

Oral Presentation Abstracts

9:00 Registration Opens

9:30 Welcome

Session 1: Fish Ecology

9:35 – 9:50

Wave exposure a bidirectional force structuring herbivorous fish communities

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The structure of fish assemblages is largely shaped by the interaction between resource availability and a complex suite of forces characterising their physical environment. Food availability and wave exposure on coral reefs may play a synergistic role in structuring herbivorous fish communities, thus driving heterogeneity in their function across a variety of spatial scales. We quantified benthic primary productivity, cover of grazable benthos, herbivorous fish biomass, and herbivory in 18 sites along a gradient of wave exposure on forereef habitats of the barrier reef surrounding the Palau Archipelago. There, primary productivity increased along a gradient of wave exposure but high productivity was not consistently associated with high overall herbivore abundance or increased bite rates. Here we measured 11 morphological traits related to fish swimming style and manoeuvrability and investigated if water turbulence acts as an environmental filter for species capable of relatively poor manoeuvrability on relatively exposed sites. Specifically, we investigated whether a) distinct groups of roving herbivore species can be separated based on morphological traits related with manoeuvrability, b) such groups respond differently to wave exposure, and c) whether turbulent environments support less functionally-diverse herbivore assemblages dominated by species capable of superior manoeuvrability, and d) the potential filtering effect of wave action has implications on the herbivory function. Three distinct manoeuvrability classes were distinguished among herbivores and these responded differently to wave exposure. Biomass of fusiform fish reliant mostly on pectoral fins propulsion was inversely and non-linearly related with wave exposure, whereas the opposite occurred with deep-bodied fish capable of high-precision manoeuvrability. The latter were mostly driven by the availability of grazable substrata. Wave exposure limited the grazing intensity of low-manoevrability species indicating that the former is a major driver of the process of herbivory, and could play an important role in shaping the spatial patterns of resilience.

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9:50 – 10:05

Thinking deep: mesophotic reefs as fish refugees

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Mesophotic coral reef ecosystems (MCEs; coral reefs >30m depth) are poorly studied, yet may play a critical hidden role in reef fishery resilience. Mesophotic and shallow reefs share many fish species, yet for most it is not known whether MCEs have specific roles in their life histories. We present findings from extensive surveys conducted on Utila Island, Honduras, during June-August 2014. Accelerated decompression diving using stereo-video systems were used to assess reef fish abundance, diversity and biomass at seven reef sites between 5m-40m. A baited remote underwater stereo-video system was deployed to survey fish populations down to 100m. Fish lengths were measured from the stereo-video system and used to calculate biomass with published length-weight relationships. Associated benthic data were collected, including structural complexity and benthic cover.

Our results show a decline in overall fish species richness, abundance and biomass with depth. Proportional declines in biomass occurred to a greater extent than abundance down shallow reefs (85% vs 58%), suggesting abundance data should be treated with caution when studying depth distributions. While depth was important in structuring reef fish communities, mesophotic reefs with relatively high coral cover were found to more closely resemble shallower reef fish communities than adjacent low coral cover mesophotic reefs. Mean reef fish body length increased with depth from shallow (110mm) to mesophotic reefs (130mm), though this varied taxonomically: Acanthuridae mean body length increased with depth, while Scaridae mean body length initially declined with depth down shallow reefs, but increased at the shallow-mesophotic reef interface. These results suggest mesophotic reefs may play a crucial role in supporting reef resilience through a local source of larger fish, with important implications for the management of tropical coastal marine fisheries.

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10:05 – 10:20

Assessing the reef fish communities of Pitcairn Island using Baited Remote Underwater Videography (BRUV)

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The marine environment of the isolated Pitcairn Islands, located in the central South Pacific, is known to contain near 'pristine' ecosystems which support unique fish assemblages. Pitcairn itself is the only inhabited island in the group, and the environmental impact of the local fishery is unclear, with insufficient evidence to inform management decisions.

In response to these issues a successful application was submitted to the UK Darwin Initiative with the aim of developing a fisheries management plan for Pitcairn. In order to gather new data for the project, Pitcairn's coastal fish assemblages were sampled using Baited Remote Underwater Videography (BRUV), a non-extractive technique recognised as a powerful tool for quantitatively assessing scientifically valuable habitats with minimal impact. Species richness, relative abundance, size and biomass data were obtained, allowing assemblage structure to be evaluated and compared with other sites.

A total of 42 BRUV deployments between May and July 2014 recorded 88 species, with the observed fish populations dominated by herbivores and mesopredators, thus creating a 'bottom heavy' assemblage with trophic level 3.9 and below accounting for 73% of biomass. Several large pelagic carnivores were recorded but reef-

associated predators were rare. Comparative analysis indicated low species richness compared to eastern French Polynesia, reflecting acknowledged biogeographical patterns, and Pitcairn's top predator assemblage was demonstrably impoverished compared to regional and global 'pristine' reefs. The scarcity of top predators may be explained by the island's artisanal fishery, which has historically targeted sharks and large carnivores, while recent fishing declines are likely to have caused the observed proliferation of small-bodied species. This study suggests that relatively small fisheries may substantially impact the trophic structure of fish assemblages. Moreover, a proposed commercial fishery on Pitcairn could lead to over-exploitation of certain target species, and the application of BRUV data to quotas in the future is recommended.

Henry Duffy (Imperial College London), Heather Koldewey (ZSL), Terry Dawson (University of Dundee), Robert Irving (Sea-scope) and Tom Letessier (University of Western Australia/ZSL).

10:20 – 10:35

Regional patterns in the diversity of coral reef fishes in the Western Indian Ocean

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Understanding geographic patterns in coral reef fish diversity is important for conservation planning, yet this information is still poorly known in the western Indian Ocean (WIO). We measured the diversity of reef fishes in WIO countries using an index based on 19 families. Surveys spanned a broad range of sites from shallow fringing protected reefs to deep exposed outer reefs to maximise the extent of reef habitats surveyed. A total of 375 species were recorded from 45 sites across four countries and species accumulation curves confirmed diversity measures were adequate at the site level. Similarity analyses showed that sites in Madagascar and Comoros had distinctly different species assemblages from each other and from mainland East Africa. Species assemblages at mainland sites in Tanzania and Mozambique differed in relation to reef characteristics rather than geography. Principal species driving the regional scale differences in species assemblages appear to reflect both natural biogeographic patterns and likely anthropogenic impacts. The implications of these results for conservation planning will be discussed.

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Speed Talks

10:35 – 10:40

Relationships between Parrotfish Density and Benthic Habitat on Caribbean coral reefs

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Parrotfishes make up more than 80% of the biomass of herbivorous fishes in the Caribbean and since 1983 have been the dominant grazers on reefs. Maintaining healthy parrotfish populations should help conserve benthic habitat cover suitable for the settlement and growth of reef building corals. However, the key environmental factors currently affecting local parrotfish abundance and population structure are scarcely known. Many reef studies are constrained to a limited geographical area, and results generalized at larger spatial scales. Parrotfish data across the wider Caribbean will help overcome the problem of over-generalization and identify the variability with scale. This study addressed the questions: what relationships exist between parrotfish density and benthic habitat (4 habitat and 3 complexity variables) at different spatial scales, and how do these vary with fish size? Habitat cover was represented by the value of PCA axis (representing coral to algal dominated benthos). Fish and benthic habitat

surveys at 7-15 sites were conducted in each of eight Caribbean countries (Antigua, Bonaire, Barbados, Curaçao, Dominican Republic, Jamaica, St. Lucia, St. Vincent and the Grenadines). In most of these individual countries, parrotfish density showed a stronger correlation with complexity (hole density and size) than benthic habitat. At the regional scale, parrotfish density was significantly correlated with hole density (+) and benthic habitat cover (-) but relationships varied with fish size. Smaller parrotfish (<20cm length) were mainly associated with coral reef rugosity while larger parrotfish (> 20 cm) associated with hole density. These findings highlight issues with generalizing large scale conditions from small-scale studies due to variations in reef habitat and fish size composition. Therefore, management of parrotfish assemblages should rely on local habitat data.

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10:40 – 10:45

The prevalence and nutritional value of algae and detritus in the epilithic algal matrix in and around *Stegastes diencaeus* (Pomacentridae) territories.

