global coral reef diversity forecasts for warmer, more acidic seas CEFAS

Coral reefs are set to undergo significant changes and ecosystem shifts over the coming decades as seas become warmer and more acidic. We investigate the environmental tolerances of over 650 Scleractinian coral species to identify short- and medium-term "winners" and "losers" and predict how coral species composition is likely to evolve in different regions around the world. Using the species distribution model Maximum Entropy (MaxEnt), we analyse the environmental requirements of each coral species and predict changes to their distributions under future warming and acidification, accounting for connectivity between reef sites driven by oceanic currents. We develop global forecasts for the evolution of coral community structure, reef diversity (coral species richness) and reef complexity (richness and evenness of coral morphotypes) over the next half century under two different emission scenarios: SSP 1-2.5 (approximately 2 degree warming, the target of the Paris Agreement) and SSP 5-8.5 (high warming, business-as-usual scenario).

Preliminary results predict key high-diversity areas like the Coral Triangle and most of the Great Barrier Reef are likely to see important declines in diversity, while high latitudes and some currently-marginal areas may retain their diversity and become suitable to new species, a process however potentially hindered by poor connectivity. Isolated and species-poor regions are particularly vulnerable to a loss of functional diversity, since this is more significantly impacted by each species lost.

Knowledge of the likely changes in coral diversity and functionality that could occur world-wide over the next half century would allow managers and conservationists to focus protection efforts on areas expected to prosper and on existing species most likely to tolerate future conditions, and suggest coral species that could be successful if introduced in particular areas.

12:40 Speed talk	Holly East	Seagrass meadows as valuable sources of reef island-building sediments	Northumbria University
<p>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. Whilst the rates of sediment production on coral reefs are becoming increasingly well constrained, the role of seagrass meadows as a potential source of island-building sediments has been largely overlooked. Here, we present detailed analyses of sediment production within a seagrass meadow surrounding Faathihutta island, Huvadho Atoll, Maldives. Using field surveys, laboratory analyses and Unmanned Aerial Vehicle (UAV) orthophotography, we quantify: (1) the rates and types of sediment production associated with a seagrass bed; and (2) the proportion of this sediment production which is of a suitable grade to contribute to reef island-building. Seagrass sediment production rates ranged from 0.07 kg m⁻² yr⁻¹ to 0.77 kg m⁻² yr⁻¹. Estimated annual sediment production by seagrass epibionts was 849 t yr⁻¹ across an area of 1.1 km². Of this material, 78% (662 t yr⁻¹) was found to be of an appropriate grade (i.e. sand-sized) to contribute to reef island building. Such volumes of sediment are sufficient to produce the volume of Faathihutta island over a ~10 year period. We thus highlight the role of seagrass meadows as 'hotspots' for the production of island-building sediments. Moreover, this role of seagrass as a reef island builder may become increasingly important as coral health in the region has declined under the recent global bleaching event. Results are discussed in the context of seagrass conservation, which is particularly pertinent in the Maldives as seagrass removal by the tourist industry is a routine practice.</p>			

12:45 Speed talk	Joerg Wiedenmann	Did nutrient levels promote the 2012 bleaching event in the Persian/Arabian Gulf?	University of Southampton
<p>Coral communities in the Southern Persian / Arabian Gulf have severely suffered from coral bleaching in 1996 and 1998. More recently, they have experienced a series of bleaching events in 2002, 2007, 2010, 2011, 2012 and 2017, putting their capacity to recover and survive under severe pressure. Recent research has found that a depletion of the water from nutrients, particularly from phosphate, renders corals more susceptible to bleaching. These conditions might be induced through nitrogen enrichment of coral reef waters and / or through a disturbance of the natural nutrient balance by phytoplankton blooms. We analysed data generated by remote sensing and in-situ measurements to pinpoint the environmental conditions accompanying the 2012 coral bleaching event in the Southern Arabian Gulf, comparing them to the non-bleaching years 2013-2015. During summer in 2012 and 2015, corals in Saadiyat reef were exposed to comparable levels of heat stress, yet they bleached only in 2012. The 2012 bleaching event coincided with high phytoplankton levels, low nitrate (N) and phosphate (P) concentrations and shifting N:P stoichiometry in the water column. In 2015, the nutrient levels were higher and comparable to those in the studied non-bleaching years. These data suggest that the coral bleaching event in 2012 might have been promoted by unfavourable nutrient levels in the water column.</p>			

12:50 Lunch break & poster session

14:15 Plenary speaker II

14:15	Estradivari	Status, trends and impacts of Indonesian Marine Protected Areas	WWF-Indonesia
<p>Estradivari is Conservation Research Manager at WWF-Indonesia. She is a leading Indonesian marine conservation scientist, with over 15 years experience coordinating marine conservation projects to promote biodiversity conservation and sustainable fisheries. Her work has influenced Indonesian government policy spanning the national to district level. Most recently, Estradivari has been responsible for developing a marine protected area network across Indonesia's Sunda-Banda region based on implementing best-practice biodiversity, fisheries, and social science. She has a diverse research background, spanning marine and coastal ecology, ecological and social impact evaluation, marine conservation, and fisheries management. Prior joining WWF Indonesia, Estradivari worked for 10 years for UNESCO and the Indonesian Coral Reef Foundation.</p>			

14:45 Session III: Sustainability and management

	Speaker	Presentation title	Institution
14:45	Emily Clark	12 years on: Blue Ventures' experiences of integrating health services into a community-based marine conservation programme in southwest Madagascar	Blue Ventures

The west coast of Madagascar hosts the world's fourth largest coral reef system. Home to remarkable marine biodiversity, this reef system provides vital resources that isolated local communities are dependent on for food and income. However, poor health, overexploitation of resources, and a lack of income alternatives have resulted in widespread coral reef degradation and dwindling fish stocks. Responding to these interrelated challenges, Blue Ventures adopted a holistic approach to conservation, integrating community-based health services with natural resource management and livelihood diversification initiatives. Locally-managed marine areas empower coastal communities to govern defined ocean areas. Aquaculture initiatives, such as seaweed and sea cucumber farming, have been successfully introduced, boosting income whilst concurrently reducing fishing pressures.

