

27th

October 2016



Maldives Marine Science Symposium

Abstract Booklet

Themes

climate change
conservation
ecology
ecosystem dynamics
fisheries
management
oceanography
resilience
resource dependence
socio-economics



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Maldives Marine Science Symposium 2016,
held on 27th October 2016, at The Maldives National University, Malé, Maldives.

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Note

1. The abstracts in this booklet maybe of preliminary findings, and may be subject to change. Hence, none should be cited without prior written permission from the author(s).
2. The abstracts were prepared and submitted well in advance of the symposium, to review by Scientific Committee and to meet the printing deadlines. As a result, some abstracts may have changed or may not have been presented at the symposium. Our apologies for inevitable omissions and errors.

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We would like to thank our partners and sponsors, The Maldives National University, Project REGENERATE (a project supported by USAID and implemented by IUCN Maldives), the Mangroves for the Future Project (a project supported by UNDP) and Banyan Tree Marine Labs for their generous support in making the First Maldives Marine Science Symposium a success.

Special thanks go to the Scientific Committee of the Symposium, for their diligence in reviewing and sorting the abstracts. Dr. M. Shiham Adam, Dr. R. Charles Anderson and Dr. Steve Newman are especially noted to have provided consistent guidance throughout the process.

Warm thanks are also due to the Dean of the Faculty of Sciences, Dr. Shazla Mohamed and her team for their contributions in organizing this Symposium. In addition, we also note the hard work and effort put in by the staff of the Marine Research Centre, especially Ms. Mariyam Nazeefa, Mr. Mohamed Shimal, Ms. Fahmeeda Islam and Ms. Shafiya Naeem.

Last, but not least, we thank all participants and their respective organizations and resorts for their contributions, without which the Symposium would not have been possible.

* * * * *

Foreword

Maldivians depend significantly on our extensive marine environment, for our subsistence as well as livelihoods. The two main drivers of our economy - tourism and the fisheries sectors - rely on the country's rich marine resources. While fisheries activities rely on extracting marine organisms, tourism activities are heavily dependent on taking advantage of the beauty of our coral reefs. Despite the significance of our marine environment, they remain largely unexplored. Efforts are being made to enhance our understanding of the marine environment, ranging from studies on selected marine species to understanding the ecosystem dynamics of our coral reef systems.

The Marine Research Centre (MRC), since its establishment in 1984, has been undertaking research with a long term vision of conducting and facilitating relevant, high quality marine scientific research in the Maldives. The Centre's scientific endeavours quickly evolved through research collaborations with institutions around the world. The Centre's work ranged from assessments of exploited fishery resources for providing relevant scientific bases for fishery management, to enhancing our understanding of coral reef systems. Over the years, MRC, in affiliation with other research institutions, has produced research published in popular peer-reviewed journals as well as numerous local publications.

In addition to MRC's contribution to marine scientific research in the Maldives, there is increasing interest within the tourism sector as well as NGOs and citizen scientists to engage in marine research. Many tourist resorts now employ resident marine biologists who engage in varying levels of marine scientific research. In addition, several collaborative research efforts are now being made amongst MRC, overseas institutions, local NGOs and resorts. Unfortunately a lot of these research efforts go unrecognized due to a lack of an adequate platform for communicating such efforts.

MRC is delighted to host the very first Maldives Marine Science Symposium (MMSS), with the objective of creating a venue for parties involved in marine scientific research to come together to share their work and develop potential partnerships.

The symposium brings together a selection of research papers and poster presentations that cover (i) coral bleaching and reef restoration, (ii) coral reef ecology, (iii) marine megafauna dynamics and (iv) conservation planning and socio-economics. With this first symposium, MRC hopes to pave the way for hosting regular events where scientists can get exposure to marine research carried out in the Maldives.

The Organising Committee of the first Maldives Marine Science Symposium sincerely thank the authors for their contribution and participation in this event. We also thank our partners, Project REGENERATE (a project supported by USAID and implemented by IUCN-Maldives), Mangroves for the Future (a project supported by UNDP), Maldives National University, and Banyan Tree Marine Labs, for their contributions in making this event a success.

M. Shiham Adam, PhD
Director General

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Session 1

Coral Bleaching and Reef Restoration

Rapid Functional Recovery of Restored Coral Reef in the Maldives

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Abstract

Reef restoration can mitigate declines and enhance recovery of degraded coral communities. However, it is particularly useful to understand the rate of recovery of restored areas and how they function relative to natural habitat. The principal aim of this study was to describe fish communities and species composition, function and temporal development on restored reef compared to natural habitats. Fish communities were surveyed in restored coral patches, back and top reefs on Vabbinfaru, North Malé Atoll, Maldives in March 2016. Benthic composition, structural complexity and fish communities were quantified in 60 plots 5 x 5m (20 in each habitat). Age of restored reefs was considered as both a continuous and categorical variable (0-5, 5-10, >10 years old) to facilitate analysis of fish community composition and development over time. Restored patch habitat composition was most similar with back reef with high percent of coral cover, which was significantly lower on the top reef (78 ± 13 % SD). Complexity was greatest on back reef, intermediate on restored patches and lowest on top reef. Restored reefs had significantly greater fish abundance but no difference in species richness or biomass from either other habitat. Restored reef fish communities were also most similar to back reef (Simpser analysis 70.82%). Percent coral cover on restored reefs was high (94 ± 7 % SD) and comparable to back reef just 6 years after planting. A curvilinear relationship existed between age of restored reef and reef complexity, coral cover, fish abundance, fish richness and fish biomass. Fish community metrics peaked at 5 years after planting; declining on older reefs. The decrease in fish abundance, biomass and richness on older restored reef may be due to a reduction of inhabitable space following successful and rapid recovery, reflecting a natural process. Recovery from major natural or human disturbances is generally slow (several decades) but these findings reveal restored reefs in ideal conditions in the Maldives may function like natural habitats within 5 years. This finding reveals low tech restoration methods can be both economically and ecologically viable and may prove invaluable in rapidly assisting natural recovery of reefs in the Maldives which have recently suffered extensive impacts from thermal bleaching and a crown-of-thorns outbreak.

Research on the Adaptability of Corals Relocated from Hulhumale Reef to Vilingili Reef, Maldives

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Abstract

The aim of this study is to find out the adaptability of corals which have been transferred from the reef of Hulhumalé to the reef of Villingili, as a mitigation measure of the ongoing project of land reclamation and coastal protection of Hulhumalé phase 2. The coral relocation project, in this case, was a measure of mitigation in order to save the corals from being destroyed. The research was carried out after 6 months from the relocation date of the corals. The objectives of this research were: (1) to find the percentage of corals which were able to adapt to the conditions of the new environment after 6 months from the date of relocation; (2) to find the percentage of corals which are healthy, stressed and bleached (dead) among the corals relocated; and (3) to find the adaptability of corals to the three different depths (3m, 5m and 7m) at which they were mounted on frames after relocation. To monitor the corals, two snorkeling visits were made to each coral frame. The first visit was to identify the corals and the second visit was to check the health of each individual coral. This coral relocation project has been very successful, with 94% of all the corals surviving the six month period. Nevertheless, the high percentage of stressed corals among the relocated corals may well be the result of the consequences of El Nino that is occurring this year (2015-16).