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The hypothesis that detritus is an easily obtainable, desirable and nutritious food item for territorial reef fishes was tested by investigating the gut contents of adult and juvenile territorial *Stegastes diencaeus* (Pomacentridae) in South Caicos (Turks and Caicos Islands). The study revealed that the most common micro-habitat among the damselfish territories was the epilithic algal matrix (EAM) and that the territory was guarded by the damselfish through aggressive behaviour towards herbivorous and some carnivorous coral reef fishes. The EAM was the micro-habitat in which the fish took the majority of bites when feeding. The stomach contents of *S. diencaeus* were composed of filamentous algae and detritus, although juveniles ingested more invertebrates and eggs than adults. The biochemical analysis of algae, coarse and fine detritus found inside and outside *S. diencaeus*'s territories showed that organic matter and carbohydrates were highest in the algal fraction and algae inside territories had more protein than outside territories. Coarse detritus (>125 µm) had more carbohydrates than fine detritus (>125 µm). Cyanobacteria and diatom presence in the fractions was measured using zeaxanthin and fucoxanthin as proxies, respectively. Zeaxanthin was found to be low in all fractions and fucoxanthin was highest in the algal fraction suggesting that macro-algae offered a support for diatom growth. Thus the nutritional value of detritus could not be fully explained by the presence of cyanobacteria or diatoms. Overall, this study brings support to the hypothesis that detritus is of nutritional value to territorial fish but the role of other photosynthetic- or micro-organisms in the territories may need to be uncovered to explain the nutritional value of detritus fully.

10:45 – 11:30 Poster Session (Tea/Coffee)

Session 2: Reef Resilience

11:30 – 11:45

Managing the resilience of the Great Barrier Reef

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One of the greatest challenges for reef management is knowing how, when, and where to intervene given the great diversity of stressors that impact the ecosystem. Here, we show how a combination of watershed, ecosystem, and disturbance modelling can provide important insights that allow management actions to be prioritised. We model the effects of coastal runoff on reefs, in part through its influence on crown-of-thorns starfish, and include reef

dynamics, and the effects of cyclones and climate change. Collectively we identify areas of the Great Barrier that are either exceptionally vulnerable to damage and those areas that have elevated resilience.

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11:45 – 12:00

Exploring long-term records of coral community development under conditions of very high terrigenous sediment influence.

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Since European settlement in c. 1850, nutrient and sediment inputs into the Great Barrier Reef (GBR) lagoon have increased markedly. This has largely resulted from agricultural intensification and river catchment modification. Due to their close proximity to the mainland, inner-shelf reefs are considered to be 'most at risk' to declining water quality and are often described as degraded with respect to live coral cover and coral diversity. However, the impacts and magnitude of these threats still remain unclear due to ongoing debates concerning the significance of increased sediment yields against the naturally high background sedimentary regimes present on the inner-shelf, and the paucity of long-term (> decadal) ecological datasets. Understanding past inner-shelf coral community development and reef growth is therefore crucial for predicting their future trajectories and for placing contemporary ecological and environmental changes within appropriate reef-building timescales (centennial-millennial). Here we present coral palaeoecological records developed from reef cores obtained from five reef structures located within the wider Paluma Shoals reef complex on the inner-shelf of the central GBR and which currently exist across a range of evolutionary stages of development. Reef establishment and growth in the area has only occurred during the last c. 2000 years, under the direct influence of terrigenous sediments, supplied by wind-driven resuspension of relict transgressive material and inputs from large river flooding events. A total of 31 coral genera are present within the palaeoecological inventory with transitions in coral community assemblages evident with depth, most notably between the incipient stages and the latter, main stages of reef development. Statistical analysis of the palaeoecological record will be used to characterise the transitions in coral community assemblages during vertical reef accretion and to develop baseline records against which modern ecological and environmental changes can be assessed.

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12:00 – 12:15

Getting down and dirty on the Great Barrier Reef: ecological and morphological mapping of turbid zone inner-shelf reefs

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Nearshore turbid zone reef environments on the inner-shelf of the Great Barrier Reef (GBR) experience naturally high sedimentation loads caused by wave-driven resuspension of fine terrigenous-dominated sediment. Such turbidity regimes are generally regarded as detrimental to reef "health" by reducing growth and calcification, abundance and diversity, and increasing incidences of disease within scleractinian corals. However, established coral communities, with long persistence through the mid- to late Holocene, have been reported for several inner-shelf

locations. Difficulties associated with conducting field studies within these reef settings has meant knowledge of the extent and ecological parameters of turbid zone reefs is limited compared with their 'clear water' mid-shelf and outer-shelf counterparts, which may result in shelf-wide underestimates of coral cover on the GBR. To generate a detailed assessment of ecological community structure, habitat types, and seafloor topography for inner-shelf reefs, towed video transect surveys and multi- and single-beam bathymetric mapping was conducted at nearshore Paluma Shoals, located within Halifax Bay, central GBR. Observations of substrate type, coral cover and coral species were recorded across reef and inter-reef areas. Geo-referenced video datasets were coupled with digital elevation models of seafloor bathymetry to examine the control of antecedent structure on the distribution of reef-building corals. Results showed that Paluma Shoals encompasses a sequence of proximal reefs that occur across a range of evolutionary states, formed upon a set of subaqueous linear ridges. Coral cover and diversity was typically high, but varied between reefs in different developmental states (21%-70%). Coral community structure was depth-stratified, with greatest diversity occurring on reef crests (-0.4 m LAT), and extensive monospecific *Turbinaria* spp. "coral carpets" inhabiting deeper inter-reefal areas (-4 m LAT). Findings highlight the importance of inner-shelf environments as critical habitat for coral reef development and contradict traditional paradigms that turbid environments are unsuitable for coral growth.

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12:15 – 12:30

Physiological response of marginal corals provide insights to the biological cost of future ocean acidification

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Present-day marginal reef environments can provide an opportunity to study the impacts of environmental change on the productivity and structure of coral reefs. This is of key importance as such systems commonly experience conditions that are predicted to be the standard experienced by future reefs, e.g. low and variable pH. Several authors describe the possibility that present-day marginal systems may provide a buffered environment reducing the impacts of ocean acidification thereby providing a refuge for future corals. In addition, corals housed within these systems are preconditioned to low pH and may be best equipped to deal with ocean acidification. We provide data on the species composition and metabolism, as described by productivity, respiration and calcification rates, of marginal systems within the Atlantic, Indian and Pacific oceans. Results demonstrate that some corals are able to tolerate changes in ocean chemistry but at a significant metabolic cost that includes reduced rates of calcification and productivity but maintained rates of respiration. Our data provides insights in to the future of coral reef form and function and the conservation relevance of marginal systems.

Emma Camp, Professor David Smith, Dr David Suggett

Speed Talks

12:30 – 12:35

Ocean acidification effects on calcification and energy reserves in the massive tropical coral, *Porites* sp.

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Ocean acidification, resulting from rising atmospheric CO₂, poses a serious threat to marine calcifying organisms. Coral reefs are of particular concern as declining seawater pH reduces the concentration of carbonate ions required for skeletal calcification. However, the effects of ocean acidification on massive corals, which support tropical reef ecosystems, are poorly understood. Using the state-of-the-art culturing facility at the University of St Andrews (photographed here), we have acclimated small heads of massive *Porites* corals over a period of > 6 months to four different pCO₂ scenarios that range from the last glacial maximum (180 ppm) to levels projected by the end of this century (750ppm). We have measured calcification, photosynthesis and respiration rates in each treatment over a four-week period following this long acclimation. Further, we are quantifying the differences in internal energy reserves (lipid, protein and carbohydrate) in response to changes in seawater carbonate chemistry, and we will determine their role in calcification. Corals precipitate aragonite from an extracellular fluid (ECF) by actively increasing the fluid pH, which drives carbonate to higher concentrations and so raises the saturation state of CaCO₃. This is an energetic process that may be more costly as the pH of seawater declines. We will use boron isotope geochemistry to reconstruct the ECF pH in corals from each treatment, enabling us to compare the energetic cost of calcification between high and low seawater pCO₂. Understanding the relationship between coral metabolism, physiology and calcification is likely to be important in predicting the ability of *Porites* to adapt to future climate change

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12:35 – 12:40

Using an isolated population boom to explore barriers to recovery in the keystone Caribbean herbivore *Diadema antillarum*

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The ecological importance of *Diadema antillarum* is well established, yet we are no closer to understanding the severe lack of population recovery in the 30 years since mass mortality decimated populations by 95-99%. However, a recently-discovered reef system off the coast of Honduras (Banco Capiro) boasts unusually high *D. antillarum* densities and provides a unique opportunity to explore barriers to their recovery. In the summers of 2013 and 2014 ecological data were collected along 50m belt transects at 10-15m depth on Banco Capiro and on nearby Utila, which has a typically suppressed population. Mean *D. antillarum* population densities in 2013 and 2014 on Banco Capiro were 1.46m⁻² and 2.25m⁻² respectively, compared to a temporally stable population of 0.004m⁻² on Utila. Concurrently, the abundance of juvenile coral recruits increased on Banco Capiro, suggesting a key role for *D. antillarum* in reef regeneration. Fish and benthic surveys were subsequently conducted to investigate potential ecological factors preventing urchin population recovery. Our results suggest that differences in predation pressure, competitive herbivory and nutrient availability cannot account for observed differences in *D. antillarum* population densities, and proxies of habitat complexity provide inconclusive results. Furthermore, the high proportion of juveniles on Utila shows that recruitment is occurring and that *D. antillarum*'s asynchronous spawning behaviour, frequently postulated as a potential barrier to recovery, has no significant effect. Our study suggests that several of

the most widely-accepted hypotheses are, in fact, not responsible for the lack of *D. antillarum* population recovery, and that there may be fundamental physiological and genetic differences between these two populations. We hypothesise that underlying reef architecture may also be a key factor. These results provide a platform for further research needed to influence conservation management strategies to aid the large-scale recovery of *D. antillarum*, and restoration of its ecological functions, throughout the Caribbean.