Responding to clearly vocalised unmet needs for health services, BV established its community health programme, Safidy. Now 12 years old, Safidy has expanded across all five BV sites, serving over 45,000 people along the remote west coast. Through a network of community health workers and close liaison with governmental health centres, clinical services are provided for family planning, maternal and child health, and water, sanitation and hygiene initiatives. These are accompanied by educational activities integrating health and conservation messages. Thus, individuals can better understand the inter-relationships between their local environment and their health.

Results from these integrated programmes demonstrate their synergism. Over 50% of sexually active women of reproductive age now use contraception, a five-fold increase. More than 4,500 unintended pregnancies have been averted. Couples report improved food security and increased income. Through this holistic approach to addressing community needs, trust has been built and barriers to engagement with conservation are overcome. BVs approach demonstrates a successful community-led approach to conservation that is now being replicated by partners throughout the Western Indian Ocean and the Coral Triangle.

15:00 John Turner The 'Growing Pains' of enhancing a Marine Protected Area system, Cayman Islands Bangor University

The expansion of Marine Protected Areas in the UK Overseas Territory of the Cayman Islands was approved in March 2019, increasing the 'no-take' area of protection from 14% of coastal waters to 48%, and to 54.6% of the shelf. This exceeds the Convention on Biological Diversity (CBD) Aichi Target 11 of 10% of coastal and marine areas, fulfils the call made by the UK at the UN General Assembly 2018 for governments to designate 30% of oceans as MPAs by 2030, and comes close to achieving the target nationally of 50% protection by 2050, likely to be proposed at the CBD in China 2020. A well established and enforced MPA system has existed in the Cayman islands since 1986, but population and tourism growth, coastal development, invasive species and climate change threaten biodiversity and ecosystem services. An 8 year programme of research part funded by 2 grants from the UK Government's DEFRA Darwin provided the evidence from field, fishery and household surveys preceded 4 public consultations prior to designing a new MPA system for the Cayman islands. The purpose was to enhance the protection of coral reefs and associated shallow water ecosystems through increasing resilience to human impact and climate change by protecting ecologically representative and well-connected ecosystems. The programme was a collaboration between Bangor University, The Nature Conservancy and the Department of the Environment, Cayman Islands Government. A campaign of public awareness, education and consultation, including 81 stakeholder meetings, 43 press articles, 54 TV and 8 radio programmes maximised understanding and support for the new MPA system, which was finally announced on the occasion of a Royal visit to the Territory earlier this year. New legislation is currently being drafted. The lessons learned from the successes, pitfalls and ambitious next steps are summarised for MPA projects.

15:15 Hugo Harrison Are marine reserve networks a good investment? Portfolio effect stabilizes recruitment benefits James Cook University

The long-term benefits of networks of marine reserves for conservation and fisheries management are predicated on there being significant and consistent larval supply from reserves to neighbouring habitats. However, larval contributions from individual reserves in a network are likely to be highly variable, which may diminish or negate such benefits. Until recently, the means to quantify variability in dispersal patterns were unavailable. Using genetic parentage analyses we tracked the dispersal trajectories of coral grouper (*Plectropomus maculatus*) from a network of no-take marine reserves on the Great Barrier Reef to reveal spatial and temporal trends in larval dispersal patterns. Here we show that dispersal patterns and the recruitment contribution of reserves is extremely variable across six discrete recruitment cohorts. However, asynchronous contributions from multiple reserves increases the temporal stability in the replenishment of local populations via a portfolio effect, reducing recruitment volatility by a factor of 1.8. The network of 4 reserves effectively halved the volatility in larval supply from individual reserves. Thus, not only did the network of marine reserves generate between 26% and 58% of all local recruitment, its aggregate effect mitigated temporal fluctuations in dispersal patterns and the local recruitment contribution of reserves. Our results indicate that effective reserve networks can provide previously unrecognized stabilizing benefits that rapidly accrue with an increasing number of individual reserves.

15:30 Dominic Andradi-Brown Beyond no-take zones: achieving locally appropriate marine management options WWF-US

Marine Protected Areas (MPAs) encompass a spectrum of protection types, ranging from strictly enforced no-take zones, to those focused on sustainable use of resources, or in some cases nearly open access. Given effective no-take MPAs on average deliver greater coral reef biodiversity benefits than those that allow extractive uses, some stakeholders have advocated that only no-take MPAs should contribute towards marine protection targets. Yet exclusive no-take MPAs are not always suitable, ethical, or

feasible in contexts where communities depend on marine resources for their food, income, and cultural identity. To ensure coral reef conservation efforts are sustainable, MPA development and implementation needs to be locally appropriate, ideally built on existing community marine resource governance practices and be co-designed with local communities. In order to inform future MPA development, we evaluated MPA regulations for 171 MPAs across 35 countries and territories. Regulations were subdivided into 26 unique aspects based on effort restrictions, spatial fisheries restrictions (e.g. no-take, gear restrictions, habitat restrictions), temporal restrictions (e.g. periodic harvest closures, fisheries seasons), and restrictions on those who can fish (e.g. based on cultural heritage, residency within an MPA, permits). Multivariate analysis was conducted to identify a typology of MPAs formed by distinct MPA clusters based on regulations and governance type. MPA clusters were compared statistically to identify defining characteristics. Different clusters are explored in more detail through a series of case study MPAs from Cambodia, Fiji, Indonesia, Madagascar, and Micronesia where positive coral reef conservation outcomes were observed under a range of government and customary governance types. Our findings highlight that to effectively protect coral reefs and ensure their long-term success MPA governance and management strategies need to be adapted to local contexts.