Impact of Bleaching-associated Habitat Degradation on Juvenile Fish Assemblages

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Abstract

Climate-induced coral bleaching is among the greatest current threats to coral reefs, causing widespread loss of live coral cover. This loss is particularly evident in shallow water habitats which show increased vulnerability to bleaching events and are in decline worldwide. Shallow water habitats are a critical living space to the vast majority of juvenile fish, providing shelter, abundant food source, and pathways among habitats, yet their decline and associated loss of nursery function has largely been overlooked. This study specifically aimed to quantitatively characterise the benthos and fishes of lagoon patch reefs in the Maldives along a disturbance regime (healthy; impacted; rubble) to investigate: (1) the function provided by healthy lagoon patch reefs; and (2) the effect of degradation in patch reefs on the functional composition of associated fish assemblages. Benthic and fish census data were collected on patch reefs within the inner lagoon of Vabbinfaru Island, Maldives, in February and March 2016. Seventy-five plots 3 x 3m (25 in each habitat) were haphazardly surveyed on snorkel. Comparisons of aerial images revealed a substantial loss of patch reef in Vabbinfaru lagoon, with a 61% decline in habitat area since 1960. High variability in benthic composition was found among the three different stages of patch reef, with high coral cover (up to 100%) and high structural complexity on healthy sites, high macro-algae cover (up to 66%) on impacted sites, and habitats dominated by rubble. This transition from healthy to rubble patch reef habitats was associated with declining species abundance and richness of fishes, and reduced diversity of fish functional groups. Declines were greatest following loss of structural complexity. Fish biomass however, showed an initial increase on impacted sites before declining on rubble sites. The three different stages of patch reef displayed markedly different fish communities. Abundances of species reliant on coral for food and shelter significantly declined following live coral loss. Conversely, herbivore abundance increased on impacted sites following a phase shift to an algae dominated reef. The abundance of juvenile fish on healthy patch reefs was 2-fold higher than that of impacted sites and 13-fold higher than rubble. In addition, small (<10 cm) fish were significantly more abundant in healthy habitats while impacted sites retained a higher abundance of large (> 20 cm) fish. In systems without alternative juvenile habitat, such as isolated oceanic and atoll environments, degradation or loss of coral patch reef habitats will be more severe and could negatively impact many coral reef ecosystem processes and services.

The Impact of the Third Global Coral Bleaching Event on Maldivian Reef Communities

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Abstract

Coral reef systems are globally threatened by increasingly severe anthropogenic and natural disturbances. The third Global Coral Bleaching Event, by far the longest bleaching event on record, severely impacted coral reefs in the Maldives in 2016. It is critical to understand both short- and long-term effects of bleaching events on local and regional habitat composition, quality, function, resilience and recovery. To this end, preliminary findings of several studies established to monitor reefs in North Malé Atoll prior to, during and immediately following this bleaching event are summarised here. Twenty permanent transects (20m x 5m) were established on Vabbinfaru reef to monitor coral cover and community composition, structural complexity, as well as richness, biomass, species and size composition of associated fish communities. Bleaching response and survivorship of over 3000 individual corals (identified to genus, growth form and size measured) at three depths (1, 5 and 10m) were tracked concurrently on two reefs during the six month period spanning the bleaching event. Regional post-bleaching survival was assessed on 30 reefs each with six replicate 10m photo-transects. Locally measured sea surface temperatures exceeded 31.5°C for 70 days with a peak of 33.6°C. Consequently, coral bleaching was widespread and severe, extending to depths beyond 30m. Coral mortality was high on all reefs surveyed and greatest in tabulate and branching acroporids. A considerable proportion of pocilloporids recovered, potentially exhibiting an adaptive response to bleaching following high mortality during the 2010 bleaching event. Species- and depth-dependent mortality resulted in a significant phase shift in benthic community composition to a macroalgae dominated system. Fish communities exhibited a shift in community composition (PERMANOVA) although functional or species specific responses varied considerably, particularly with some corallivorous or coral-dependent species (e.g. *Gobiodon* sp) which exhibited considerable declines in abundance and biomass. Post bleaching fish community composition was maintained in the short term, likely due to the persistence of structural complexity, much like lag effects in fish communities reported following the 1998 mass coral bleaching. Ongoing long term monitoring will determine the duration and outcome of the phase shift, the recovery of coral communities and the impacts of restoration efforts. Healthy fish communities and in particular high herbivore biomass on many reefs surveyed support reef resilience and a high likelihood of natural recovery in the Maldives.

Preliminary Findings of Coral Bleaching Assessments for 2016 Mass Coral Bleaching Event in the Maldives

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Abstract

Mass coral bleaching is the single most devastating impact on coral reefs and is usually associated with prolonged elevation of sea surface temperatures (SST). The coral reefs of the Maldives lost over 95% of their live coral cover during the El Nino of 1997/1998, taking over a decade for their recovery. 2016 is the worst El Nino year ever recorded, with SST reaching a record high in the month of April. First signs of coral bleaching in the Maldives were observed in early April and continued until late May. Nationwide bleaching assessment surveys were conducted by Marine Research Centre, in collaboration with the International Union for Conservation of Nature (IUCN), marine biologists stationed at tourist resorts, and interested citizen scientists. The main aim of these surveys was to assess the severity of coral bleaching throughout the Maldives during the bleaching window. Point Intercept Transect (PIT) and belt transect methods were employed on three 50 meters transect tapes fixed in 5m and 10m depth at 72 sites located in 10 atolls. Preliminary findings showed that coral bleaching was observed at all the survey sites at varying degree of severity. While some sites showed bleaching levels as low as 17% relative to the live coral cover, the majority of sites suffered from extreme bleaching >60%, and in some cases reaching 100%. From the analyzed bleaching data, it can be concluded that 2016 coral bleaching is one of the most severe episodes of recorded coral bleaching in the Maldives, comparable in mortality of coral reefs to the 1997 episode.

Impacts of the 2016 Bleaching Event on South Malé and Baa Atolls

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Abstract

We established 10 permanent monitoring sites in January 2016 to document changes to the reef coral community due to the 2016 El Niño event, as one component of Coral Reef CPR and Anantara Resort's Holistic Approach to Reef Protection (HARP) Program. Survey methods included: (1) 10m x 1m photo-transects of the same area at 3-5, 7 and 10m depths; (2) 10m point intercept transects (100 points per line) extended along depth gradients (3-20 m depth) within permanent sites; and (3) additional point intercept surveys conducted on surrounding reefs. Thermometers were deployed at each site at 7m depth. Baseline data were collected in January, followed by reexamination in April/May and July/August. Reef temperatures climbed above 30°C by the beginning of March and remained at 31-32°C from early April until 5 May. Similar temperatures extended to depths greater than 30m, while surface waters and shallow lagoonal areas exceeded 33°C in some locations. Bleaching was first noted in early April and steadily worsened, with 80-90% of colonies becoming severely bleached by early May. The severity of bleaching was highly variable among sites and species, with branching and tabular acroporids, *Pocillopora* spp. and foliaceous *Echinopora* sp. becoming fully bleached. In some lagoonal reefs over 90% of colonies died by early May, while 10-15% mortality was noted in fore-reef locations. Bleaching of massive corals, especially *Porites*, was much more variable with only 10-20% becoming fully bleached and other colonies becoming pale, mottled or light blue in color. By late July most of the acroporids and *Echinopora* colonies and 50-70% of pocilloporids had died, and living coral cover on reef tops had declined to <5%. Mortality was less common in *Porites* and other massive corals, although up to 40-50% showed signs of partial mortality. Furthermore, many of the surviving massive corals that had bleached during April had not fully regained their pigmentation by July; plate-like and encrusting genera, such as *Pachyseris*, *Leptoria*, *Mycedium* and *Leptoseris* that were pale in color in early May, were fully bleached by July and had begun to die. Some colonies that had begun to regain their pigmentation, especially *Pocillopora*, and the few remaining *Acropora* spp., showed signs of recent mortality from disease (white syndrome). All skeletons of corals that died during the bleaching event were rapidly colonized by filamentous algae. Overall, the lowest proportion of bleached colonies was noted on channel reefs and other locations where there was high water movement. Some individual colonies adjacent to fully bleached colonies of the same species failed to bleach, or produced vivid fluorescent pigments. These corals may be more resilient to temperature perturbations and provide ideal candidates for use in coral restoration projects.