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12:40 – 12:45

Reproductive patterns of dominant scleractinian corals at Rapa Nui (Easter Island)

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The mode, frequency and timing of coral reproduction can have an important influence on recovery of disturbed coral communities, particularly for isolated populations. Moreover, climate-induced disturbances that modify temperature and light can significantly alter reproductive cycles, and susceptibility to such events may depend upon reproductive mode and between-colony synchrony of gametogenesis. As a first step to begin to understand variability in reproductive capacity of coral communities at Rapa Nui, we characterize the reproductive patterns of the two dominant and abundant corals: hermaphroditic *Pocillopora verrucosa* and gonochronic *Porites lobata*. Samples of both species were collected monthly from 12 m depth at a single site on the northwest coast from December 2012 to April 2014. Colony fragments were processed by histological techniques and analyzed under a microscope. Oocytes, some with zooxanthellae, and spermaries in different developmental states were found in both species. In general, *P. verrucosa* was reproductively more active than *P. lobata*, as suggested by higher percentage of colonies containing gametes. Both species had annual gametogenic cycles lasting approximately 4 months confined to spring-summer. Onset of oogenesis for *P. verrucosa* preceded *P. lobata* by 1-2 months. No clear changes in egg color was observed throughout oogenesis. Monthly changes in oocyte diameter showed between-species differences in growth curves. Although spawning in the field was not observed, the timing in the disappearance of mature oocytes differed between species, suggesting *P. verrucosa* and *P. lobata* do not spawn simultaneously. Further high-frequency sampling is needed in order to determine whether these corals demonstrate lunar spawning activity. The degree of gametogenic synchronization within the population differed for *P. verrucosa* and *P. lobata*. The lack of planula larvae suggests both species are broadcast spawners.

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12:45 – 13:50 Lunch

Session 3: Molecular Tools on Reefs

13:50 – 14:05

Reef cryptofauna community structure

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Cryptofauna are hugely understudied despite comprising the majority of coral reef biodiversity and being crucial to ecosystem function, and ultimately, reef health. Over the last 3 years our project has been quantifying the species richness and diversity of the two most numerous cryptofauna taxa inhabiting dead coral colonies, crustaceans and molluscs, from two geographical locations in the Indian Ocean. These two locations were chosen to represent varying levels of human coastal population and consequently reef health, allowing us to investigate variation in cryptofauna biodiversity with varying anthropogenic pressure on the reef.

Here I will present one component of this work that seeks to understand the processes underpinning the composition of the Pontoniinae (a sub-family of cryptofauna shrimp) on dead coral colonies using a novel approach which links phylogeny, traits, environmental variables, and space. To do this we use the species composition of the Pontoniinae from the dead coral colonies, their phylogeny coupled with select life-history traits for each species, and environmental variables. We explore whether species within a community (a dead coral colony) have similar life-history traits and if species within a geographical area show phylogenetic similarities, and if this changes over different spatial scales, from the coral colony to the Indian Ocean region. Finally we discuss whether any similarities in trait states among co-occurring species is due to environmental conditions and if these environmental conditions act on species traits independently of the phylogeny.

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14:05 – 14:20

Tag metagenomic analysis of *Symbiodinium* from twelve coral species along a gradient of bleaching susceptibilities

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Global warming¹ poses a significant threat to the future of coral reef ecosystems and recent decades have seen a rise in reports of bleaching and mortality of corals worldwide. The severity of these bleaching events varies with respect to a number of biotic and abiotic factors, including the magnitude of thermal stress, levels of irradiance, symbiont types, coral species composition and the local thermal history. In 2010, a major thermal anomaly led to extensive bleaching on reefs in South-East Asia. Whilst species composition has previously proven to be one of the strongest drivers of bleaching susceptibility, we saw an unprecedented reversal in the thermal sensitivity of coral genera on Singaporean reefs; the usually highly susceptible branching taxa such as *Acropora* remained relatively unaffected, whilst classically tolerant massive taxa such as *Porites* bleached severely. Recent phylogenetic studies have demonstrated that certain clades of the dinoflagellate coral symbiont *Symbiodinium* may confer a limited thermal tolerance on the coral host and thus diminish bleaching susceptibility. We therefore returned to the reefs of Singapore to sample a range of twelve coral species that exhibited varying bleaching responses during the 2010 event. Using massively parallel next-generation sequencing technologies, we targeted the *Symbiodinium* ITS2 region with 454 tag pyrosequencing. This approach generated 265,758 sequences and these sequences were identified with a novel bioinformatics pipeline for classifying *Symbiodinium* cladal and subcladal types. Preliminary analyses reveal that whilst Clade C was predominant amongst the twelve coral genera, a significant number of hitherto unidentified subcladal types were also discovered. Of special note, corals of the genus *Galaxea*, which were least affected during the 2010 bleaching event, uniquely amongst the genera sampled were comprised almost entirely of the classically

thermotolerant Clade D. This study may reveal the answer to the paradox of the unique response to bleaching of Singapore's corals.

Keywords: Bleaching, Tag metagenomics, Symbiont Clade Diversity

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14:20 – 14:35

Assisted migration of heat tolerant corals – a way out of the coral reef crisis?

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Corals from the world's hottest sea, the Persian/Arabian Gulf ("the Gulf"), have been proposed as candidates to help the restoration of reefs devastated by rising sea surface temperatures (SST) in other regions of the world. It is unknown, however, whether local adaptations to the unusually high salinity of the Gulf and its uncertain connectivity to the adjacent Gulf of Oman (normal oceanic salinity) will allow a wide distribution of heat tolerant corals either by assisted migration or natural dispersal. Here, I will discuss whether the intentional translocation of Gulf corals represents a realistic solution for coral reef conservation.

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Speed Talks

14:35 – 14:40

Coral bleaching and the regulation of host fluorescent pigments: implications for monitoring coral stress.

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Like many other cnidarians, reef-building corals contain photoprotective pigments of the Green Fluorescent Protein (GFP) family, which have been widely utilised as imaging tools in biomedical research. A decrease in host fluorescence associated with thermal stress has been reported by several laboratory studies, which contrast field observations of reefs appearing more colourful at the onset of bleaching events. To address this issue, we exposed *Porites lichen* to a gradual increase in water temperature using our experimental mesocosm at the National Oceanography Centre Southampton. Throughout the stress treatment and subsequent recovery phase we monitored the emission intensity of the green tissue fluorescence *in vivo* and used chlorophyll fluorescence and photography to assess the degree of bleaching. Our findings suggest that a close relationship exists between bleaching and host pigment regulation; this bears potentially wider implications for the use of fluorescence as a biomarker of coral stress and an *in vivo* tool for monitoring coral health, as well as providing new insights into the function and regulation of fluorescent pigments in zooxanthellate corals.

Elena Bollati, Cecilia D'Angelo & Joerg Wiedenmann

Coral Reef Laboratory, University of Southampton

14:40 – 14:45

Colony size related shifts in bacterial diversity; an indication of senescence?

Alex Williams

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The expression of senescence, a defining feature of ageing and development has received little in- depth attention in the context of corals. Despite this, much research into coral disease refers to possible instances of senescence in corals, such as the generation of tissue abnormalities and potential increases in disease susceptibility. As diseases in corals are often associated with shifts in the corals natural microbiota, this study aimed to assess the microbial community composition of variously sized *Goniastrea aspera*, with the aim of identifying whether size, and by extension age-related shifts in the bacterial communities are present. There was a significant difference (ANOSIM, $R = 0.529$, $P = 0.001$) between 16S rRNA gene diversity from small, medium and large corals, showing that the bacterial diversity does indeed change between coral size and therefore age, yet were consistent between replicates from the same grouping. Furthermore, we were able to show that the dominant microbial species present in the tissue of *G. aspera*, was also associated with the endolithic algal band present within the skeleton. This strengthens the idea that corals endolithic algae play an important role in the overall coral holobiont and can influence the bacterial community of the corals tissues directly. However, further work to understand the extent of this role would be necessary to fully understand this aspect.

Williams, A.D., Brown, B., Putchim, L., Sweet, M.J.

14:45 – 14:50

DNA barcodes reveal patterns of biodiversity in snapping shrimp (Alpheidae) from coral reefs across the Chagos Archipelago and western Madagascar.