15:45
Speed talk

Eva Maire

Disentangling key drivers of nutrient concentration in coral reef fish to achieve food and nutrition security

Lancaster University

Fish are particularly rich in micronutrients essential to human health and development, and deficiencies in these micronutrients result in over a million deaths annually. However, considerable variation exists in micronutrient availability within and between species. It has recently been established that diet, thermal regime, and energetic demand significantly affect the nutrient content of marine fish globally. More specifically, species from tropical thermal regimes contain higher concentrations of calcium, iron, and zinc; species from cold thermal regimes or those with a pelagic feeding pathway contain higher concentrations of omega-3 fatty acids; and smaller species are richer in calcium, iron, and omega-3 fatty acids. However, the nutrient content of only a few coral reef species is effectively quantified and we still lack a generalizable understanding of which species are most able to address pressing nutritional needs in tropical coastal countries. Here, we analyze the concentration of key minerals, vitamins and fatty acids in >100 species of coral reef fish and integrate contemporary scientific knowledge regarding the environmental, ecological and physiological drivers shaping the nutritional value of fish to predict nutrient content among reef fish communities in the Western Indian Ocean. We find that size, feeding pathway, and benthic habitat quality shape the quantity and diversity of micronutrients in fish species. Importantly, we identify suites of species, that are both rich in nutrients important to human health and with a low vulnerability to fishing and climate change, that have the potential to substantially meet the dietary requirements for several key nutrients. Our findings also emphasize that shifts in reef fish communities caused by coral habitat changes can ultimately alter the nutritional outcomes provided by coral reef fisheries. Projecting the nutritional compositions and yields of predicted future coral reef configurations and associated fisheries will be essential to sustain the nutritional needs of some of the most vulnerable food insecure human populations in the near future.

15:50
Speed talk

Henry Duffy

Innovative approaches to co-management of reefs and small-scale fisheries in Southeast Asia

Fauna & Flora International

Fauna & Flora International (FFI) works in collaboration with governments and communities to safeguard coral reef biodiversity and small-scale fisheries in a number of countries, including an extensive programme in Southeast Asia. This includes initiatives in Cambodia and Myanmar, two nations which, for understandable and complex reasons, have lagged behind in protection of their marine resources. In Cambodia, FFI supported the establishment of the country's first Marine Protected Area (MPA) in the Koh Rong Archipelago, a critical step towards future implementation of an MPA network across Cambodia's coast. In Myanmar, FFI and partners conducted the first inventory of coral reefs in the remote Myeik Archipelago, revealing previously unknown and highly vulnerable reef communities. Since then, FFI has supported the creation and legal documentation of Myanmar's first locally managed marine areas (LMMAs) in Myeik, ensuring recognition of community fishing grounds and indigenous groups as the government rolls out a national MPA network.

The main local threat to reefs in both these countries is illegal and destructive fishing. While the value of community-based reef conservation approaches is well established, robust management interventions in newly created MPAs require mixed, innovative methods. FFI is working to introduce a range of tools to tackle destructive fishing threats, such as SMART (open-source patrol software) technology which is being used to help Cambodian communities monitor their fishing grounds. Community-led patrols are also ongoing in Myanmar, and satellite imagery is being trialled in Cambodia as a tool to assess spatial and temporal distribution of illegal fishing. Whilst obstacles undoubtedly remain, these approaches are showing signs of progress, with evidence of threat reduction in both Cambodia and Myanmar sites. This presentation will share results, lessons and the challenges encountered when working towards positive conservation outcomes in countries with low capacity and urgent need for sustainable reef management.