Session 2

Coral Reef Ecology

The Cellular Stress Response of Corals Affected by Different Diseases in Maldives

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Abstract

Coral diseases are increasing in both occurrence and incidence, threatening the health of coral reefs worldwide. To date, many diseases are ecologically well documented and efforts have been made in the identification of the microbial communities involved. However, less attention has been given to the effects of the pathogen presence on coral health/physiology and to the mechanisms employed by corals to resist infection. The earliest steps of an organism's response to any environmental stress occur at cellular level. Therefore to clarify this issue the analysis of the expression of cellular stress molecular biomarkers (which reflect changes in cellular structural integrity and functional cellular pathways and performance) may constitute a useful diagnostic tool. For this reason, in our studies the expression of some cellular stress biomarkers for detecting early signs of change in physiological state were analyzed in corals affected by different diseases. The biomarker levels were investigated in the apparently healthy coral polyps located at different distances from the advancing infection front. In particular, the modulation of the mitochondrial chaperonine, Heat shock protein 60-kDa (Hsp60), was investigated in *Acropora muricata* colonies infected by the ciliate-related diseases Skeleton Eroding Band and Brown Band in the lagoon of Maghodhoo Island, Faafu Atoll, Maldives. At the same time, the expression profiles of Hsps, oxidative stress-inducible proteins and antioxidant enzymes, such as superoxide dismutase and hemeoxygenase, were compared during the progression of the Black Band disease in colonies of *Goniopora cf. columna* at different stages of the disease. The results provide new insights into the immune response of corals and on the modulation over time of the cellular stress response triggered by the pathogen activity before visible signs of the disease appear. They also show that different pathogens trigger different cellular responses and defense mechanisms in corals, suggesting that the analysis of the expression of these cellular-stress markers could be a useful tool for examining physiological variations that are not detected at the morphological level.

Spatial Variation in Abundance and Distribution of two Rare and Vulnerable Coral Species under different Management Regimes in Maldives

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Abstract

Healthy coral reefs are critical to the existence of atoll states such as the Maldives and consequently, the livelihoods of their populations. However, anthropogenic pressures are increasing and 75% of coral reefs are threatened globally. Such reefs include species of corals such as the elephant skin coral, *Pachyseris rugosa*, and pearl bubble coral, *Physogyra lichtensteini*. These species are globally distributed but highly susceptible to catastrophic events such as mass bleaching, and have been listed as globally vulnerable under the IUCN Red List for Threatened species. The population status of these species in the Maldives is not known. To understand the spatial variation in abundance and distribution of the two species in Maldives, surveys were undertaken around 18 islands across two atolls. Islands were chosen to represent different management regimes and reef habitats. At each island three sites were surveyed to assess a) presence/absence, b) colony size, c) mortality, and 4) bleaching susceptibility of the two species. This paper presents the results of the study and shows what effects, if any, management regime and habitat may have on abundance, size and distribution of these species.

Scleractinian Coral Species Delimitation of the Genera *Acropora* and *Pocillopora* by Molecular Taxonomy at Baa Atoll, Republic of Maldives

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Abstract

The diversity of coral species presents a number of problems to scientists when an identification name must be given. Numerous species can vary their morphology as parameters change including depth, luminosity, substrate, current, predation, wave action and interspecific competition. It also appears that different species are able to interbreed which result in hybrids that cannot yet be identified with certainty. The most common way to identify corals is to use published morphological identification keys. Unfortunately, this technique is not very reliable as most coral species can vary in shape and colour depending on the environment and region of the world in which they are found. For example what is applicable in Australia might not always be applicable in the Maldives. For more than ten years, Seamarc Pvt Ltd has been working to restore the coral reefs in the Maldives, providing expertise to resorts and small organisations as well as spreading awareness to the local communities and guests. In order to optimise the selection of corals used for its Reefscapers Coral Propagation Programme and increase our knowledge on corals in the Maldives, a coral DNA Analysis Project was set-up, as only such methodology can provide guaranteed species identification. DNA analysis will also give the possibility to discover hybrids and symbiotic algae that have the potential of being more resistant to climate change. This study focused on *Acropora* and *Pocillopora* corals, which represent the most common species on the reef and those used on our coral frames. A total of 152 fragments of *Acropora* and 50 fragments of *Pocillopora* were collected from 12 different sites. The corals selected for collection were the ones showing the most similar characteristics but where identification doubts still remained. A small piece measuring 1 cm³ was placed in 1mL buffer solution allowing the samples to be kept at an ambient temperature during transport for later analysis. Each specimen sampled was bleached, photographed and archived ensuring accurate traceability. An average of 16 chromatograms were needed to analyse each sample of coral and its symbiotic algae as several regions of the DNA need to be covered in order to avoid any bias. Results will be presented.

Ecological and Behavioural Traits of the Crown-of-thorns Starfish *Acanthaster planci* in an Ongoing Population Outbreak in Ari Atoll, Republic of Maldives

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Abstract

The crown-of-thorns starfish (*Acanthaster planci*) is well known throughout the Indo-Pacific region as a corallivorous predator. When this species occurs in extremely high densities, the resulting destruction to live coral cover can be extensive. In this study, we investigated the ecology, behaviour and population dynamics of the crown-of-thorns starfish at 9 different reefs in Ari Atoll, Republic of Maldives. The largest data was collected on the reef of Athuruga Island, where a severe outbreak has been occurring since 2014. At this site alone we surveyed more than 1,000 starfish during May-July 2016. In these conditions the crown-of-thorns preyed mainly on corals belonging to the family Poritidae. This may have been due to the extremely low percentage of live coral cover of Athuruga Island reef. Starfish were observed preying on corals during the night as well as during the day, suggesting a loss of the typical cryptic behaviour. Only juvenile specimens (<16cm) were found with a higher frequency during night time. The starfish were often found in aggregations (2-10 individuals) surrounding and covering the few and isolated live coral colonies. These starfish patches sometimes included other species of corallivore echinoderms like the pincushion starfish *Culcita* sp. In all the reefs considered in this study we surveyed more than 1,500 starfish and collected more than 10,000 COTS as part of a control program. We also observed that reefs with a high density of crown-of-thorns starfish are mainly located in the central area of the atoll, relatively far from the open ocean water. To date, the reefs on the margin of Ari Atoll do not show any sign of *A. planci* outbreak and no starfish were recorded in our surveys in these sites. These results confirm that *A. planci* is a dynamic animal, which may be able to modify his ecological features in response to reef condition changes during an outbreak.

