Corals, mangroves, and conservation ecology in the Seychelles

Dr David Smith

Background

The island archipelago of the Republic of Seychelles is part of the Madagascar and Indian Ocean Islands biodiversity hotspot. The Seychelles is heavily dependent on the marine environment, both in terms of the provision of food and the importance of coastal tourism to the economy. There is a willingness to ensure that reefs within the region are sustainably managed to maintain the balance between conservation and the need to exploit natural resources.

The Seychelles encompasses 115 islands (figure 1). With respect to coral communities there are two major habitat types: carbonaceous reefs (predominantly ancient reef structures) and veneering coral communities on granitic islands. In 2006, intertidal and subtidal research was carried out on the carbonaceous coral atoll of Desroches, and in 2007 surveys were conducted in these same coastal zones around the granitic inner island of Silhouette. Based on findings from these investigations, it was decided that a long-term study site was needed that had both veneering and carbonaceous reef systems, and an environmental gradient with respect to light (for 'optimal' versus 'sub-optimal' conditions). The chosen site was Curieuse Island, in the northeast of the archipelago. As well as both major types of reef community, Curieuse has extensive mangrove and lagoon systems. The island is uniquely placed and provides a perfect study area to examine patterns of diversity and the past and future effects of climate change on tropical coastal systems. Anecdotal evidence suggested that Curieuse was heavily impacted by the El Niño event of 1998, when higher than average sea surface temperatures led to extensive coral bleaching on many reefs, as well as the Asian Tsunami of 2004. The latter caused significant damage to coastal structures and would have severely impacted the sublittoral coral community.

The Curieuse Marine National Park is managed by Seychelles National Park Authority (SNPA), who require detailed knowledge of the community structure, drivers of change, long-term monitoring and management recommendations for the Island.

Project overview

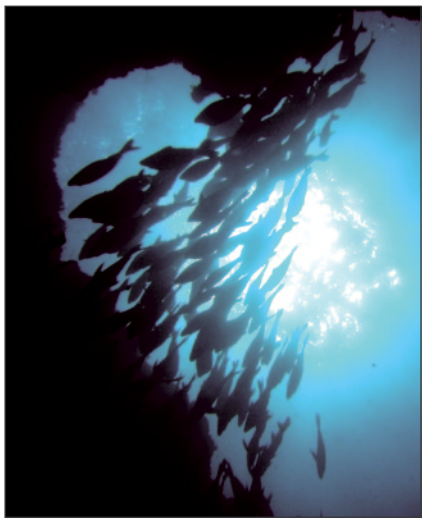
The goal of the research is to examine the varied reef environments of Curieuse Island to study how they respond to environmental stress, and gain a better understanding of the ecology and physiology of the key ecosystem architects. Specific objectives of the study are to determine:

- Spatial and temporal patterns in the dynamics of the reef and reef-associated community
- Eco-physiology of hard corals
- Behavioural plasticity of specific invertebrate and fish taxa

Long-term monitoring sites are being established and a start has been made toward identifying the key drivers in determining the structure of the coral community, including environmental variables and past disturbance events. An experimental approach is being used to identify tolerance levels of key coral taxa to the 1998 El Niño event and to assess the possible impact suffered. Results will be used by SNPA to help (1) implement a multi-zoned management strategy to protect core sites, and (2) identify key threats and undertake direct conservation action to protect Seychelles reefs against current anthropogenic induced threats and predicted climate change.

The project has been running since 2006. Volunteer teams comprise Mitsubishi Corporation employees, teachers from the Seychelles and the UK, local and African conservation

Figure 1. Map of the Seychelles showing the location of three study sites: Desroches, Silhouette and Curieuse Islands



professionals, as well as Earthwatch volunteers. SNPA staff have also joined teams to allow them to increase their skill base through interactions with the research staff and to share their knowledge with conservation professionals from other African countries.

Volunteers assist with transect surveys of fish, coral and invertebrates and with monitoring permanent quadrats to record changes in the coral community. Volunteers are also involved in running non-invasive experimental work on corals in aquaria.

Increasing knowledge on status, threats and management interventions for Marine Protected Areas, and incorporating such data into management plans are part of Earthwatch's Oceans Research Programme.

Outcomes and actions

In 2008, baseline surveys of coral, fish, and invertebrates around Curieuse were completed, and the research team are now conducting detailed investigations to address both anthropogenic impacts and natural phenomena at the site.