15:55 Afternoon break & poster session

16:40 Session IV: Reef gubbins

Speaker	Presentation title	Institution
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16:40	Kieran McCloskey	Mitigating the impacts of motorboat noise on nest defence in tropical damselfish	University of Exeter
<p><i>Vessel traffic is recognised as one of the most pervasive sources of underwater anthropogenic noise. While vessel noise has been found to negatively affect several aspects of fish biology, few mitigation strategies have been tested and proposed. However, noise-conscious changes to recreational motorboats could be made by altering engine types and/or driving practice. We investigated the effects of motorboat noise on parental care in a demersal spawning coral reef fish, Pomacentrus amboinensis, in the field. Additionally, we determined whether driving practice can be altered to influence behavioural responses. Results showed that motorboat noise impacts egg-tending and nest defence behaviours of P. amboinensis males. Noise produced from motoring at full-speed increased the proportion of time that males time spent sheltering and decreased the time spent interacting with conspecific male intruders. Alternatively, motoring at slower speeds or greater distances negated these changes, and behavioural responses were similar to those observed in control trials with no motorboat noise. This research suggests strong effects of motorboat noise on important reproductive behaviours of coral reef fish, and highlights the scope for successfully mitigating these negative effects on whole fish populations using simple management strategies.</i></p>			
16:55	Sanni Hintikka	A targeted capture method for reducing non-specific amplification by COI primers in eDNA metabarcoding studies	University College Dublin
<p><i>Metabarcoding environmental (e)DNA samples has become a popular tool for determining species presence/absence in marine habitats. However, the most popular eukaryotic barcode – the mitochondrial gene cytochrome oxidase I (COI) – suffers from high levels of non-specific amplification, most notably by amplifying bacterial DNA. As metabarcoding culminates in high throughput sequencing (HTS), the prevalence of bacteria in seawater can lead to >95% of the sequencing output to match to available bacterial reference sequences. Although other markers have been suggested in place of COI (e.g. 12S for fish), the fact remains that COI has the most comprehensive reference sequence database available (Barcode of Life Database). Therefore, this study focused on reducing bacterial DNA in eDNA samples prior to amplification, by utilising a targeted magnetic bead capture method. Biotinylated primer-probes were designed to target (i) the bacterial 16S sequence and (ii) the eukaryotic COI sequence. First, the samples were hybridised with the 16S probes and subjected to streptavidin coated magnetic beads (Dynabeads®) to remove bacterial DNA. This was followed by the eluent from the first capture being hybridised with the COI probes, and a new aliquot of Dynabeads® was used to capture the hybridised COI-probe complexes. At each step, an aliquot of the sample was amplified using COI minibarcode primer pair jgHCO2198/mlCOIintF (~313 bp amplicon) and the products were run on a 1.5% agarose gel to confirm amplification. Initial results show the removal and capture steps are enriching target DNA as intended. Furthermore, sequencing these products will allow us to determine how the proportions of bacterial vs. eukaryotic sequences in HTS outputs change throughout the capture protocol, ideally showing a significant decrease in bacterial sequences vs. eukaryotic (i.e. target) sequences. This relatively simple 4-step protocol is applicable to any metabarcoding study, and with modifications can be extended to other markers suffering from non-specific amplification.</i></p>			
17:10 Speed talk	Ines Lange	Photogrammetry and 3D model comparison: A quick, easy and non-invasive method to quantify coral growth	University of Exeter
<p><i>Coral growth rates are significant indicators of coral health and reef growth potential, yet data for most coral genera in the Indo-Pacific is scarce. Traditional methods to obtain growth rates, such as coral coring or staining with alizarin are destructive and only work for a limited number of species and morphological growth forms. Emerging non-invasive approaches, using underwater photogrammetry to create digital models of coral colonies, are providing novel ways to explore colony-scale growth patterns. We developed an easy-to-follow workflow to construct 3D models from overlapping photographs and measure annual extension rates of branching, massive and encrusting corals after aligning colony models of subsequent years. The method was successfully applied to measure growth rates for 64 coral colonies of 20 genera in the remote Chagos Archipelago, Indian Ocean. Measured extension rates are similar to published rates where comparable data is available, and provide first rates for several genera. For encrusting corals, the results emphasise the importance of differentiating between radial and vertical growth. We demonstrated that photogrammetry and 3D model comparison provide a quick, easy and non-invasive tool to quantify coral growth. The simplicity of our workflow will support its repeatability and permits non-specialists to learn photogrammetry with the goal to obtain coral growth rates. Coral growth rates are key metrics to quantify functional consequences of ongoing community changes on coral reefs and are essential to explore how coral reefs will respond to exponentially increasing global stressors.</i></p>			
17:15 Speed talk	Till Roethig	Warm water deep-sea corals – microbiome analysis provides insight into functional adaption to a unique environment	University of Derby
<p><i>Recently, deep-sea corals from the Red Sea were re-discovered posing the question how the corals can adapt to the challenging habitats featuring low nutrients and oxygen level (<2 mg oxygen L⁻¹) at warm temperatures (>20 °C). The lack of symbiotic algae may suggest that associated microbes play a role in maintaining a viable coral host via acquisition and recycling of nutrients. To gain insight into potential functions of the bacterial microbiome, we employed 16S rRNA gene sequencing to study bacterial communities of three scleractinian deep-sea corals from the Red Sea, Dendrophyllia sp., Eguchipsammia fistula, and Rhizotrochus typus. We found diverse, species-specific microbiomes, distinct from the surrounding seawater. Microbiomes were comprised of</i></p>			

few abundant bacteria and a high diversity of rare bacteria, thus following a rank-abundance distribution. Interestingly, we identified anaerobic bacteria, potentially providing metabolic functions at low oxygen conditions, as well as bacteria harboring the potential to degrade crude oil components. Considering the presence of oil and gas fields in the Red Sea, these bacteria may unlock this carbon source for the coral host, although further experimental work is needed to confirm this. In conclusion, the prevailing environmental conditions of the deep Red Sea may require distinct functional adaptations, and our data suggest that bacterial communities may contribute to coral functioning in this unique deep-sea environment.

17:20
Speed talk

Cathryn Quick

Can NMR based metabolomics elucidate mechanisms of hyperosmotic stress tolerance in symbiotic corals?

University of
Southampton

Understanding mechanisms of temperature tolerance in reef building corals will be crucial as we seek to predict how tropical coral reefs will respond to global climate change and mass bleaching events. Corals found in areas of unusually high salinity, for example the Persian Gulf, can withstand larger annual temperature fluctuations than corals from regions of normal oceanic salinities. Since this thermal tolerance may be linked to high salinities, a crucial step in understanding the molecular mechanisms of thermal tolerance in symbiotic corals is to investigate the underlying mechanisms of hyperosmotic stress tolerance. Analytical chemistry techniques, such as Nuclear Magnetic Resonance (NMR) spectroscopy, offer exciting opportunities for the identification of metabolic pathways involved in an organism's responses to changing environmental conditions. We have used NMR based metabolomics to analyse entire metabolic profiles of symbiotic corals under different salinity regimes, and to identify metabolites of interest. We will present the results of these experiments and discuss the impact of the data on our understanding of the molecular mechanisms of salinity tolerance in symbiotic corals.