Coral-associated Hydrozoans from the Maldives

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Abstract

Corals are able to establish intimate associations with several organisms, including other cnidarians such as hydrozoans. These symbioses are often obligate, with the hydrozoan symbionts growing partially embedded by coral tissues. In this work, we evaluated the ecology and the diversity of two hydroid genera, namely *Zanclaea* and *Pteroclava*, associated with scleractinian and alcyonacean corals, respectively. Our studies were conducted in the central Maldives at the MaRHE Centre based in Magoodhoo, Faafu Atoll and using ecological, morphological and molecular approaches. *Zanclaea* hydrozoans were common in the study area and were found in association with 24 scleractinian genera. According to polyp and medusa morphology, three morpho-types were identified. Nevertheless, molecular phylogenetic analyses revealed an unexpectedly high genetic diversity and several divergent molecular clades were identified. The majority of these genetic lineages were host-specific and cryptic since they were not identifiable through morphological analyses. We therefore applied DNA taxonomy techniques to our dataset and we identified several independent species. The detected *Zanclaea* species showed different degrees of host specificity, with generalist clades associated with up to 16 coral genera and other more specific clades associated with just one coral genus. Regarding *Pteroclava* hydroids, we found polyps associated with four genera of octocorals, belonging to two families. As with *Zanclaea* hydroids, morphological features were not reliable for discriminating different species, since both polyps and medusae were identical in all the observed hydroids. However, according to molecular analyses, we detected two highly divergent lineages ascribable to two independent cryptic species associated with different octocoral families. The first was associated with three genera of shallow-water soft-corals belonging to the family Alcyonidae, whereas the second was found growing exclusively on octocorals belonging to the family Plexauridae. Overall, this work suggests that these diminutive hydroids are more widespread and more commonly associated with coral than previously known and that they hide an unexpected cryptic biodiversity.

Low-tech, Large-scale Reef Restoration Following a Severe Bleaching Event

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Abstract

Coral reefs have been in decline around the world due to increasing pressures from climate change, overfishing, physical damage, and more. The reefs of the Maldives are no exception. Small coral restoration projects have been implemented throughout the Maldives, however, it has been shown that greater success of reef restoration occurs with larger-scale efforts. This project aimed to assess the ability of large-scale nurseries and coral transplantation to increase overall biodiversity on degraded reefs and to promote 'self-restoration' through larval dispersion and fish recruitment. The particular objectives of this project were to study the survivorship and growth of corals within a large-scale rope nursery and to examine the use of the nursery as a microhabitat for fish assemblages. Health (percentage of dead tissue, presence of predators, and disease prevalence) and bleach percentage were determined by visual examination of each coral fragment every three months. Coral growth was determined by calculating ecological volume index (EVI) and growth constant (k) for 112 random fragments. Fish censuses were carried out at the nursery and a control site. All corallivorous and herbivorous fish species were recorded as well as species within families considered ecologically important for coral reef communities. The coral nursery was constructed in June 2016, and preliminary results will be presented. It is expected that coral colonies will be ready for transplantation within one to two years and have the potential to restore a large area of the house reef around a resort island. Future plans are to cultivate massive, encrusting, and soft corals to promote heterogeneity, maintain structural complexity of the reef, and implement a holistic approach to restoration by increasing biodiversity of all reef organisms.

Session 3

Marine Megafauna Dynamics

Leaders and Followers in Manta Ray (*Manta alfredi*) Foraging Groups

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Abstract

Coordinated actions within groups can be expedited by the emergence of a leader who initiates and/or directs group movement, with other members of the group adopting the role of follower. Leaders (or decision makers) are those individuals that, even when animals decide collectively, are more influential with respect to the decision outcome, whereas the others will simply accept their decision. This study investigated whether environmental factors (food availability and current strength), demographic traits (age and sex) and personality traits (social phenotype) are associated with the propensity of Manta Rays to take the leadership or follower role in group foraging contexts. We filmed Mantas as they fed in large aggregations in areas of high plankton abundance. Within aggregations, individuals fed either solo or in groups, forming chains with a clear leader and on average one follower. For each individual, sex, maturity, size class and whether they were seen feeding alone or as part of a group were noted. Group feeding was defined as two or more animals feeding together within two body lengths of each other. A 'grouping score' was calculated for each individual recorded and for those individuals which had a grouping score higher than zero a 'leadership score' to examine the propensity for these individuals to be a leader or a follower was calculated. Our data showed that age had no effect on leadership or grouping behaviour across both study years. However, females were significantly more likely to be leaders than males in times of low food availability and high competition (GLM leadership score, sex, $p=0.037$). As females are generally larger than males, our results suggest a benefit to them adopting the leadership role such as increased plankton intake. Mantas were significantly more likely to feed in groups at a higher plankton density (GLM grouping score, Plankton Density, $p = 0.037$) and individuals of a size class 3 (2.7-3.1m) were significantly more likely to feed in groups than feed individually (GLM grouping score, Size, $p=0.029$). This long term study of an unfished population of Mantas resident in the Maldives provides unique opportunities to test hypotheses concerning sociality.

Understanding a Manta Ray (*Manta alfredi*) Population Using Photo-Identification and Paired-Laser Photogrammetry (Laamu Atoll, Maldives)

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Abstract

The Maldives hosts the largest known population of reef manta rays (*Manta alfredi*) in the world. Research in the northern part of the country indicates strong seasonality in their presence. However, studies conducted between 2012 and 2016 in Laamu Atoll, southern Maldives, suggests a sub-population that is present year-round, with peak numbers occurring in June and November and mating trains observed biannually within these months. Individuals were usually present in the mornings, with numbers decreasing throughout the day. A total of 107 unique individuals have been photo-identified from the main study area at Laamu, a cluster of cleaning stations between 17 and 22 m, that are frequented almost daily by manta rays. Within any given year, 78%-90% of the Laamu individuals were seen more than once. This population was slightly biased towards females (59%) with 32%-46% considered mature based on evidence of mating scars. Among the 44 males, 93% were considered mature based on their claspers extending beyond their pelvic fins. Sizes were obtained on 44 manta rays (26 females, 18 males) using paired-laser photogrammetry, with disc widths (DW) ranging between 241 and 348 cm. Average DW was 318 cm for females and 287 cm for males. The largest female measured was 348 cm DW, 15% larger than the largest male at 304 cm DW. Only one individual (female) measured <270 cm DW. Certain males displayed scarring on their left pectoral fin during breeding months, potentially supporting the hypothesis of direct physical competition between males for access to available females. The paired-laser photogrammetry measurements provided evidence of sexual dimorphism and age class-segregation, as observed in other populations. High within-year and across-year resight rates imply long-term site fidelity. A discovery curve suggests that most of the individuals that are visiting the study area have been photo-identified. Resights of Laamu manta rays in other atolls were low, implying a small home range for this population. Given the apparent small population size and limited connectivity to larger populations in the northern Maldives, we recommend local management for the Laamu manta rays.