A total of 151 species of fish were observed from 91 transects. While this represents a significant sampling effort, it is still a very small area and it is likely that cryptic and less common species were not encountered. Consequently the calculated fish species richness of the area cannot be considered a true estimate for the island and the fish species list is expected to increase dramatically during future surveys. However, classification analysis does suggest that coral cover and the topographic diversity it offers is the key driver of fish community structure. Consequently, management plans aimed at increasing fish diversity and enhancing community structure should focus attention on ensuring that the coral itself is healthy and productive.

Key invertebrate groups recorded include Echinoidea (sea urchins, e.g. *Diadema*), Asteroidea starfish (e.g. *Linckia*; *Acanthaster*), Holothuroidea (sea cucumbers), Nudibranchia (shell-less molluscs), and *Tridacna* (giant clam). These taxa were considered to play a significant ecological role (e.g. algae-grazing *Diadema*) or are heavily exploited (e.g. *Tridacna* for aquaria, and in other parts of the world, Holothuroidea for food). Also, many *Acropora* colonies had *Drupella* infestations (a coralivorous gastropod) and evidence of damage was often seen, which suggests that *Drupella* abundance needs further investigation.

In places around Curieuse, coral cover was as high as 80%, and a total of 63 species of hard coral were identified. However, it is expected that species richness is considerably higher than this if off-transect areas are considered. Overall the greatest amount of live coral was found at a 10 m depth at the majority of sites. High coral cover was found at shallower depths, but was patchy. There was a clear significant difference in live coral cover between sites, with the south coast having much higher cover than other areas. Some species (e.g. *Pavona clavus*) formed extremely large stands, over 13 m in length and supported a high diversity of other coral species, as well as fish from most taxonomic groups. The south side of the island consisted of the carbonaceous reef type, even in a sediment-laden site, and the very large colonies suggest that several species tolerated both the 2004 tsunami and the 1998 bleaching. The north side of the island consists mostly of encrusting and submassive coral colonies that veneer the dominant granitic boulder formations. The lowest coral cover was found on the west side, an area of diverse patch reefs (~10m diameter), but dominated by sandy substratum or macroalgae. The coral surveys therefore demonstrated that coraline habitats of Curieuse are diverse in structure, and most probably function. Therefore, the site represents a perfect study area to investigate the fundamental processes that sculpture reef communities.

Physiological experiments have clearly demonstrated the two different mechanisms of coral bleaching when they are subjected to high light and temperature stress. Some species maintain their cellular integrity (Type II), while some rapidly loose their surface tissue (Type I). Therefore, a hypothesis was that Type II species could recover and survive bleaching events, whilst Type I would not. To test this the 1998 El Niño event was used as a case study to determine whether there was evidence of coral species survival after this devastating event, using colony size as a proxy for age. The results proved the hypothesis correct. Age structure of Type II species was much more variable than Type I and even peaked prior to 1998 (Figure 2). This represents an inherent

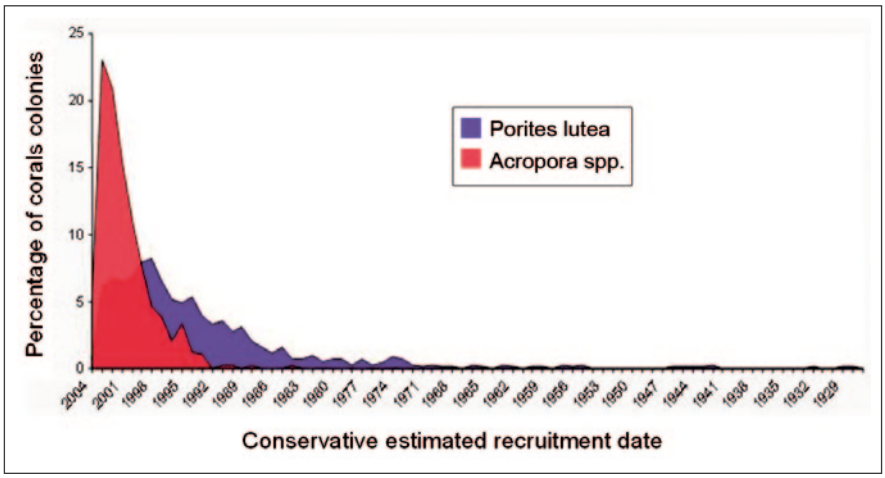


Figure 2. Conservative estimations of recruitment date for species categorised as Type I (Red, n=387) and Type II (Blue, n=695) from all sites around Curieuse.