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Coral reefs are thought to be the most biodiverse marine ecosystems. However, it is only recently that species richness estimates of reef communities have included studies of the cryptofauna. These organisms reside in the interstitial spaces within the coral framework and are likely to comprise the largest component of reef biodiversity. Here, DNA barcodes were used to compare the diversity of snapping shrimp across the Chagos Archipelago and two separate sites along the west coast of Madagascar (Andavadoaka and Nosy Sakatia). The samples were collected from dead branching coral colonies at depths of 8-12m and partial fragments of the 16S ribosomal gene were sequenced and sorted into molecular operational taxonomic units (MOTUs). Overall, 39 putative species were resolved using the generalised mixed Yule coalescent method. The mean species richness per dead coral colony was shown to be significantly higher in the Chagos Archipelago compared to both Andavadoaka and Nosy Sakatia. Furthermore, the total species diversity estimated by Chao 1 and ACE statistics suggested at least 34 species of snapping shrimp in Chagos, 22 in Andavadoaka, and 10 in Nosy Sakatia. These results indicate that the northern Mozambique Channel does not necessarily harbour high levels of marine biodiversity for all taxa, as shown by stony corals. In addition, the high diversity across Chagos provides further evidence for the importance of the archipelago. In a world where the future of coral reefs is uncertain, it is important to continue preserving areas like the Chagos Archipelago, which have the potential to act as source populations to replenish localities under more direct human pressures.

14:50 – 15:35 Poster Session (Tea/Coffee & Mince Pies)

Session 4: Conservation Management

15:35 – 15:50

Is direct seeding of mass cultured coral larvae an effective option for reef rehabilitation?

Alasdair Edwards

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Large scale rearing of coral larvae during mass spawning events and subsequent direct introduction of competent larvae onto denuded reefs (“larval seeding”) has been proposed as a low-tech way of enhancing coral recruitment and hence rates of recovery of degraded reefs. Such techniques potentially offer a relatively cheap way to enhance coral larval settlement on reefs that show low rates of natural recovery. While some studies have shown positive effects on settlement in the short-term, to date none have examined the long-term effects of larval seeding for a broadcast spawning coral. Here we test whether larval seeding significantly increased coral recruitment rates both in the short (5 weeks) and longer term (~6 mo to 1 year). Larvae of *Acropora digitifera* were reared *ex situ* during a mass coral spawning event in Palau and approx. 1 million larvae were introduced to 7 artificial reefs while 7 others were left unseeded. Settlement tiles deployed on both seeded and control artificial reefs were retrieved for examination 5 weeks and 30 weeks after seeding. In addition, the presence of visible coral recruits on the artificial reef surfaces was monitored before and for ~13 months after the larval seeding. Density of acroporid spat was significantly higher on seeded tiles than controls 5 weeks after seeding but this effect had vanished by 30 weeks. Similarly, comparison of the densities of new visible *Acropora* recruits between seeded and control artificial reefs showed no significant difference ~13 months after seeding. We conclude that while larval seeding can markedly increase spat settlement rates, post-settlement mortality levels are so high that this has no significant long-term effect. Furthermore, the rate of loss of acroporid spat between 5 and 30 weeks appeared to be density-dependent. The results show that reef rehabilitation methods that aim to harness coral sexual reproduction would be better to focus on rearing corals through the initial stages to overcome massive early post-settlement mortality bottlenecks.

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15:50 – 16:05

A framework for exploring variable relationships between ecosystem health and human wellbeing

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The Millennium Ecosystem Assessment highlighted the role of ecosystem services for human wellbeing. However, although the ecosystem service concept suggests a positive relationship between ecosystem health and human wellbeing, the complexities within this relationship are poorly understood. In particular, the “environmentalists’ paradox” refers to the apparently simultaneous improvements in human wellbeing that can occur while ecosystems are degraded. This is particularly the case in rapidly transforming coastal areas where coral reefs occur, with many people in these areas dependent on ecosystems that are under threat or already degraded. The NERC funded Sustainable Poverty Alleviation from Coastal Ecosystem Services (SPACES) project has constructed a heuristic

framework that can be used to identify feedbacks, links and distribution of benefits from ecosystem services in coastal Kenya and Mozambique.

The SPACES framework takes the form of multiple interlinked chains of ecosystem services, each describing how ecosystem service goods are obtained from coral reefs, how they are given value through the access and markets, and how the benefits are disbursed among people impacted by the service. Each chain contains elements that describe the ecological stocks, flows, goods, value and share, while multipliers are processes, such as coral growth or human inputs that determines the relationship between these elements. We present on our use of Ecopath and fishery catch data, reef carbonate budget censuses, household and community surveys to populate this framework to describe how human needs and wellbeing can drive feedbacks within the coastal protection and reef fishery chains, and the linkages and conflicts between chains. By exploring how the linkages in the chains interact under different future scenarios (e.g. changes in the price of reef fish) we identify where policy and management tools can be applied to increase wellbeing of coastal populations while maintaining ecosystem quality.

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16:05 – 16:20

Evolution of the Darwin Initiative: integrating poverty into biodiversity conservation priorities

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Since its launch in 1992, all projects funded by the Darwin Initiative have had to show how they are **contributing to building capacity in biodiversity conservation**. In 2011, the Department for International Development (DFID) became a co-funder of the Darwin Initiative and introduced a second, dual objective for DFID-funded Darwin projects to contribute to **poverty alleviation**. Circa 90% of all Darwin projects are now funded by DFID and must therefore meet this objective.

Linking biodiversity and poverty as dual objectives is not a new issue. The Convention on Biological Diversity opened for signature at the Earth Summit in 1992 in part to address concerns about the sustainability of biodiversity use. In 2002, the CBD set a series of targets including ‘to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation’.

This paper discusses the response we have witnessed from the biodiversity conservation community to the new challenge – both in building poverty into biodiversity projects as an explicit objective but also of meeting DFID’s requirements for evidence of their contribution to both biodiversity and poverty. We have evidence that suggests that we are witnessing a wholesale shift of how we communicate the importance of biodiversity and how we capture evidence of the importance of biodiversity.

16:20 – 16:35

Darwin Initiative to ensure engagement in Cayman’s Enhanced Marine protected area system

John Turner

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The Darwin initiative project to *Enhance an Established Marine Protected Area System* will increase No-Take protection from 15% to ~50% of representative reef habitat. Through detailed field study and extensive public consultations, four aspects were highlighted as integral to the success of the new MPA system and these have been investigated this year through a Darwin Initiative Post-Project. These challenges are: (1) Effectiveness of culling invasive lionfish *Pterois volitans*; (2) Protection of multi-species fish spawning aggregations (SPAGs) throughout the

year and not just during grouper spawning; (3) Sustainability of zoned concessions to allow fishers to fish 'over spill' from the Marine Reserves; and (4) New technology to support enforcement of an MPA system which has increased in area by a factor of 3. Results indicate that: (1) lionfish are now exploiting seagrass and mangrove habitats as well as patch reef and fore-reef environments, and comparisons of culled and uncultured areas indicate that the fish are learning to evade cullers; (2) 27 species of fish aggregate to spawn at known SPAGs at different times throughout the year, indicating the need for continuous, rather than seasonal protection of SPAGs; (3) Biomass of both herbivores and carnivorous fish is highly variable within and between the Cayman Islands, with overspill being demonstrated across some Marine Reserve boundaries, and fishers are evidently aware and benefiting from this effect, and baseline levels of fish biomass have been mapped before designation of the new Marine Reserves; (4) Innovative smart phone 'apps' have been developed to engage and empower users of the MPA, and provide an anonymous reporting system of violations, and enforcement officers have been equipped with wi fi cellular tablets giving real time access to permit databases and to allow reporting while on patrol. The findings improve MPA management with increased support from all stakeholders.

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Speed Talks

16:40 – 16:45

A Caribbean Coastal Island Community vs. Regulatory Capture, Island of Culebra, Puerto Rico

William Taylor

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The traditionally underserved island archipelago of Culebra, Puerto Rico's recent history began as spoils of the Spanish-American war at the turn of the 20th century. Local Spanish colonists were forced to tolerate decades of target practice by US and NATO military forces, even pushing much of the population to surrounding islands. In the mid-seventies through local protests involving less than 800 families and led by the local fishermen's association and courageous mayor, the community managed to remove the U.S. Navy.

In 1981 the Fishermen's association of Culebra proposed a no-take marine protected area in an attempt to recover coastal resources. However it was not until 1999, through decades of conflict with the local government that the no-take marine protected area -the first in Puerto Rico- was established. Fifteen years on, and the reserve has maintained its community-led structure, with little regulatory and nearly non-existent financial support from the government and agencies, the functionality of the reserve is down to local compliance. Academic alliances produce coral farms, eco jobs, and national science foundation jobs for local students in the reserve. A coral farming and transplanting project established in 2004, has grown into the most successful in the eastern Caribbean, conducted through a strong locally established network.