17:25 Student prizes & closing remarks

17:30 Drinks reception in the Zoo

19:30 Reception finishes



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Saturday 14th December 2019

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Poster Abstracts

Presenter	Presentation title	Institution
Amkieltiela	Effect of Marine Customary Governance on Fish Biomass	WWF Indonesia
<p><i>The Sunda Banda Seascape, located in central-eastern Indonesia, contains a wealth of marine biodiversity and customary marine tenure practices such as sasi (periodic harvest closures), pamali (full closures), bameti (targeted harvest), etc. With the rapid development of formal government-implemented MPAs in Indonesia, it is crucial to consider current and historic marine tenure when designing MPA zonation for the sustainable use of marine resources. We conducted ecological, social, and economic surveys within six Indonesian government-implemented MPAs. Two of these MPAs have undergone spatial zonation with community involvement to align zone types with community needs. We analyzed how customary governance correlated with recorded herbivorous and commercially valuable fisheries biomass. Our results suggest that herbivore fisheries (Family: Acanthuridae, Siganidae and Scaridae) and key fisheries (Family: Haemulidae, Lutjanidae, and Serranidae) fish biomass are higher in area highly recognized as a customary area compared to area that less recognized as a customary area within the MPA. Customary management may thus increase conservation gains by maintaining fish biomass while sustainably using marine resources. Involvement of communities in an MPA designation through community-based conservation projects or local knowledge integrations may also reduce MPA conflicts associated with establishment and management.</i></p>		
Austin Bowden-Kirby	Facilitating Coral Adaptation to Warming Oceans, the “Reefs of Hope” Strategy	Corals for Conservation
<p><i>The goal of the ‘Reefs of Hope’ strategy is to accelerate natural recovery and climate change adaptation processes on coral reefs. Gene bank nurseries of bleaching resistant corals have been established in Fiji, Kiribati, Tuvalu, Vanuatu, and Moorea. Based on experience, populations of hot-water adapted corals found within shallow and enclosed hot pockets sometimes die out in mass bleaching events- when water temperatures can spike to near 40C. We sample and secure these corals to less stressed waters within nurseries. Following mass bleaching, coral survivors can be killed out by coral predators, as predation rates increase sharply due to an increase in predator/prey ratios. We therefore sample corals from the wider reef area after bleaching. After securing bleaching resistant corals within the gene bank nurseries, the corals are trimmed at one year to produce second generation fragments for use in restoring patches of heat-adapted corals to impacted reefs. The aim of outplanting is to create dense and genetically diverse patches of corals, which in turn restore sexual reproduction to multiple species, with the formation of larger numbers of coral larvae. These restored reef patches in theory will also create a strong settlement signal, stimulating the settlement of coral larvae, and helping restore the denuded reefs. The bleaching resistant corals might also share their bleaching resistant algae among the newly settled recruits. Aspects of the work are hypothetical and so the work is experimental in nature, however, the gene bank nurseries and restored patches of corals represent hope for the future adaptation and survival of coral reefs. The strategy is best implemented within no-take MPAs and on reefs where problems of overfishing and nutrient pollution have been solved. We invite other researchers and reef conservationists all over the planet to participate with us in this strategy to help coral reefs adapt.</i></p>		
Neil Cook	Identifying shark refuges in the Caribbean: using baited remote underwater video to inform policy development in Tobago	Cardiff University
<p><i>Overfishing has significantly reduced shark populations worldwide, including a major historical fishery in Trinidad and Tobago, exacerbated by additional factors including prey depletion. In the Caribbean, sharks are now largely absent from populated</i></p>		

areas despite their important ecological role and tourism value. Marine protected areas (MPAs) are tools for population recovery, although their effectiveness is dependent on design, community support and enforcement.

Northeast Tobago is a biodiversity hotspot proposed for both MPA and UNESCO Man and Biosphere status, centred around coastal communities dependent on fishing and ecotourism. Between January 2016 and April 2018 baited remote underwater videos (BRUV) were used to address knowledge gaps regarding relative abundance and distribution of sharks throughout Tobago. Study sites included long-established Buccoo Reef Marine Park (1973) and adjacent waters in the southwest region, plus the proposed Northeast Tobago MPA.

Three species of international conservation importance were identified (great hammerhead, scalloped hammerhead, silky shark) as well as tiger, sharpnose and smoothhound sharks, but only within the proposed MPA. Additionally, Caribbean reef and nurse sharks were observed throughout study sites. Captures per unit effort (CPUE; mean maximum number of sharks/90min BRUV \pm S.E.) were higher inside Buccoo Reef Marine Park than adjacent waters (0.4 ± 0.16 vs 0.2 ± 0.11), but there was no difference when nurse sharks were excluded due to data dominance and skew (0.1 ± 0.06 vs 0.1 ± 0.08). CPUE was higher in the proposed MPA than the southwest (0.4 ± 0.05 vs 0.3 ± 0.09), with the difference increased by nurse shark exclusion (0.3 ± 0.05 vs 0.1 ± 0.05).

Tobago represents a refuge where globally endangered sharks persist despite historical fishing pressure. However, Buccoo Reef Marine Park has limited positive impact on sharks with species diversity and relative abundance highest in Northeast Tobago. Our study provides evidence to support proposed regional management development, which could ultimately include specific shark conservation measures, improved fisheries and population recovery.