Socio-Economic Impact Assessment of the Complete Shark Fishing Ban on Former Shark Fishermen

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Abstract

After decades of commercial shark fisheries in the Maldives, a complete fishing ban on sharks was declared in 2010. After the ban, the main impact mitigation strategy adopted by government was a compensation scheme for fishermen in exchange for shark fishing gear. Another initiative was a Shark Trust Fund, to assist fishermen with alternative livelihood options. Three years after the ban, this study assessed the socio-economic impact of the shark fishing ban on former shark fishermen. 125 fishermen were interviewed from seven prominent shark fishing islands. The surveyed group comprised more than 60% of the former shark fishermen. The most popular alternative livelihood was reef fishing, followed by tuna fishing. Current incomes were less than US\$260/month for 34.5% of the surveyed group, whereas during shark fishing times 34% received a minimum income level of US\$625/month. Thus for a large number of shark fishermen, income levels had reduced by over 60% since the ban. From the gear-buy-back scheme, the largest group (33%) received compensations between MVR10,000-25,000. Only 9% of the fishermen received compensations over MVR75,000 and these fishermen were from H.Dh. Kulhudhuffushi, the most prominent island for shark fishing. 28% spent their compensation on daily basic needs, while 21% invested it in another business or fishing activity. Another impact mitigation strategy was to prioritize the former shark fishermen in government soft loan schemes. When questioned about this, 49% did not apply and 44% were not even aware of this opportunity. Most fishermen showed little interest in soft loans. Some expressed their interest in larger loans provided with lowered interest rates, which would enable them start a livelihood such as tuna fishing. A significant number of fishermen (particularly from A.Dh. Dhangethi) criticized the tourism industry for not assisting with compensation for their lost livelihoods (the dive tourism industry being the main beneficiary of the shark ban). The Shark Trust Fund, established to alleviate the impact of the ban, was not well supported by the tourism industry. This could reflect insufficient negotiations between the tourism and fisheries sector before declaring the ban, and inadequate publicity subsequently. There is still an opportunity to strengthen the Shark Trust Fund and establish a mechanism where funds flow back to previous shark fishing communities.

Socio-economic and Ecological Assessment of Shark Populations in the Maldives

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Abstract

As apex predators, sharks play a critical role in maintaining ecosystem integrity and health, but populations are declining globally due to their inherent vulnerability to overexploitation. Efforts to manage and monitor sharks worldwide are limited by incomplete or absent baseline records of abundance and distribution. Without a historical comparison to contextualise contemporary estimates, management is stunted by insufficiently informed standards of what constitutes robust populations and monitoring is poorly acquainted with priority areas for focused study. The present study implements an interdisciplinary approach to expand the local scientific record of shark population dynamics by collecting and integrating the knowledge of former shark fishermen to bridge gaps in our understanding compared with contemporary ecological assessments. Experiences of Maldivian fishers (n=32) were mapped to describe trends in the spatial and temporal distributions of seven native species of shark. Memorable encounters with rare species were utilised to infer relative abundance and size, and analysed to reveal changes leading up to and after the closure of the fishery. Contemporary ecological assessments were piloted using Baited Remote Underwater Video (BRUV) at 33 sites covering ca. 300km² in the southwest of North Malé Atoll. Shark abundances and distributions were quantified using three key metrics, and hotspots of reef associated shark abundance identified. High encounter rates of sharks on film in comparison to studies conducted elsewhere in the world suggest the Maldivian shark ban may offer a sanctuary and support healthy populations of some reef associated species. The outcomes of this research include a replicable model for integrating communal knowledge systems into conservation science worldwide, that will be validated with long term BRUV surveys and ecological modelling. Future work will build on these pilot studies to elucidate population recovery trajectories over the long term and identify local ecological and environmental drivers and hotspots of distribution and diversity and thus contribute towards the aims of the National Plan of Action on the Conservation and Management of Sharks in the Maldives.

Review of the Status of Marine Turtles in the Maldives

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Abstract

For the past two decades, marine turtles have been protected under two consecutive harvesting moratoria. Despite this legislation, consumption for turtle meat is still common in parts of the Maldives. This is particularly of concern in hotspot atolls for turtle nesting, as turtles are most commonly poached while nesting. Until recently, there has been no systematic data collection to establish estimates of turtle abundance in their feeding and nesting grounds. Under a citizen-science program, Turtlewatch Maldives, we collected information on nesting and foraging turtle abundances through tourist resorts and hired local surveyors. The in-water component of the study showed hawksbill turtles to be the most frequently sighted, followed by green turtles. The highest turtle sighting per in-water survey was recorded for Baa Atoll. The study found that in-water sightings of the green turtle were low for most of the surveyed atolls with the exception of Lhaviyani Atoll. The results of the nesting surveys conducted at selected islands and resorts showed highest nesting occurrences at L. Gaadhoo. However, annual nesting estimate for L. Gaadhoo from this study showed a 40% decline when compared with 1984's annual nesting estimate. In spite of turtles being protected for the past two decades, awareness of and regard for turtle conservation issues is very limited among the public. The situation is made worse by the limited law enforcement and lenient penalties in place for violating conservation measures such as poaching of turtles and their eggs. However, when nesting beach was regularly surveyed in local islands, an appreciable decline in poaching rates of turtles and eggs were seen. This is proof that by engaging locals in surveying protected species, they are made more aware of conservation issues and there is more buy-in of legislation on conservation of threatened species. Based on the findings of this study, policy recommendations including declaring a total ban on harvest of turtles for an indefinite period of time and imposing a nation-wide ban on harvesting of turtle eggs were provided. The importance of continuing monitoring efforts at turtle nesting islands to identify the 'best turtle islands', in order to facilitate the inclusion of two most significant turtle habitats in the Maldives into the IOSEA-MoU's Site Network were also highlighted. Increasing public awareness on turtle conservation issues were also strongly recommended.

The 'Big Fish Network': Using New Technology to Incentivize Citizen Science Engagement in the Maldives

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Abstract

The use of citizen scientist contributions is a cost-effective approach that can provide valuable information, usually at scales larger than those attainable by individual researchers. A challenge, however, is to motivate contributors to continuously supply data when doing so can be time consuming and monotonous and where the results of the contributions they make are part of long term studies with infrequent outputs. When studying a highly mobile animal such as the whale shark (*Rhincodon typus*) in a geographically dispersed location such as the Maldives, a widely spread network of contributors submitting encounter information on sightings is vital to providing information on spatial movements and residency patterns. We therefore aimed to develop a platform that facilitates and incentivizes the submission of useful whale shark encounter data from the Maldives tourist industry, thus increasing the quality, volume and geographical range of whale shark encounter data submissions. The Maldives Whale Shark Research Programme achieved this by creating a prototype of a mobile device friendly version of the identification software I3S and linked it to an established, interactive online portal called the Big Fish Network, designed to provide a platform for data exchange. Tour operators were invited to submit standardised data logs from their excursions. In return, operators were provided access to a photo-identification database of whale shark individuals and 8 years of corresponding encounter data. Outputs from the portal for the operators include an interactive map, a customised trip report, social-media bulletins and a mobile app. These features were designed to aid tour guides in planning and marketing their excursions and informing and engaging tourists. Since the launch of the Big Fish Network in July 2013, 834 stakeholder data submissions were received from external contributors; equivalent to 59.8% of the total encounters recorded in the same period (compared to 23.4% between April 2006 and July 2013). In addition, this network produced evidence for 5 instances of inter-atoll movements using sightings submitted from locations outside the main survey areas.