Community leaders established coastal zone management laws which implemented special zoning regulations, protecting the critical habitat resources of Culebra since 1976. Today the community faces blatant corruption and/or regulatory capture of the planning process. Climate change impacts are compounded as the community is forced to defend its rights and resources from a new fast track permitting process which incapacitates meaningful public participation, now changing the nature and character of the coastal zone community.

Taylor, W C; Lucking, M A

16:45 – 16:50

Coral diversity and reef resilience in the northern Myeik Archipelago, Myanmar

Sophie Benbow

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Intensive surveys of coral community structure and reef resilience were conducted in the Myeik Archipelago, Myanmar in March 2014. Hard corals were dominant at 33% cover overall (maximum 80%), highest on inner reefs, then rock walls then outer reefs. A total of 287 hard coral species (68 genera, 17 families) were observed, giving a prediction of ~ 309 species. Coral species diversity was highest on inner reefs due to dominance and high diversity of the genus *Acropora*, but overall, coral communities were dominated by *Porites*, particularly on outer fringing reefs. Coral community composition was similar to the Coral Triangle/Indonesian region, though some species characteristic of the west and northern Indian Ocean were present (including *Acropora roseni*, *A. rudis*, *Plesiastrea devantieri* and *Anomastrea irregularis*) emphasizing the character of the Andaman Sea as a transition zone between the west and eastern parts of the Indo-Pacific. Two coral species were listed as Endangered (*Acropora roseni* and *A. rudis*), and 36 as Vulnerable.

Overall reef resilience was scored at average to below average levels. Some sites, particularly those on outer fringing reefs, showed unmistakable evidence of past mortality consistent with the presence of high sea surface temperatures in 2010, likely due to a combination of El Nino and negative Indian Ocean Dipole (IOD) phases. Inner reefs may have been sheltered from thermal stress by high turbidity, and/or the dominance of fast growing *Acropora* resulting in faster recovery from past impacts. There was a general absence of fish, high presence of sea urchins, and high frequency of observed coral entanglement by fishing gears, suggesting high fishing pressure.

These results will be used to inform spatial planning for marine protection zones within the archipelago. We recommend an archipelago-wide participatory approach to management, to facilitate an understanding of the multiple goals for management at different reef sites.

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16:50 – 16:55

Using social networks to study marine species

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Social networks have become a common method for sharing images, for example Facebook which has over 250 billion uploaded images from its community of users, and a further 350 million posted every day. Shared images of marine life that have been given tags by recreational SCUBA divers, aquarists, marine researchers, shell collectors, etc., may only represent 0.01% of this data but it is still in the order of 25 million images and increasing.

Manual analysis of these images show potential for very high accuracy (0.97) of image tags, however there are significant challenges, namely how to access and search the data, how to automatically process the text and how to apply the methodology in different research scenarios. In response to these challenges a prototype system [<http://www.jonchamberlain.com/groupsourcing>] has been developed that:

- Presents a methodology for accessing, caching and processing social media posts;
- Aligns data with a marine species taxonomy (in this case WoRMS);
- Provides a simple interface to search for text and images of a particular species.

The initial cached dataset contains 39,039 message threads, of which over half are linked to an image, posted by 14,793 users in 34 groups. These messages contain over 14,000 mentions of marine species. Applications include

modelling associations between species, such as physical similarity, feeding, commensalism, etc., and to monitor changes in species range and habitat.

Engaging a large audience via social networks to take an interest in marine species and conservation issues is crucial at a time of unprecedented loss due to human impacts. In comparison to other methods of citizen science in the domain of marine biology this approach offers a high accuracy and low cost alternative with substantial participation.

Jon Chamberlain, Udo Kruschwitz, Massimo Poesio, David Smith
Coral Reef Research Unit, University of Essex

16:55 – 17:00 Closing remarks

17:00 – 20:00 Reception in the London Zoo Aquarium

Poster Presentation Abstracts

Trends in organic carbon storage in mangrove sediments along a tidal gradient on Unguja Island, Zanzibar

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Land use conversion is the second largest source of anthropogenic greenhouse gas emissions after fossil fuel combustion. Carbon payment schemes provide financial incentives for sustainable forest management; so far coastal wetlands are not included in these schemes despite high carbon sequestration potential and large soil carbon stores. This study aimed to investigate parameters affecting soil organic storage across a tidal gradient in mangroves in Zanzibar. It was expected that low intertidal areas would have highly anoxic sediments supplemented by organic matter from marine sources leading to large organic carbon stores. Sediment cores were taken from three intertidal zones in three mangrove forests and sub-samples were analysed. A relationship between LOI and organic carbon from dry combustion was investigated, shown to be significant and consequently applied to the LOI dataset. There was a strong inverse exponential relationship between bulk density and organic carbon content ($R^2=0.79$) however sediment properties were shown to vary between sites and across the intertidal gradient. There was an unexpected down-core increase in organic carbon content at all high intertidal zones (Kisakasaka: $R^2=0.222$, $p<0.001$; Pete: $R^2=0.184$, $p=0.014$; Unguja Ukuu: $R^2=0.211$, $p=0.014$) and some mid intertidal zones. There was a significant negative relationship between intertidal height and organic carbon (Mg/ha) in the upper metre of sediment ($R^2=0.331$, $p=0.001$). Over the full sediment depth however, the relationship between intertidal height and organic carbon was reversed due a positive relationship between mean sediment depth and intertidal height ($R^2=0.5$, $P<0.001$). This study concludes that sediment depth is the main driver in soil organic carbon storage however when sediment depth remains constant, the size of the organic carbon store is highest in low intertidal zones. The results of this study provide valuable data from mangroves on island settings in East Africa, an area which has been significantly under-represented in soil organic carbon research.

Second generation experimental mesocosm for long-term reef coral experiments at the University of Southampton

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The University of Southampton's Coral Reef Laboratory (CRL) based at the National Oceanography Centre Southampton has extended its experimental capacity by adding a 7500 litre multi-compartment experimental aquarium system to the existing facility. Coral research benefits from tightly controlled laboratory experiments in which environmental conditions can be manipulated over extended periods. For long-term experimental studies, stability in the aquatic environment and replication between mesocosms is essential to identify the effects of specific treatments on coral physiology, survival and resilience. The CRL's second generation of experimental mesocosm consists of five identical 1500 litre systems that can be connected in different configurations depending on experimental requirements. Per individual systems, three 50 l experimental tanks with adjustable metal halide lighting units, are connected to a 1000 l reservoir and 300 l sump for filtration, heating and other optional equipment. Each system is additionally connected to a glass tank on a custom built rack allowing side by side observations of experimental conditions, with computer controlled cameras offering online monitoring and scheduled time-lapse videoing/imaging over extended periods. Glass aquaria are fitted with the latest technology in LED lighting with wireless computer controlled capabilities to manipulate light colour and intensity. The large water volumes circulated through the individual systems sustains stable water quality even during harsh stress treatments (e.g. heat stress) in the integrated experimental tanks. The identical set-up of the systems allow optimal replication and control. The capacity of the facility offers extended opportunities for comparative studies in coral physiology and maintains the UK at the forefront of experimental coral reef research.

Adam J. Reed, Cecilia D'Angelo and Jörg Wiedenmann

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A comparison of the marine biodiversity of Queensland's tropical and subtropical reef habitats by the Reef Check Australia community monitoring program

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Reef Check Australia's (RCA) trained volunteers have been monitoring the health of coral reefs on the Great Barrier Reef (GBR) since 2001 and subtropical reefs in South East Queensland (SEQ) since 2007. Both divergences and similarities in biodiversity were evident when the two regions were compared. Results from pooled regional surveys show differences in substratum composition as well as distribution and abundance of fish & invertebrate communities. The tropical coral reefs of the GBR had higher average coral cover (37%) than the rocky reefs of SEQ (20%). Coral trout and grouper were found on more GBR research sites (36% and 45% respectively), although in relatively low abundances (<1/100m²). Sweetlips (>3/100m²) and snapper (>6/100m²) were found on more SEQ research sites (49% and 65% respectively). Butterflyfish were found on more SEQ sites (86%), but in greater abundance on the GBR (>5/100m²). Urchins and anemones were found on more SEQ sites (15% and 30% respectively) and in greater abundances (>3/100m² and >5/100m² respectively). Giant clams were found on more sites (>80%) and in much higher abundances on the GBR (>12/100m²). Data is stored in a publically-accessible database, a useful tool for detecting temporal and spatial changes in reef biodiversity and health.