Benjamin Cowburn

Untangling components of reef resilience to bleaching and other pressures to make effective management decisions

CEFAS

The use of resilience based management (RBM) for coral reefs has been hampered by a lack of suitable data, a large number of potential resilience indicators, and uncertainty about the interactions between different components of resilience. Watamu Marine National Park (WMNP), Kenya, has been a no-take marine protected area (MPA) since 1968, and supports healthy fish populations due to effective control of human activities in the park. However, pressures from multiple past coral bleaching events, coupled with extensive coastal development adjacent to the park has led to a decline in coral cover. Using data from the 1980s to present, we investigate different components of resilience to determine which factors are preventing a return to historical conditions. Sea surface temperature data show there have been eight bleaching events since 1985 in WMNP, while observations of bleaching response in four of these years indicate that some coral taxa appear to have gained more resistance to thermal stress, especially in relation to the most recent bleaching in 2016. Since the most severe event in 1998, there has been a decline in thermally sensitive branching coral taxa, but with no phase-shift to a macroalgal dominated state. The growth and mortality rates of different coral taxa remained similar pre and post-1998, but there was a significant decline in recruitment. We conclude that corals in WMNP have become more resistant to thermal stress, but that recovery potential is reduced because of lower recruitment. For WMNP this narrows down the RBM options to: 1) boosting recruitment by increasing connectivity between WMNP and other MPAs and 2) using restoration techniques to boost the juvenile coral population. Our data demonstrate the unique nature of reef resilience in a local ecological and anthropogenic context, but also show common patterns emerging from our global understanding of reef resilience under multiple pressures.

Amanda Ford

Characterising the impacts of benthic cyanobacterial mats on coral reefs in Fiji

University of the South Pacific

Benthic cyanobacterial mats are becoming increasingly common around tropical coastlines to the detriment of marine ecosystems. In Fiji, blooms can occur annually in nearshore reef areas during warm months, but in recent years some mats have begun to prevail through the cold season as well. Little is known about how these mats influence underlying reef processes and functions, and many fundamental knowledge gaps remain including mat composition, characteristics, and dynamics. This study focuses on a cyanobacteria bloom at an inshore protected area on Fiji's Coral Coast in February 2019. Benthic surveys quantified the types and extent of mats on reef substrate, and stationary point counts measured the biomass and species diversity of key functional groups of herbivorous fish communities. Samples of different mat morphologies were analysed using a combination of microscopy and genetics. Using remote video observations, we also assessed fish grazing functions (bite rates and functional diversity) on hard substrate covered primarily by cyanobacterial mats (> 50%) compared to hard substrate lacking

cyanobacterial mats (< 10%) and looked for indications of any fish species that (opportunistically) consume mats. Cyanobacterial mats covered $51 \pm 4\%$ (mean \pm SE) of the benthos, and seven different mat morphologies were identified. Most mats contained a complex consortium of cyanobacteria. Herbivorous fish biomass was relatively high (212 ± 36 kg ha⁻²) with good representation of species across all main functional groups. Preliminary video observations indicate that bite rates on the substratum were several-fold lower when mats dominated, and no fish seemed to specifically consume the mats. These results provide insight into the most common cyanobacterial mats proliferating on inshore Pacific reefs and the effect that they have on herbivorous fish function. Further work directed at supporting management to reduce the continued expansion of mats is urgent to avoid potential long-lasting ecosystem-wide changes.

Helen Ford

Quantifying spatial scaling properties of coral reef benthic communities across tropical seascapes

Bangor University

Scale and spatial autocorrelation are inherent to understanding spatial patterns in ecology. The issue of scale, however, has largely been ignored in coral reef benthic ecology. Observational scales in coral reef research are often limited by the traditional approach of using spatially limited transects within spatially dispersed sites, which limit our understanding of broader seascape patterns and processes. In this study, we quantified benthic community patterns from 6022 digital images taken across ~140 linear km of reef around the circumference of 5 uninhabited tropical Pacific islands using sub-surface towed-diver surveys. We characterised the spatial structure, specifically the degree of spatial clustering, of the benthic communities and their physical drivers over multiple scales. Within individual islands, benthic functional groups and coral morphologies had structured and predictable scaling properties across the seascape, with some groups showing consistently higher levels of spatial clustering than others. Between islands, some scaling properties of the benthic communities were consistent, particularly between islands within similar geographies. Interestingly, the scales at which benthic communities became spatially random were similar to the scales at which wave energy and sub-surface temperature, two key physical drivers of benthic community structure on coral reefs, also became spatially unstructured. This suggests these physical drivers play a large role in governing the spatial scaling properties of the communities across the broader seascape. Our results demonstrate the importance of quantifying patterns of coral reef benthic communities across multiple scales in order to better understand their spatial ecology and the underlying processes governing their structure and function. It would appear that key physical drivers of coral reef benthic communities operate at scales that differ from the scales at which management decisions of these systems are often made. Our findings provide motivation for adopting a seascape approach to the study and management of coral reef social-ecological systems.

Abigail Leadbeater/
Charlie Gough

Big data tools for small-scale fisheries: using technology to improve access to data

Blue Ventures

Small-scale fisheries, on which millions of people depend for food security, livelihood provision and cultural identity, are in decline globally. In order to secure these fisheries for the future, decision making on management measures should be rooted in evidence and be led by the communities that are affected.

Many of these fisheries are data poor, despite a wealth of traditional knowledge and experience. Data collection by community members is a key tool for gathering the data required to identify baselines, track trends and assess the impacts of fisheries management interventions. However, turning data into information that is timely, accessible and useful to fishing communities for adaptive management remains a challenge, particularly in areas where literacy and numeracy levels are low.

A constant flow of data requires complex systems and repeated analyses. This results in lag times between data collection and results dissemination which is dependent on highly skilled analysts. Working in remote areas with limited connectivity presents challenges for sharing outputs and differing audiences (communities vs governments, staff vs funders) mean that visualisations of the information presented cannot be one size fits all.

Using emerging data visualisation technologies, designed for corporate business and big data, we are finding ways to make data available and accessible to fishing communities. Interactive online dashboards, updated in real time, reduce the time and input required by specialist staff. These dashboards are hosted online and updates can be accessed anywhere with a connection, or downloaded for offline use. Creating dashboards in partnership with end users (fishermen and women) ensures that the most useful information is displayed in an understandable and appropriate way, ranging from complex graphs to basic icons.

In this presentation, we share examples of visualisations created, how they have been used and our experience in using technology to overcome barriers to data dissemination.