ability to tolerate environmental stress by processes of acclimatisation which enable post-stress recovery. The exact opposite was found for Type I species, for which only relatively young colonies were observed, indicating die-out after 1998, suggesting a lack of ability to tolerate stress. Type I species are therefore at most risk from climatic events and unlikely to be able to adapt in time to rapid climate change. It seems most likely that many Type I species will be lost from future coral reef systems.

The physical complexity of this reef ecosystem is key to its biological diversity. Type I coral species support a large number of fish species, whereas the same species are supported by Type II corals to a lesser extent. A reduction in fish diversity and overall fish biomass could have major consequences for coral reefs and reduced biomass will dramatically decrease the Indian Ocean reef system's ability to fulfill key functional roles (e.g. herbivory and grazing pressure reducing the competitive ability of algae). This increases the risks of the ecosystem undergoing complete system change to an alternative stable state, which in reefs could amount to a diverse coral reef system changing to a relatively homogenous, low diversity algal or sponge dominated community. Predicted climate change causing loss of structural species (i.e. Type I) will exaggerate the impact of fisheries pressure and consequently the point at which new alternative stable states are reached will change.

The results of the first year of research on Curieuse Island suggest that much effort is needed to ensure that the system is as diverse and healthy as possible to afford it resilience and the best possible chance to tolerate and survive rapid climate change. For example, direct action is required to ensure zero fisheries activities within the Park, which is not the case at present despite regulation enforcement by rangers. Another direct action could be the establishment of mooring buoys, as boats are allowed to anchor on the south side of the island, adjacent to an area diverse in Type I and II corals. Installation of buoys prevents the need for boats to drop their anchor on the reef, a practice which causes coral breakage and other damage. Future studies will build on this research and continue to engage with stakeholders that depend on, or otherwise utilise, the protected area. Focus will be on coral growth rates to enable more resolute estimates of coral recruitment; ecosystem dynamics to address potential for reef recovery; and importantly, functionality and resource utilisation of key fish groups. With this data the project scientists aim to be able to estimate the threshold at which alternative stable states would be reached and will continue detailed physiological assessment of corals and associated species.

Lead scientist profile

Dr David J. Smith is a senior lecturer in Marine Biology at the University of Essex, UK. He is Director of the Coral Reef Research Unit (CRRU), and of the International Marine Research Organisation Operation Wallacea. He is Senior Advisor to the Institute of Marine Environmental Research in the Aegean Sea and was recently made a Fellow of the Royal Geographic Society, UK. He is a PADI Dive Master and BSAC Advanced Diver with 4,000 logged dives. Dr Smith's research interests include spatial and temporal patterns in coral reef diversity, factors impacting coral reef diversity and productivity, aspects of zooxanthellae and coral bleaching, the biological and economical value of coral reefs and the use of traditional knowledge in sustainable biodiversity management.

Additional key scientists

- **Dr David Barnes** – British Antarctic Survey; visiting lecturer at Cambridge University, UK
- **Dr Richard Barnes** – Cambridge University, UK; CRRU
- **Dr David Suggett** – Assistant Director, CRRU; Cambridge University, UK
- **Dr Sebastian Hennige** – Essex University, UK
- **Michelle Etienne** – SNPA
- **Nat Spring** – Senior Research Director, Earthwatch Institute

Collaborative organisations

- SNPA

Project website

http://www.earthwatch.org/europe/exped/smith_research.html

Key publications

Barnes, D.K.A., Barnes, R.S.K., Smith, D.J. & Rothery, P. *in press*. Littoral biodiversity across scales in the Seychelles, Indian Ocean. *Marine Biodiversity*

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Barnes, R.S.K., Smith, D.J., Barnes, D.K.A. & Gerlach, J. (2008) Variation in the distribution of supralittoral vegetation around an atoll cay: Desroches (Amirante Islands, Seychelles). *Atoll Research Bulletin*, **565**. Available at http://www.sil.si.edu/digitalcollections/atollresearchbulletin/issues/00565.pdf

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