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Coral reef functioning in upwelling-influenced Northwestern Costa Rica

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The northern Pacific coast of Costa Rica experiences pronounced seasonal changes in key water parameters such as temperature, pH and nutrient concentrations due to wind-induced coastal upwelling between December and April. This may control functioning of local coral reef communities, but related knowledge is scarce. Thus, this study monitored water quality and benthic community composition of reefs in Papagayo Bay weekly over one year from April 2013 to April 2014. Distinct drops in water-temperature of up to 7 °C in February and March 2014 indicated major upwelling events, which were accompanied by increases in nutrient and chlorophyll *a* concentrations and subsequent increases in organic matter. Benthic surveys showed a sharp decline in benthic fleshy macro-algal cover from 15 to 1 % in April 2013 after synchronised sexual reproduction of the green algae *Caulerpa sertularioides*. Macro-algal cover remained low throughout the year before increasing to 9 % in March 2014 in response to significantly elevated nutrient concentrations during upwelling. Over the year, live coral cover of the dominating hard coral *Pocillopora damicornis* increased dramatically from 22 to 51 %. Findings therefore hint to a dynamic reef ecosystem with high resilience against substantial environmental variations. The continuous and rapid coral recovery demonstrates that local corals are highly adaptable to abrupt changes in water quality, and suggests that benthic community composition may oscillate on a multi-annual rather than a seasonal cycle.

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Reef resilience: a relationship between herbivorous fish biomass and the benthic community in Utila, Honduras

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Herbivorous reef fish are major determinants in structuring the benthic community which in turn provides reef resilience. Assessing their functional impact through population composition and feeding selectivity is essential with present global reef vulnerability to benthic phase shifts, in addition to climatic and local anthropogenic stressors. With a focus on functional group biomass, we assess the ability of the herbivorous fish community to promote reef recovery and resilience on an archetypical Caribbean reef. Benthic video and diver-operated stereo-video transects were conducted across four sites to quantify benthic community structure and herbivorous fish biomass and composition respectively. Macroalgal feeding assays using remote video observations were undertaken to directly assess feeding preferences and grazing rates of individual fish species. Across sites, the benthic community comprised low live hard coral cover ranging from $17.15 \pm 1.93\%$ to $23.63 \pm 2.31\%$, but exhibited macroalgal dominance representing $< 46\%$ total benthic cover. The herbivorous fish community displayed low species richness supporting eighteen species, typifying low functional redundancy across and within functional groups. Grazers were most dominant in terms of biomass, followed by excavator parrotfish *Scarus vetula* and *Sparisoma viride*. The biomass of excavators solely predicted the algal benthic community, with a positive and negative association with crustose coralline algae and macroalgal cover respectively. Selectivity trials showed juvenile and intermediate phases displayed a diverse utilisation of food source and higher grazing rates on macroalgal species, but a clear avoidance and lower grazing rate at terminal phase. The low functional redundancy and compositional biomass of functional groups remain below the critical threshold needed to exert their ecological role in promoting reef recovery and resilience. Ultimately, top-down and bottom-up processes of overfishing and nutrient loading may further manipulate the herbivorous fish and benthic community relationship, highlighting the need for local management of anthropogenic impacts on these reefs.

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Applying Community-Based Coastal Resource Management Approaches in the Ancestral Waters of the Agta-Dumagat-Remontado and Tagbanua Tribes

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The Philippines lies within the Coral Triangle, the epicenter of marine biodiversity. There is also a diverse human population with approximately 14% of the population considered indigenous. In many cases areas of high biodiversity are inhabited by indigenous peoples (IPs).

Conflict between marine resource users is increasing as commercial fishers take an ever larger percentage of total catch, outcompeting local fishermen for dwindling resources. Conflict has also arisen over the use of the indigenous people's ancestral fishing grounds by non-indigenous in-migrants. The indigenous people consider their traditional fishing areas sacred as their ancestors have fished there for generations, a view not necessarily appreciated by recent settlers.

Community-based coastal resource management (CBCRM) process is being practiced to address coastal degradation in indigenous people's ancestral domains through people-centered management strategies. In the last three decades CBCRM has been practiced in Philippine fisher communities, FFI has replicated this process with the Tagbanua and Agta-Dumagat-Remontado ancestral waters. The factors necessary to facilitate the successful establishment of CBCRM includes heightening of environmental awareness, community mobilization, and institutional support. These factors rely on the distinctive cultural capacity of the indigenous peoples to understand their problems culturally as against the modernity of urban necessities and draw-up plans and solutions through internal capability examination.

After two years of implementation initiative gains are 1) two no-take zones are being established in the ancestral waters, 2) Indigenous people's organizations are strengthened through cultural values renewal, 3) Local government awareness is raised towards co-management agreements, 4) Local community organizers are developed.

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Sedimentary oxygen consumption as an effective process indicator of organic matter stress on coral reefs

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For coral reef management, it is essential to distinguish the key drivers of ecosystem degradation. Identifying process indicators that can indicate long-term responses and ecosystem trajectories after exposure to specific stressors may provide important quantitative metrics to set specific conservation goals. Sedimentary oxygen (O₂) consumption reflects OM degradation, and benthic-pelagic coupling allows sediments to reflect OM changes in the overlying water, suggesting that this parameter could represent a process indicator of OM pollution. We investigated the potential to identify OM pollution at varying exposures to points of discharge at local scales, using a simple method that can be applied in areas with limited infrastructure. The study focused on neighbouring coral cays off Manus Island (Papua New Guinea) which offer a 'natural laboratory', displaying similar physical characteristics while ranging from uninhabited (Onetah) to relatively densely inhabited (Ahus). Three sites were investigated including two on Ahus Island; one directly adjacent to, and one at 300m distance from, an OM point of discharge, and one control site on Onetah Island. Reef flat sediment cores were incubated *in situ* inside opaque bags and O₂ consumption was quantified. Back reef benthic community composition, coral recruitment and fish abundance were quantified. O₂ consumption decreased with increasing distance from the source of discharge, and differences in the benthic community mirrored these results. Macroalgae and cyanobacteria were most abundant in the reef adjacent to the point of discharge, and live coral was highest on the control site without any direct exposure. Key herbivorous fish functional groups were not significantly different between islands. Our findings suggest that top-down drivers (fish) play a less significant role than bottom-up drivers (OM) in shaping these benthic communities, and that sedimentary O₂ consumption is an effective process indicator of the response to OM stress on coral reefs.

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Adding Value to LMMAs: Coral Gardening and Transplantation to enhance community-managed coral reef systems

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Reef systems in the Bay of Ranobe, Southwest Madagascar, are under chronic anthropogenic stress from overfishing and are unlikely to recover from environmental stressors without active intervention. Rose Garden, a locally managed marine area (LMMA) in the bay, has been protected since 2007 and is managed at the community-level by the fishermen's association 'FI.MI.HA.RA'. Passive reef restoration efforts in the form of fishing closures have not yet resulted in coral rehabilitation. For the first time in Madagascar, corals are being nursery grown for transplantation to degraded reef systems. The NGO ReefDoctor is developing and implementing a two-step methodology for a straightforward, low-cost and community-appropriate coral rehabilitation programme.

Nurseries were first implemented in the Rose Garden in 2012 and have since changed in design to suit environmental conditions and for ease of maintenance. 'Corals of opportunity' - healthy, unconsolidated coral fragments which would otherwise perish, are collected for growing on the nurseries. A pilot study is currently being conducted to assess a simple means of transplantation. Transplantation of nursery-grown coral colonies can result in a direct and immediate increase in live coral cover. However, coral rehabilitation of a LMMA will be a long, slow process. Many coral restoration schemes around the world have lacked quantifiable aims to evaluate success. ReefDoctor understands that such a long term commitment to the local community requires diligent monitoring to meet success criteria and report on past mistakes and good practices. The aim of the coral rehabilitation programme is to promote local increases in coral cover and biodiversity, with the ultimate goal of improving ecosystem complexity and function at the LMMA Rose Garden.

Bethan Greenwood, Emma Gibbons, Shane M. Abeare, [Roderick Stein-Rostaing](#)

***Anomastrea irregularis*, a Vulnerable coral of the rocky intertidal zone of Watamu Marine National Park, Kenya.**

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Anomastrea irregularis is a rare scleractinian coral found in tropical coastal ecosystems. This coral is classified as Vulnerable by the IUCN, an EDGE species, and the only species in its genus. Previously there have been no projects focusing solely on *A. irregularis*. Colonies were studied in three main sites of Watamu Marine National Park in Watamu, Kenya with a total of 131 colonies located. Most colonies were found in the northern end in the park (57%), with fewer in the central region (28%), and even fewer near the southern end (15%). *A. irregularis* found in the northern site were generally the largest (13.68 cm²), but colonies found in the southern most site were the most likely to be found with other coral species. In addition to *A. irregularis* specific data, transects were laid parallel to the shore near the seaward edge of each group of rock pools. *A. irregularis* seems to be minimally dependent on conspecifics and able to survive in pools with varying benthic cover. We suggest that further research be completed on the population dynamics of this species and that management of these inshore habitats be included in the ongoing conservation in this national park.