Rachel Gunn Preparing for the future? The influences of coral cover on butterflyfish (*C. lunulatus*) personality Lancaster University

Whilst animal behaviour is becoming increasingly focussed on understanding the response of an organism to human induced rapid environmental change, a better understanding of consistent individual variation in behaviour, or personality, in response to environmental change is required. Coral reefs are undergoing substantial change around the world as mass coral bleaching and other disturbance events disrupt ecological communities. Animal behaviour is thought to be a crucial mechanism underlying this disruption, which could shape the potential for species to cope with on-going environmental change, yet our understanding of these links is in its infancy. Species that depend on live coral for survival will therefore be affected by declines in coral health. Butterflyfishes (*Chaetodon* spp.) are iconic reef fish that are particularly susceptible to environmental change because they depend directly on corals as food. Certain personalities could provide a selective advantage under environmental change e.g., bold and explorative individuals might have increased potential to exploit novel conditions. This project explored the personality traits of an obligate corallivore, *Chaetodon lunulatus*, in relation to coral cover. By employing behavioural observation and territory mapping methods on the reefs surrounding the Island of Hoga within the Wakatobi National Park, Indonesia, this study identified differences in personality traits in *C.lunulatus* individuals across two sites of varying coral cover. Aggression, Activity, and Sociability traits were higher on the site where coral coverage was higher, whereas exploratory traits were higher, and territories larger on the site where coral cover was sparse. Abundance of *C.lunulatus* was also lower on the site with lower coral cover. These results provide further evidence that animal personality is influenced by environmental change, and can be applied to understanding of the persistence of butterflyfish in the future based on personality differences that could allow some individuals to buffer the effects of climate change.

Sebastian Hennige Crumbling Reefs University of Edinburgh

Cold-water coral reefs, such as those found off the west coast of the UK and globally, 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. While ocean acidification may act directly on the dead coral skeleton, deoxygenation may determine the tissue coverage extent, and ultimately the amount of dead skeleton accessible to ocean acidification conditions. 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 current research on the skeletal mechanical properties of CWCs, including microindentation and synchrotron data, and cast a look forwards at our emerging modelling research on how we can build on these data to create a risk model of CWC habitat loss in a changing ocean.

Christina Hunt Invasive lionfish decrease shelter-use in the presence of native spiny lobster University of Oxford

Lionfish (*Pterois volitans* and *P. miles*) have become invasive throughout the tropical western Atlantic, with *P. volitans* widely distributed across the region. Most lionfish research has focused on their consumptive effects on reef fish and so little is known about their non-consumptive effects and their effects on invertebrates. Lionfish often shelter around biotic and abiotic structures on the reef, thus there is potential for competition between lionfish and other shelter using organisms. I will summarise the results of research carried out in Tela bay, Honduras, from June – August 2019. The aim of this research was to test whether the presence of invasive lionfish alters shelter-use behaviour of native spiny lobster, or vice versa. Shelter use was assessed ex-situ in a large tank with a single shelter, using infrared cameras to film for 60 seconds every hour over a 24 hour period. A subsidiary aim was to investigate what factors influence individual sheltering behaviour. Our preliminary results suggest that lionfish reduce their shelter use in the presence of lobster. Lionfish spent 29.2 ± 6.0 % (mean \pm standard error) of their time in shelter when alone, compared with only 9.9 ± 3.7 % when lobster were present. However, the same trend was not seen in lobsters, which spent similar percentages of time in shelter when alone (12.6 ± 4.8 %) and when lionfish were present (11.7 ± 5.2 %). Lionfish and lobsters rarely shared the shelter. Our results are positive for lobster populations because lionfish did not influence lobster shelter use. However, lionfish may impact lobster fisheries because once a lionfish entered a shelter, the lobster rarely co-

habited the shelter. The exclusion of lionfish from their preferred habitat may reduce survival or feeding success, resulting in lionfish being less successful invaders on reefs with limited shelters.

Cathryn Quick Can NMR based metabolomics elucidate mechanisms of hyperosmotic stress tolerance in symbiotic corals? **University of Southampton**

Understanding mechanisms of temperature tolerance in reef building corals will be crucial as we seek to predict how tropical coral reefs will respond to global climate change and mass bleaching events. Corals found in areas of unusually high salinity, for example the Persian Gulf, can withstand larger annual temperature fluctuations than corals from regions of normal oceanic salinities. Since this thermal tolerance may be linked to high salinities, a crucial step in understanding the molecular mechanisms of thermal tolerance in symbiotic corals is to investigate the underlying mechanisms of hyperosmotic stress tolerance. Analytical chemistry techniques, such as Nuclear Magnetic Resonance (NMR) spectroscopy, offer exciting opportunities for the identification of metabolic pathways involved in an organism's responses to changing environmental conditions. We have used NMR based metabolomics to analyse entire metabolic profiles of symbiotic corals under different salinity regimes, and to identify metabolites of interest. We will present the results of these experiments and discuss the impact of the data on our understanding of the molecular mechanisms of salinity tolerance in symbiotic corals.

Ana Samperiz Linking environmental changes and coral calcification in Fijian inshore reefs using computed tomography **Cardiff University**

The Fiji archipelago includes approximately 35% of coral reef area in the southwestern Pacific that provides essential ecosystem services for the livelihoods and well-being of Fijians. However, these reefs are at risk of irreversible damage due to global (e.g. seawater warming, ocean acidification) and local stressors (e.g. overfishing, poor water quality). Recent studies from Fiji have linked variability in inshore benthic condition and reef fish populations to catchment land use. Additionally, these coral reefs have also been exposed to enhanced surface ocean temperatures and cyclone activity. While various local organizations routinely monitor coral reef condition in Fiji through direct in situ observations, these provide only a limited snapshot the current ecosystem state. Coral growth reconstructions from massive reef-building corals can provide unique insight to understand how past environmental conditions (e.g. light intensity, rainfall) affected coral calcification.