Session 4

Conservation Planning and Socio-economics

The Role of Women in Natural Resource Use and Management in North Ari Atoll, Maldives

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Abstract

Participatory resource management has grown to become a popular approach to environmental management. This is largely due to increased recognition that sustainable development cannot be achieved without involving individuals and communities that use natural resources. Studies show that access to, use of and control over common pool resources varies as a function of gender as well as age, social class, ethnicity, education level, etc. In many places, men and women tend to have different interests and perform significantly different roles in environmental conservation. To identify women's roles, interests, and levels of participation in natural resource management in Maldives, we surveyed women in four islands of North Ari Atoll using open ended interviews through a participatory approach. Our results indicate that in the last two decades there has been a shift in the use of natural resources by women in North Ari. In the past, women were more involved in fisheries but have recently transitioned into handicraft production driven by growth in tourism. In terms of resource management, women are not actively involved in any decision making processes. There is no representation of women in any island council, and rules and protocols are shared with end-users only after the decision is made at the council level. The majority of survey participants were content with the current arrangement as they were relatively well informed about their Island Council's decisions. However, many participants stated that councils should involve them more in resource management and decision-making. Our results show that women are currently under-represented in decision making and their knowledge and skills are not reflected in resource management. To address this, an Environment and Gender Index (EGI) for the Maldives should be developed that would act as a baseline to guide policies.

Coastal Vulnerability of Islands and Communities in North Ari Atoll

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Abstract

North Ari Atoll is an administrative unit comprising three natural atolls: the northern half of Ari Atoll, Rasdhoo Atoll and Thoddoo Atoll. There are 80 reef systems and 56 islands, totalling 460 Ha. The two main coastal vulnerabilities for the islands of North Ari Atoll are beach erosion and flooding. Beach erosion is considered a high frequency hazard for all the islands as it affects inhabitants on a regular basis. Based on the interviews, erosion is considered an issue in inhabited islands if it occurs close to the settlement or if any structures are at risk. Erosion in resort islands is considered a major hazard if it affects the facilities constructed near the beach or if there is no beach to support the tourism product offered on the island. The resort islands in the atoll are particularly vulnerable to erosion due to their physiographic features, particularly their small size. Coastal erosion conditions on the islands have been analyzed in detail using remote sensing technology. The key finding is that most islands have been relatively stable in the medium-term. However, substantial shoreline changes were observed over the last 45 years in Ukulhas, Mathiveri and Himandhoo. The smaller islands have also shown proportionally substantial changes. Most of these changes have been natural. The coastal processes operating around the different types of islands noted above also differ based on their location within the atoll, orientation, shape, size, coastal process characteristics and intensity of the monsoon. Based on these assessments, this study provides a set of guiding principles and recommendations for coastal infrastructure development in North Ari Atoll. The aim of these guidelines is to provide decision support for coastal infrastructure development with a focus on preserving long-term resilience.

Baseline Assessment of Protected Areas in Maldives

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Abstract

Marine Protected Areas improve ocean resilience when developed with specific objectives of managing the uses of an area. Establishing representative and ecologically coherent Marine Protected Areas is a global goal under the Convention of Biological Diversity where Aichi Biodiversity Target 11 commits signatory states to protect 10% of important marine and coastal biodiversity, and ecosystem services in national waters. In the Maldives, a presidential decree committed to nominating the country as a UNESCO Biosphere Reserve by 2017. To support the Government of Maldives in these tasks, we conducted a national baseline assessment of existing Marine Protected Areas and potential protected areas. Potential protected areas are areas with a management framework in place but no protection mandate that can volunteer to be designated as protected areas in the future. Evaluation metrics were used to determine representation and distribution of habitats in existing Marine Protected Areas and potential protected areas. Unique types of habitats of the Maldives were found to be under-represented and unequally distributed within Marine Protected Areas and potential protected area boundaries. We propose additional areas that should be protected in order to ensure full habitat representation. This analysis demonstrates the possibility of supplementing the current network of MPAs and potential private sector protected areas with new future proposed MPAs as core areas in order to enhance protection of national habitats. The new proposed network would meet both the CBD Aichi Target 11 and the UNESCO's Biosphere Reserve requirements.

Ecosystem Services in North Ari Atoll: The Case for Coral Reef Management

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Abstract

Understanding the values of ecosystem services and integrating them into spatial conservation plans can allow policy-makers and managers to make decisions about use of resources. Ecosystem services provide a key link between ecological resilience, which supports ecosystem services, and social resilience, which is supported by ecosystem services. Managing marine areas for ecosystem services can thus promote socio-ecological resilience. However, measuring the values of ecosystem services and integrating this information into spatial plans remains challenging due to the complex nature of ecosystems and the services that they provide to people, as well as the paucity of data sets. In this study of North Ari Atoll in the Maldives, we collected ecological and social data and analyzed them to determine the total economic value of ecosystem services such as tourism and reef fisheries. A net present value analysis was undertaken in order to make the economic case for coral reef management. It was found that depending on the scenario, investments in developing and running managed areas yielded benefits of US\$ 15.8 – 75.7 million annually for the atoll economy, depending on the discount rate used and the level of investment made in coral reef management. Ecosystem services were also mapped, and areas of high intensity of ecosystem services were identified. Recommendations are made for coral reef management in order to gain maximum benefits from ecosystem services and to promote socio-ecological resilience in North Ari Atoll.

Understanding the Scale of Coral Reef Fisheries in North Ari Atoll

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Abstract

Over the last two decades, coral reef fisheries in the Maldives have been growing to meet consumer demand. There are two main fisheries: the bait fishery, and the multispecies coral reef fish fishery which targets. A major reason for the growth in demand for coral reef fish (mainly snappers, jacks, groupers and emperors) is the increase in number of resorts and local guesthouses which routinely purchase reef fish from local fishermen. In addition, an increase in tuna fishing for local consumption and export has led to an increase in livebait harvest. To date this increase in reef fish harvest has been undocumented. This study aimed to understand the dynamics of coral reef fisheries in North Ari Atoll as a case study for the Maldives. Fishermen from all 8 community islands were surveyed using a questionnaire that addressed both bait fishery and other types of coral reef fishery. The survey included questions on: (a) main types of gear used; (b) most commonly caught species; (c) catch per trip; and (d) fishing grounds within the atoll. Results indicate that there is a high use of livebait in North Ari, compared to other atolls, and that this is due to the increasing number of tuna fishing vessels in the atoll. The fishermen of this atoll catch livebait by both night (using lights) and by day. The most commonly caught bait species are fusiliers (Caesionidae), big-eye scad (*Selar crumenophthalmus*), round scad (*Decapterus macarellus*) and red-tooth triggerfish (*Odonus niger*) which are mostly used to catch yellowfin tuna. To catch the coral reef fishes, the fishermen use two main types of gears: hand line and drop line. Most coral reef fishing is carried out in the northern and western reefs of the atoll. Results from this study will be useful in developing spatial management plans specific to regulating coral reef fisheries.