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Population genetics parameters of the emerging corallivorous snail *Drupella cornus* in the northern Gulf of Eilat and Tanzanian coastlines based on mitochondrial COI gene sequences

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The genetic diversity and population genetic structures of *Drupella cornus* populations from six localities in the northern Gulf of Eilat (GOE) and five localities in Tanzania (269 individuals) were investigated using mitochondrial cytochrome c oxidase subunit I (COI) gene sequences. Overall 108 haplotypes 47 in GOE and 61 in Tanzania were revealed with similar calculated haplotype diversity for all *D. cornus* populations within each location (0.9 +/- 0.00025 and 0.903 +/- 0.00078 respectively). Only one haplotype was shared between the GOE and Tanzanian populations. Network analysis for the 108 COI haplotypes displayed two major clades separated by nine mutations. Bayesian analyses of population structures revealed two clusters highly correlated with the collecting region. Analysis of molecular variance showed 73% of the molecular variance for all *Drupella* populations is a result of the differences among regions. Within regions most of the molecular variance is based on within population differences 89% north vs. south in Tanzania and 98% Israel vs. Jordan in GOE. Fu's and Tajima's D values for all populations were negative suggesting that the *Drupella* populations in GOE and Tanzania underwent population expansion or purifying selection. Based on the differences in genetic structuring within populations the study strongly recommends application of conservation approaches that suit the description of the population in each region.

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Supporting policy makers to achieve Climate Compatible Development (CCD) in the coastal zone

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With understanding of global climate impacts improving, it is becoming clear that climate change will have significant negative impact on the functioning of many coastal ecosystems (Stern 2007). These ecosystems support a large proportion of the world's poor (Coulthard, Johnson, & McGregor, 2011; Food and Agricultural Organisation (FAO), 2005). Of these coastal populations, it is often the poorest communities that are in the worst position to adapt to changes in their environment and livelihoods (Gasper, Blohm, & Ruth, 2011; IPCC, 2007).

Incorporating climate change into development planning is challenging. Policy makers are often hampered by incompatible or conflicting policies, low organisational capacity, restricted financial resources and poor understanding of the predicted impacts of climate change at the local level (Mirza, 2003). These constraints can lead to policies that may have negative impacts for the very people that they are intended to benefit.

Whilst climate change is not a new or emerging issue, developing countries have been slow to respond to the issue (Kok & de Coninck, 2007; Munang, Thiaw, Alverson, Liu, & Han, 2013). This has meant its integration in national planning, sector planning and regional planning has often been poor. Knowledge of climate change and its predicted risks is often very low at the sub-national level – in both developed and developing countries (Marshall, 2011; Sovacool, D'Agostino, Rawlani, & Meenawat, 2012).

The aim of this paper is to describe participatory methods that can be used by government policy makers for the design of a CCD policy. It involves comparing a business as usual scenario to a climate compatible scenario using evidence from multiple sources (social, economic and political) to develop an understanding of the potential for a climate compatible future and what the costs and benefits of achieving this future would be.

Successfully applied in Kenya and Sri Lanka, this method shows how these countries might achieve a climate compatible future for their coastal areas. This paper also seeks to show that the path to achieving a CCD future does not require significant investment in new policies and legislation.

In both Kenya and Sri Lanka, the coastal areas are seen as prime areas for investment. This investment is set out in national development plans and is seen as a way of contributing to the national economy while lifting local people out of poverty.

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Mitigating the Environmental Threats Posed by the Diving Industry: The Green Fins Approach

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Scuba diving and snorkelling are highly accessible activities enjoyed by a mass audience globally. Every year, one million new divers, with limited knowledge of the fragility of the environment, come into contact with coral reefs. Intensive scuba diving and boating can directly damage corals, making them susceptible to other stresses and reducing live coral cover. Significant diver damage is often seen on frequently visited reefs and as a result there has been a call to regulate the scuba diving industry in these sensitive habitats.

Green Fins is a public-private partnership which aims to promote environmental stewardship within the diving industry. Since 2004, it has become widely adopted across numerous diving hotspots in South-East Asia. Dive operators receive Green Fins certification following an agreement to adhere to an environmental code of conduct. A robust annual assessment system was developed between 2007 and 2010 to quantify the environmental risk of individual dive operators and to monitor their compliance to the code of conduct. The approach also provides strategic outreach to certified diving and snorkelling operators and their customers.

Here we present an analysis of environmental risk assessment data from dive operators in two intensively dived areas in the Philippines (Puerto Galera and Moalboal) over a four year period of Green Fins implementation. In Puerto Galera, 15 dive operators reduced their environmental risk by 19% over four years and in Moalboal, eight dive centres reduced in their risk by 21% over three years. These findings indicate that implementation of the Green Fins approach can lead to effective compliance with environmental diving standards, reducing the impact of diving-related stressors on coral reefs. We also discuss the effectiveness of the Green Fins' strategic outreach campaigns, training systems and support tools used to effect long term changes to the dive industries' operations and environmental practices.

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Are fluorescent coral pigments photoprotective?

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The vital symbiosis between corals and photosynthetic zooxanthellae can be disrupted by changes in environmental conditions, causing corals to lose their zooxanthellae, in a phenomenon known as 'coral bleaching'. Excess light and elevated temperatures act together as important drivers of coral bleaching. Therefore, the understanding of photoprotective mechanisms employed by the corals are important to assess the capacity of the reef founding species to resist climate change. A role in photoprotection of the symbiotic partners was assigned to fluorescent host pigments of zooxanthellate reef corals. To investigate this hypothesis, two colour morphs of *Hydnophora grandis* were studied: a cyan morph containing high concentrations of a cyan fluorescent protein (CFP); and a brown morph

containing lower concentrations of the same CFP. The cyan morph suffered less photodamage than the brown morph upon exposure of the corals to high intensities of blue light with a wavelength matching the excitation spectrum of the CFP. In contrast, both morphs suffered comparable photodamage under orange light, a spectral region not absorbed by the CFP. These results prove that the spectral properties are essential for the functioning of the pigments and indicate that under high light conditions, elevated tissue concentrations of fluorescent pigments can indeed provide photoprotection for the zooxanthellae.

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Transmission Electron Microscopic (TEM) markers indicate nutrient stress in reef corals

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Increasing evidence indicates that anthropogenic nutrient enrichment, both through primary effects on coral physiology as well as through secondary effects of an altered nutrient environment, has negative repercussions on the resilience of corals to environmental stress. Specifically, the susceptibility of corals to thermal- and irradiance stress induced bleaching increases as a result of a disproportionately high concentration of dissolved inorganic nitrogen compared to phosphate and carbon, such as occurs as a consequence of agricultural runoff into coastal waters. This study aimed to further investigate the impact of an imbalanced nutrient environment on zooxanthellae *in hospite* by culturing *Euphyllia paradivisia* in our experimental mesocosm at the National Oceanography Centre Southampton, allowing for the long term study on the effects of distinctive dissolved inorganic nutrient concentrations. Analysis by transmission electron microscopy revealed significant changes in zooxanthellae cell morphology in corals exposed to nutrient stress, specifically under phosphate starvation. The changes in the ultrastructure of zooxanthellae were associated with severe detrimental effects for the holobiont physiology. Our study provides further evidence that, in face of climate change, it is imperative to manage nutrient input into coastal waters in order to support the resilience of corals and thus the conservation of coral reefs.

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Utilizing GIS & Remote Sensing to Improve Coastal & Marine Resource Management in the La Parguera Nature Reserve, Puerto Rico

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This project is carrying out a time series analysis of the link between development and the health of the marine resources of the community of La Parguera, PR to provide information to aid in establishing levels of appropriate development to facilitate a transition to sustainability. The community is located in a Nature Reserve, and has also been designated a region of special interest for Ecotourism Development but lacks any implemented management plan to control development and provide resource protections for the extensive coral reef ecosystem. This is an attempt to improve on the information available for a Spatial Decision Support System (SDSS) and promote Coastal & Marine Spatial Planning towards improving coastal and marine resource management in this region. Methods being used include:

Image enhancements, image to image, & image to map rectification of original digital ortho aerial photos using ArcGIS 10.1

Unsupervised classification & Multi-temporal compositing for coastal change detection analysis using ArcGIS 10.1

Developing geodatabases of land use changes, socio-economic demographics, & the health of the coral reef over time.

Statistical & spatial data analysis of geodatabases for land use changes, socio-economic demographics, biological & physical indicators of reef health to identify correlations between land use & health of the reef.