We aim to disentangle the relationships between coral degradation, water quality and climatic events in Fijian inshore reefs, and reconstruct the sensitivity of reef-building corals to environmental changes in the last century. We use computed tomography (CT) to investigate the coral growth response under a range of different catchment environments and a number of stress events (e.g. bleaching, cyclones). A total of 14 modern coral cores (Porites sp. and Diploastrea sp.), spanning up to ~90 years of growth, were collected from inshore reefs at 5 different locations around the island of Viti Levu (Fiji). We focus on coral calcification rates (seasonal linear extension and skeletal density) to explore coral response to local stressors and past climatic events. Preliminary results suggest that corals in the vicinity of catchments with anthropogenic impact exhibit slower growth rates and relatively prolonged recovery after a stress event.

Ellie Vaughan Assessing the precision and cost-effectiveness of bioindicators for estimating nutrient regimes on coral reefs **Lancaster University**

The nutrient signatures in the tissues of fleshy macroalgae are widely accepted as spatially-extensive and time-integrated bioindicators of anthropogenic nutrient runoff and their subsequent impacts on coral reefs. However, a single algal species may not always be present on all reefs which need to be investigated for environmental monitoring purposes (i.e. along a nutrient gradient), so a suite of bioindicators may sometimes be more appropriate. In the current study, the precision, congruency and cost-effectiveness of eight potential bioindicators (brown and green macroalgae, turf algae, cyanobacteria, soft corals, zoanths, sponges, and sediment) were compared both within and between 21 coral reefs that had either experienced high coral mortality (n=12) or become dominated by macroalgae (n=9) across the Inner Seychelles Islands. The bioindicators were analysed for five different nitrogen- and carbon-based stable isotopic and elemental signatures ($\delta^{15}N$, $\delta^{13}C$, %C, %N, and C:N Ratio). The cost-effectiveness of each bioindicator was also assessed in terms of cost (time taken to collect and process samples) and effectiveness (abundance, sample availability). $\delta^{15}N$ signatures in brown and green macroalgae showed the lowest average coefficient of variation (CoV) values, both within and across sites (3.60 ± 0.50 , n=17; 4.07 ± 0.28 , n=11, respectively), and so

could be considered the most precise, especially for macroalgal-dominated sites, though zooxanthids, the third most precise, were more readily available and therefore consistent across all reefs (11.8 ± 2.02 , $n=19$). However, congruency (the relative similarity in nutrient signature patterns) between these three was low. Though previous studies have used a variety of bioindicators to estimate the causes and extent of nutrient enrichment, there is almost no knowledge of their precision, cost-effectiveness and congruency across environmental gradients. This research has therefore assessed these important criteria to help improve selection of bioindicators for capturing nutrient regimes, particularly across multiple reefs facing different types of disturbance.

Katie Watson

Mapping anthropogenic threats to coral reef ecosystems in the Indo-Pacific: A tool for prioritising mitigation actions

University of Leeds

Coral reef ecosystems are being degraded through concurrent direct and indirect anthropogenic disturbances. Understanding the spatial and temporal scale of anthropogenic threat events is crucial to determining ecosystem vulnerability, cumulative ecological impacts, and the potential recovery trajectory. However, the spatial extent and event history across the globe for many key stressors is unknown. Without this fundamental understanding, the likely effectiveness of reef management is questionable. A database of key anthropogenic threat events and their severity was generated to produce detailed threat maps covering the Indo-Pacific, with events being categorised as either discrete or cumulative. Threat maps highlighted degraded reefs which are under chronic stress and potentially reaching ecological collapse. Using information from the threat maps, and from pertinent reef restoration case studies, action maps were then created showing suggested management interventions, likelihood of prescription success, timescale and cost. Mapping of anthropogenic threats and quantifying stressor severity across the Indo-Pacific can serve as a useful tool to prioritise local-scale management areas. This information, alongside pertinent case studies on reef restoration actions, will allow prioritisation of management interventions, highlighting where management options can deliver the greatest ecosystem function gains.

Anna Woodhead

Perceptions of change in coral reef ecosystem services

Lancaster University

Coral reef ecosystems are changing under continued anthropogenic pressures. Reefs also underpin important ecosystem services (ES) that contribute to human wellbeing. To date, few studies have investigated if or how people perceive changes in coral reef ES and to what extent these changes matter. In this talk we ask: 1) have reef fishers perceived changes in ES?, 2) do perceptions of change correlate with fishers' characteristics?, and 3) which changes are most significant to this group?

Data were collected in the Seychelles where reefs were affected by bleaching in the 1998 and 2016 marine heat waves (>90% and >70% mortality of live coral cover respectively). Working with the Seychelles Fishing Authority, we conducted 41 interviews with trap fishers to capture perceptions of change in four ES (fishery, coastal protection, habitat, and recreation services), as well as the opinions and background of interviewees.

Combining quantitative and qualitative approaches, we show that fishers have perceived changes in the four services. Fishers who reported a higher number of changes in ES were more educated, had invested more in their fishing, spent time underwater and had more dependents. Descriptions of change highlighted its diverse nature and stressed the importance of understanding relationships between ES.

Changes in habitat and fishery services were most significant to fishers. Individuals who were more educated and used a greater variety of fishing gears, reported changing habitat services as most significant. Fishers who had to rely on casual work, in addition to fishing, tended to report changing fishery services as the most significant. Reasons given for identifying changes as significant were again diverse, showing that change means different things to different people. This study has identified important factors and considerations to help in managing for future ES and for understanding the wellbeing implications of changing reefs.