Assessing Stakeholder Perceptions of Natural Resources and Integrating them into Management of Atolls: The Case of North Ari Atoll

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Abstract

Climate change is altering the availability and quality of marine resources with cascading and potentially catastrophic implications to resource users. This requires resource managers to implement policies and develop management plans that formally integrate climate change considerations with the uncertainties associated. Policies and management plans are frequently developed to regulate the balance between resource use and access. However, they can inadvertently compromise the ability of resource users to adapt. Thus, detailed understanding of stakeholder concerns and their preferred resource management options is critical for the successful design and implementation of required policies and management plans. We assessed the perceptions of different stakeholders (Island Council members, fishers, guest house operators and dive school operators) in seven islands in North Ari Atoll regarding issues such as common resource uses, environmental concerns and priority geographic areas in need of management. Results indicate that all islands of North Ari Atoll share similar ideas, values and issues. All participants agreed that ecologically significant areas need to be managed more sustainably since their survival and livelihoods depend on them. Anthropogenic threats to the environment are a common concern and resort operations have an effect on the relationship between community islands and resorts in the Atoll. In terms of management, locals perceive a bottom-up approach to resource management to be more effective than a centralised top-down approach. Results of this study can be used to identify suitable management plans for different geographic areas in North Ari and guide policy development. This study can be replicated across atolls in the Maldives to better understand stakeholder perceptions and concerns and develop sustainable management frameworks that are built on local stewardship and ownership.

Abstracts of Poster Presentations

Holistic Approach to Reef Protection (HARP): A Partnership between Coral Reef CPR and Anantara Resorts

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Abstract

In recognition of the rapid and ongoing decline of coral reefs from human and natural stressors in the Maldives and around the globe, Anantara joined forces with Coral Reef CPR in October 2015 to implement the Holistic Approach to Reef Protection (HARP) Program. HARP, a conservation program designed to bridge science and corporate social responsibility, was developed to provide information on the status and trends of coral reefs, mitigate threats, rehabilitate degraded reef ecosystems and educate local user groups on marine conservation strategies. Following an extensive, and successful, crown-of-thorns starfish (COTS) removal effort, Coral Reef CPR established permanent long-term monitoring sites on two atolls, Baa and South Malé. The team is using their findings to determine the effectiveness of efforts to control outbreaks of COTS, to identify strategies to optimize coral gardening, and to identify corals that can be used to rehabilitate damaged reef systems. Throughout the Maldives, numerous resorts have implemented an 'adopt a coral frame' initiative that provides opportunities for sponsorship by encouraging guests to purchase a frame seeded with coral fragments. While this effort has raised awareness of reef importance and threats they face, these frames are seldom used in reef restoration and their long-term viability is limited. Through HARP, Coral Reef CPR is implementing novel techniques to propagate coral fragments and plant these out on reefs. Sources of corals for nurseries include: 1) 'fragments of opportunity', those corals that would otherwise die because they are located in sites subjected to dredging or land reclamation and those naturally broken by recreational users and wave action; and 2) corals identified during the 2016 bleaching event that appear to be resistant to bleaching. Corals are grown and propagated on nylon mesh tables and suspended ropes, and second and third generation colonies from these nurseries will be planted out on degraded reefs to speed up natural recovery. Through analysis of the cells of the corals and their intracellular dinoflagellates, we are characterizing the genes and proteins that allow a coral to resist bleaching. Key to the success of HARP is 'citizen science' where local divers, school students, resort staff and guests will receive educational seminars and hands-on training in coral monitoring, COTS removal and coral mariculture, with opportunities to participate with scientists in coral nursery and restoration efforts.

Resilience-Based Management in Remote Atolls of the Indian Ocean: An Operational Case Study from the Maldives

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Abstract

The Maldives is an archipelago containing approximately 1200 coral reef islands with approximately 300 that harbor communities and permanent settlements. All are heavily dependent on reef resources. Due to the Maldives' vulnerability to climate change and its high resource-dependence, there is a need to incorporate resilience science into conservation planning and local management. We collected detailed ecological and socio-economic data for coral reefs and local communities and mapped them at a national scale. We then developed a management framework that explicitly incorporates both ecological and social resilience, variations in human impact and uncertainty, and identifies the necessary interventions required to address multiple objectives in different atolls. The analysis identified atoll areas regularly used by local communities and private sector resorts, areas that present potential conflict between users, and also ecologically significant areas. Specific locations were designated conservation priorities as they contain both ecological and social values that are not currently addressed by any existing management scheme. Systematic conservation and spatial planning processes were useful in identifying priority areas but will only be effective if accompanied with innovative decentralized governance. Specific management actions are needed for each atoll and must be integrated into national policy.

An Integrative Approach to Environment and Human Geography: The Case Study of Magoodhoo Island, Maldives

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Abstract

Several regions around the world are currently undergoing rapid, wide-ranging changes in land use and land cover. Conversion of rural areas through development is occurring at an unprecedented rate and is having a marked effect on natural ecosystem functioning. Pronounced climate change and landuse/ land-cover change represent the two primary challenges that most ecosystems will face this century. In tropical coastal regions, fragile marine coral reef ecosystems, already threatened by increasing carbon dioxide, are exposed to an increased load of terrestrial sediment, nutrients and other pollutants. These factors compromise the resistance of corals to thermal stress and their potential to recover from bleaching events. This work offers an integrative perspective on the political and ecological processes shaping landscapes and resource used in Magoodhoo, Faafu Atoll, Republic of Maldives as case study. Our research has demonstrated how the union of environmental and human geographical studies can contribute to understanding key environmental and developmental issues and to developing effective policies.

The Maldives Grouper Fishery and Conservation Project: Improving the Protection and Management of Groupers Targeted for the Live-fish Trade

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Abstract

The Maldives grouper fishery has escalated since the 1980s, spreading throughout the country. The most recent study in 2011 revealed that grouper stocks are declining and smaller sized fish are being taken. Larger fish have been selectively removed and some fishers are targeting spawning aggregation sites. There are between 40 and 45 species of grouper in the Maldives. Of these, 11 species, or one quarter, are listed as Vulnerable, Near Threatened or Data Deficient (IUCN Red List). Recent catch data show that 7 of the ten most commonly exploited species of groupers are being taken prior to reaching maturity. This project aims to support the delivery of the National Management Plan for the Grouper Fishery through four activities: (1) collection of size and maturity data for groupers by sampling the fish holding cage systems in Laamu and a second atoll; (2) collection of baseline information on the grouper fishery in Laamu Atoll by interviewing pfishers; (3) provision of evidence to support the management of existing grouper reserves and the identification and mapping of new grouper spawning aggregation sites; and (4) conducting an Environmental Education and Awareness (EEA) Programme for grouper fishers and fishing communities in Laamu and nationally. Preliminary results of the fisher interviews and aggregation site assessments will be presented.

Review of the Maldives Livebait Fishery*Ahmed Riyaz Jauharee**Marine Research Centre, H. Whitewaves, Malé, Maldives, arjauhary@mrc.gov.mv***Abstract**

Since 2010, logbook data has been collected throughout the Maldives on the quantity and type of bait being collected by pole-and-line fishers. Initially, low numbers of logbook records were returned. Logbook returns peaked in 2013 at over ten thousand records but not all of these could be used due to missing pieces of information. Nevertheless, once the data had been filtered for full records, many thousands of data points were used in the analysis. Analysis of catches showed great variability in quantities of livebait between region, year and month. Statistical comparison of catches between years was impaired in many cases by lack of data, but many species showed either no significant difference in catches between years or a decrease from 2011 to 2014, depending on region. Importantly, any differences between years were not consistent by species or region and therefore changes in catches may be related to local depletion or inter-annual variability in abundance of these short-lived species rather than population-level effects of the bait fishery.