Environmental Regulation of early life history traits of the Indo-Pacific coral *Pocillopora damicornis*

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"Little is known of the response of early life history traits of corals to the environmental regulation of adult colonies. As the nutrient enrichment of coral reefs from coastal input increases, this study aims to provide insight into the survival strategies of nutritionally enriched corals, in terms of fecundity and quality of planulae. 18 *Pocillopora damicornis* colonies were split into six nutritionally different treatment groups. Zooxanthellae densities and net photosynthesis was calculated to investigate the effect of nutrient availability on metabolic rate. Planulae were counted and collected for six weeks to determine coral fecundity and early life history traits were assessed, to determine the response of reproductive output and planulae fitness to changes in nutrient status. Yeast culture had a positive effect on fecundity and all early life history traits. Mean fecundity was 32.16 planulae/cm², (\pm SD=10.71), 39.27% (\pm SD=5.5%) of planulae settled before collection and 48.03% (\pm SD=24.75%) settled within one day after release. *Artemia* nauplii negatively affected fecundity (mean total, 32.16 planulae/cm², \pm SD=10.71). The time between settlement and primary polyp development was not significantly different between treatments. Mortalities were highest in the treatment fed shellfish diet and lowest in the treatment receiving no food (mean, 71.8% \pm SD=8.52% and 42.31% \pm SD=7.51% respectively). Increasing nutrient input on coral reefs is causing a shift to primarily heterotrophic corals, with stress causing corals to reduce fecundity. The level of recruitment needed to sustain coral reefs will not be met, and planulae may not have the energy stores required for successful settlement and primary polyp development."

The development and evolution of Maldivian coral reef rim islands

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Coral reef islands are low-lying (typically <3 m above MSL) accumulations of bioclastic sediment deposited by waves on atoll rims or platforms within atoll lagoons. They are of great ecological and socioeconomic significance, particularly as they represent the only habitable land in several regions. However, reef islands are thought to be among the most vulnerable environments to climate change, especially to sea-level rise. Understanding past responses of reef islands to environmental change and the timescales over which they have developed is fundamental to assessing their future resilience. The Maldives Archipelago is a nation comprised of 1,190 reef islands inhabited by a population of over 320,000. To date no detailed chronostratigraphic studies have been undertaken on the islands formed around atoll rims in the region; this is despite the fact that the rim islands are host to the majority of the population (88.93%), land area (82.43%) and infrastructure (all regional administrative capitals, hospitals, designated 'safe islands' and 57% of resorts are on rim islands). This study examines the geomorphology, stratigraphy, sedimentary composition and chronologies (via AMS dating) of reef islands at two study sites (windward and leeward) on Huvadhu Atoll. Models of reef island evolution and development have been found to differ between the two sites with models of rollover and lateral accretion characteristic of the windward and leeward sites respectively. Marked differences were also found in island ages, with underlying substrates dated at 4442 \pm 62 yr BP at the windward site and 2829 \pm 62 yr BP at the leeward site. While prior work has focused on regional differences in reef island development, this study highlights that there is no single model, but great diversity exists in reef island geomorphology, ages and modes of development even at the local scale.

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Coral reef framework production and bioerosion on windward and leeward coasts of Grand Cayman

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Anthropogenic and environmental factors are driving major ecological transitions on coral reefs with the impacts of these changes on the natural functioning and resilience of reefs receiving widespread attention. In contrast, our understanding of the implications for reefs as focal points for carbonate production and accumulation remains more limited, despite the critical role in creating and maintaining reef habitats and complexity. *ReefBudget* census based surveys were used to estimate the abundance of calcium carbonate framework producers and bioeroders at discrete sites on the windward south coast and leeward west coast of Grand Cayman within two distinct habitat types; *Acropora palmata* and *Orbicella spp.* framework dominated habitats. Carbonate budgets were calculated for each reef site and here we describe the results which provide an indication of structural resilience, while identifying the species responsible for the production and erosion of coral reef framework. Net rates of carbonate production ranged from +4.02 to -1.28 kg CaCO₃.m⁻².yr⁻¹. Corals were the dominant carbonate producers and parrotfish the dominant substrate bioeroders at all sites, but most carbonate framework production and erosion was driven by just a few key species. The shallow *Acropora palmata* habitat (1-6m) on the south coast was net erosional while the deeper *Orbicella* habitat (7-15m) had positive rates of net framework production. The leeward, west coast sites had positive carbonate budgets or were in stasis. Net erosion will have serious consequences for the south coast reefs and their ecosystem services over time; available habitat reduces and presumably the reef community carrying capacity; reef growth may stall and this threatens the coastal protection role of the reef particularly as sea-level rises.

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The Gulf of Aqaba as a coral reef refuge; *Stylophora pistillata*'s tolerance to extreme thermal stress

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There is scientific consensus that coral bleaching will increase in severity and regularity as sea surface temperatures rise over the course of the next century. The "HotSpot" model (NOAA) infers that a 1°C anomaly above the mean maximum summer temperature is likely to result in bleaching. This temperature threshold is combined with the duration of heat stress into a "degree heating week" (DHW) model, which aims to predict mass bleaching and mortality events worldwide. However, observational and experimental evidence has indicated that coral populations' bleaching response and level of thermotolerance is not uniform. It has been suggested that intrinsically thermotolerant populations should be identified and conserved to function as coral reef refugia in the face of climate change.

Herein, we discuss the Gulf of Aqaba as a likely coral refuge. *Stylophora pistillata*, a common shallow water scleractinian coral, was exposed to a succession of temperatures up to 5°C above ambient at the peak of summer in Eilat, Israel. The intensity and duration of heat stress was equivalent to 9 DHW which, in other regions, has previously induced "widespread bleaching and some mortality". The experimental corals showed no visible signs of temperature-induced bleaching and physiological tests revealed no significant differences between treatments and controls. It is concluded that *S. pistillata* in Eilat live well below its thermal bleaching threshold and may therefore survive significant future global warming.

Future research aims to investigate the evolutionary origin and mechanisms behind this characteristic and to assess whether the thermotolerant propensity is a result of phenotypic acclimatisation or adaptation. The findings of these studies will be used to examine the likelihood of using Red Sea corals to replenish reefs affected by bleaching events.

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Thermal tolerance of Red Sea corals and influences of past bleaching events

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Marginal coral reefs within the Red Sea provide clear evidence as to how corals can adapt to stressors and thus potentially future climate change; however, virtually nothing is still known of the inherent variability of key environmental factors that regulate coral fitness (e.g. temperature, chlorophyll *a*, light) or how this variability ultimately drives sensitivity to bleaching-induced mortality. This work bridges this gap in understanding. Remotely sensed environmental data (2003-2012) revealed significant spatial differences along the Red Sea: the southern Red Sea was warmer with higher chlorophyll *a* content and turbidity (light attenuation, K_d) than northern sites. Warmer southerly sites exhibited lower seasonal sea surface temperature (SST) variance (Farasan, 31.5-5.2 °C and Jeddah 30.9-5.6 °C), compared to the cooler northerly sites (Hurghada 29.2- 6.7°C and Wadi El Gemal 29-7.5 °C). Annual positive ST anomalies appear to have migrated northwards particularly during 2010 and 2012 but are still below the upper SST limit (Maximum Monthly Mean), considered to trigger bleaching, except in Jeddah 2010 and Wadi El Gemal during 2012 by ~1°C. Past bleaching episodes indicate that *Pocillopora sp*, *Acropora sp*, *Millepora sp*, *Stylophora sp* and *Porites* have been the most frequently bleached coral genera along the Red Sea. Surprisingly, massive coral species were observed to bleach more frequently (45.6%) than branching species (36.3%). A thermal stress-assay experiment conducted in the summer of 2013 at a northerly (Hurghada) versus southerly (Jeddah) sites indicated that coral species in the more highly variable northern site were more tolerant and demonstrated greater heat stress tolerance for massive coral than branching and soft coral species. Our data provides a new framework for coral susceptibility to future bleaching events.

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Going with the flow: Coral dispersal and climate change

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Dispersal by ocean currents is a major process controlling coral biogeography and resilience to disturbance, and as such will play an important role in influencing reef responses to environmental change. Experimental evidence also suggests that the process of dispersal will be affected by climate change as, for example, increased temperatures affect larval survival and development rates. Biophysical modelling provides a useful tool to predict coral dispersal on a large scale, filling in the gaps of empirical sampling efforts, as well as to explore the most important factors influencing dispersal and how this may change under future climate.

We present the first global-scale model of coral larval dispersal, uniquely incorporating 3 factors thought to influence this process: temperature, salinity and aragonite saturation state. The model confirms that most coral settle close to home, but that rarer long distance dispersal can connect entire ocean basins via 'stepping-stone' dispersal. However, long distance dispersal is reduced when abiotic factors are incorporated in the model, completely isolating some regions from sources of population replenishment. In this poster, I demonstrate how the model output can be used in various ways to provide evidence regarding marine population connectivity and theories of coral biogeography.