The soft and hard coral-associated hydrozoans from an ecological point of view

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Abstract

Scleractinian reef corals have been acknowledged as the most numerous host group for associated hydrozoans belonging to the genus *Zanclaea*. However, the benefits and costs of this symbiosis are still not clear. Although trophic and/or protection mutualism seems a plausible explanation of the association, a possible relationship between the occurrence of hydrozoans and coral diseases has also been proposed. The objective of this study is to test if *Zanclaea* hydrozoans significantly influence the health of the reef-building corals. To do that, we test the relationship between the occurrence of *Zanclaea* hydrozoans on corals in relation to different colony conditions: healthy, stressed (bleaching, algae overgrowth, fishes and gastropods feeding scars), and diseased (WS, SEB, BrB, BBD). Our preliminary field surveys revealed as the association is widespread in the coral communities of Maldives and Red Sea. A total of 29 scleractinian genera were found in association with *Zanclaea* hydrozoans. The overall *Zanclaea*-scleractinians prevalence resulted high in the coral reefs, but no significant differences were observed between scleractinian genera and coral communities.

Furthermore, no positive implications were found for both diseases and stressed corals, although a positive effect against predation (fish bites and *Drupella* sp.) was observed for scleractinians hosting *Zanclaea*. In conclusion, the potential implications of the hydrozoan-scleractinian symbiosis for coral health, its wide distribution, and the number of species it involves indicate urgent need for further investigations.

Large-scale Reef Restoration in the Maldives: Is this the Way of the Future?

Tess Moriarty

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Abstract

Coral reefs are the most productive, diverse and rich marine ecosystems. There is unprecedented evidence that coral reefs worldwide are at risk, with major impacts on marine biodiversity, coastal protection and the economy. The rate at which coral reefs are declining is such that they cannot be revived through passive conservation alone. Active restoration is required. We outline the trial of the first mid-water floating coral nursery in the Maldives. This methodology was chosen as it provides a large-scale restoration effort with a minimal environmental footprint. This project aims to grow corals on a large scale with minimal mortality. A mid-water floating nursery will be located 100m away from a coral reef and snorkel and diving activities. Previous studies indicate that the nursery can house over 2,500 branching coral fragments. This study will focus on *Pocillopora* spp. all of which will be fragmented between 2cm and 12cm in size. Fragments of 15 healthy coral colonies that saw little to no bleaching, with no more than 10% of the colony being used, as well as corals of opportunity will be used when possible. The donor coral colonies will be tagged and monitored to assess recovery and survival rates. The corals will be left to grow, with survivability being monitored every three months. Maintenance will be carried out on the nursery, cleaning the ropes of algae and other species impeding on the corals health. This study is still ongoing, however, we expect to see 85-95% survival in the nursery phase.

Efficacy of Localised Citizen Science Control of a Crown-Of-Thorns Outbreak in the Maldives

Arzan Mohamed, M. Carolina D'Angelo, Danielle Robinson and Steven Newman

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Abstract

Outbreaks of the corallivorous crown-of-thorns starfish (COTS, *Acanthaster planci*) remain a major cause of coral mortality. Their effective control is regarded as a promising strategy to mitigate coral declines in the Indo-Pacific. Control of COTS populations have been on-going at Vabbinfaru (Banyan Tree Resort) and Ihuru (Angsana Resort) in North Malé Atoll, Maldives since 2001. Since 2008, 6096 COTS and 1029 pin-cushion seastars (PIN, *Culcita novaeguineae*) have been manually removed from these reefs. 1888 COTS were removed in 2015 by 417 staff and guests searching over 24km of reef. Removal efforts revealed the current COTS outbreak in the Maldives had been ongoing for much longer than first reported with outbreak conditions on Ihuru since 2013 and Vabbinfaru since 2014. In response, control efforts were increased to twice per month on each reef and injection of bile salts implemented for rapid control of high densities while eliminating risk associated with manual removal (such as damage to reef or injury to person). High numbers of COTS and PIN removed in 2015 in part reflected increased removal effort. Only reef area searched had a significant effect on the number of COTS removed, with location, number of people and days between searches dropped from a generalised linear model. While intuitive, this suggests during outbreaks frequent searches with even only a few people may be effective in removing large numbers of COTS. When corrected for effort, the number of COTS did not increase from 2014, with low numbers since September 2015 suggesting the outbreak was either under control or had moved on from Ihuru and Vabbinfaru. The outbreak caused devastating losses in live coral on nearby reefs such as Coral Garden with declines of up to 95% from pre-outbreak levels in 2011. Removal efforts have been critical in maintaining high coral cover on both Vabbinfaru and Ihuru. This analysis presents the first demonstrable support for the efficacy of citizen based control efforts of a COTS outbreak in the Maldives. The methods employed can easily be adopted by resorts, dive centres and citizen scientists across the Maldives which can play an important role as both an early warning network and in controlling future COTS outbreaks.

A Painting Exhibition on Marine Corals

Uma

The medium of painting: Acrylic on Canvas, number of paintings: 12.

Abstract

The theme 'Marine Coral' is constant in all my paintings. Being a PADI certified open water scuba diver, I am very passionate about these intricate lifeforms. I have so far conducted 5 painting exhibitions on this theme. And it is very concerning to know there are so many people yet to understand that 'if there are no coral reefs, there are no fishes'. There is a need to understand the importance of the Marine Corals in the ocean and the dire need to protect them.

The Monthly Climate Advisory for Maldives - a resource for marine Scientists

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Abstract

Climate affects oceans in marked ways sometimes posing risk to marine organisms and ecosystems and as such ongoing climate information can help scientists and managers in their work. The Foundation for Environment, Climate and Technology (FECT), International Research Institute for Climate and Society and the Maldives Meteorological Service have been developing tools and databases and undertaking research to generate such information over the last 8 years. The overall objective is to provide timely, state of the art and comprehensive information useful for managing the resources. This advisory provides historical, monitored and predicted information on Maldives land and sea climate. The analysis for the advisory are obtained from customized tools developed at the IRI Data Library for Maldives. We use analysis from the Maldives Meteorological Service, US National Oceanic and Atmospheric Agency, (NOAA), the Australian Bureau of Meteorology (BoM) and from the Indian Meteorological Department among others. The advisory comprises of 3 sections, namely: Climatology, Monitoring & Predictions. The climatology section has maps that provide information about usual climate conditions (rainfall and wind) expected in given months. The monitoring section contains information on the rainfall conditions in the previous month and comparisons with rainfall in past years in the same period. The monitoring section contains daily rainfall maps for the previous 15 days derived from satellite estimates. The analysis is done in three regions (northern, central and southern) separately. In the predictions section, there are rainfall and temperature predictions from daily to seasonal (up to 6 months). Dissemination of this report started in June 2012 after two trial reports published in April 2011 and November 2011. Since June 2012 we have been publishing this advisory continuously, to the end of the month. In May 2016 we started publishing a bi-weekly report containing only the highlights in the middle of the month. The advisory is published on www.tropicalclimate.org/maldives and www.fectmv.blogspot.com as well as on social media www.facebook.com/fectmv and www.twitter.com/fectmv. Additionally, a monthly newsletter is released as soon as an advisory is published. Presentations on the interpretation of the Climate Bulletin were presented in the Maldives at the Workshop on Climate and Water in September 2015 at the Maldives National University. A long-standing research effort has led to the sustained production of customized climate bulletin for the Maldives and consultation by experts. In the future, we shall extend the impact analysis to selected sectors, seek to better communicate the information and seek to reach a larger audience.

