



FIELD REPORT

Marketing title: Coral and Coastal Ecology of the Seychelles

PI name: Dr David Smith

Research site/ region: Curieuse Marine National Park

Country: Seychelles

Research site latitude/ longitude: 4°17' E and 55°44' S

Protected area status: Marine Park

Period covered by this report: 1st Jan 2009 – 4th Dec 2009

Report completed by Dr David Smith, Sept '09



Dear All,

Just a short note to thank you all for such a great effort this year. I hope you gained as much as we did. It was a fantastic expedition season and we managed, one way or another, to hit all of our scientific objectives. Being able to undertake research around the Praslin coast was a real bonus for us particularly as it yielded some excellent results and introduced us to a wider range of habitat types. Also of course the data was fed directly back to our collaborators (i.e. SNPA) who are acting on it as we speak. As we hypothesised the coral reefs around Curieuse and Praslin were heavily impacted by the 1998 event and the species we see doing well now we deemed the most tolerant of thermal stress as demonstrated by the aquarium work you were all involved with. As usual the dive survey data raised other interesting questions that relate to the mechanism of bleaching and we are currently following this line of thought here in our laboratories. Another interesting point was the very rapid growth rates that we obtained from the permanent quadrats. These are amongst the fastest reported and of course that suggests that recovery potential post environmental impact is high. We are still trying to determine whether the very abundant Acroporiids at Praslin are thermally tolerant (a very unexpected result) or whether the environment there protected these corals from past environmental impacts e.g. due to the seasonal turbid water: we suspect the latter but we will need to do some more work and this will involve a trip at a different time of the year. For the next expedition we will characterise the environment around Praslin, gain more data on growth rates, undertake further experimentation on thermal tolerance and of course re-investigate the impacts of the new hotel on the dynamics of coral growth. Finally the fish data collected has helped us demonstrate the importance of reef architecture on associated biodiversity and reef functionality. Thus we are able to highlight the need to conserve coral species so that they provide complex topography that in turn stimulates fish diversity.

I trust you are all well and thank you again

David

SECTION ONE

Top highlight from the past field season

The most exciting and significant findings include the extremely high coral abundance found at the Praslin coast of the Curieuse Marine National park when coral, of a known sensitive genus reached > 70 %. This is an extremely important finding. The thermal stress experiments identified two clear outcomes of thermal stress which greatly enhances our understanding of a species ability to a) tolerate predicted climate change / climatic events and b) recover from periods of thermal stress. Finally, and less positively, the obvious detrimental impact of high sedimentation influencing key areas the Praslin coast was also a very important finding and will hopefully lead to environmental mitigation so that important biodiverse areas are protected.

Non-technical overview of results

Coral reefs are in global decline. Understanding how present day and future reef systems respond to environmental change is key to managing coral reef ecosystems of the future. This research has examined reef responses to large environmental disturbance events and has utilised an experimental approach to assess the tolerance of reef building corals to climate change predictions. We have identified both resilient and sensitive coral species and through detailed examination of associated biodiversity on reefs of coral structure have alluded to the likely impacts of future climate events on the overall diversity and productivity of coral reef systems. Importantly the research has also identified ecological refuge environments and that these environments may buffer reef systems from future environmental events (e.g. future El Niño events). The research has highlighted the importance of changing management practises by: i) focusing, not only on rare species, but also focusing on corals that are naturally abundant during non-impact event (traditionally given low conservation value) as it is by high abundance and wide distribution (across environmental gradients) that species will survive future events, and ii) focusing on protecting non-clear water sites (turbid environments) due to their ability to buffer more sensitive coral species from environmental events. Hence the research has provided us with greater insight in to coral species response to environmental change whilst also highlighting the possibilities of instigating changes to management practises that will in turn lead to a more resilient reef systems that has the greatest potential to recover from / be resilient to environmental impacts.

Acknowledgements

We gratefully acknowledge the assistance of Earthwatch volunteers, the Earthwatch Institute, Mitsubishi Corporation and finally to our Seychelles Collaborators from the Seychelles National Park Authorities who have been actively involved with every aspect of the expeditions and research.

PHOTOS: Curieuse Marine National Park, Seychelles



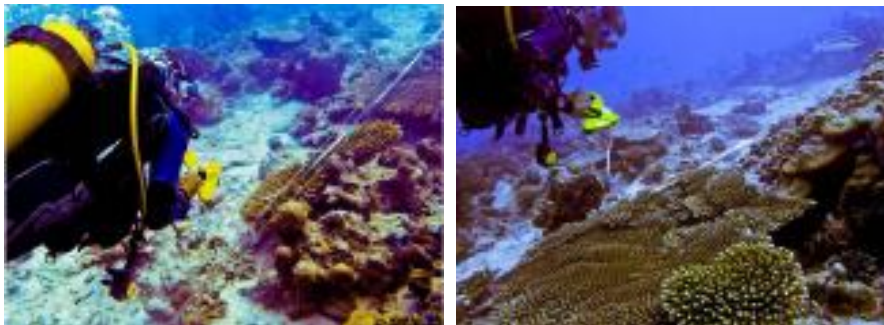
The high abundance of Acropora species at the proposed Praslin Ecological refuge site.



Earthwatch scientist examining the high abundance of fish within the Curieuse Marine National Park, Seychelles



An economic and ecological important but rare Napoleon Wrasse and Earthwatch volunteer within the Curieuse Marine National Park, Seychelles



Earthwatch scientist assessing habitat quality within the Curieuse Marine National Park, Seychelles



Close up showing deposition of anoxic sediments at Praslin Site 6 within Curieuse Marine National Park, Seychelles



Anchor damage within the Curieuse Marine National Park, Seychelles

SECTION TWO

1. REPORTING ON RESEARCH OBJECTIVES

Objective 1

Provide a baseline for patterns of richness of Curieuse coral and associated intertidal, including mangrove and seagrass, communities and establish long term monitoring stations

The intertidal team has completed surveys of the mangrove forest and shallow subtidal environments. The coral reef team established 9 permanent quadrats (10 x 2 m) around Curieuse Island (2008) and a further 3 during 2009. During 2009 the 2008 quadrats were re-assessed for coral cover (3 x 10 m transects across each quadrat) and coral cover ranged between 7.21 and 44.7 % (minimum and maximum value calculated per transect); there was a significant site effect, with significantly lower cover being found at the turbid (Baie Laraie) and most exposed (Pointe Rouge) sites. The number of coral recruits (6 mini-quadrats per permanent quadrat) were also determined and all coral colonies (maximum width, length and height) so that growth rates could be determined. In addition 10 stations were examined off the Praslin coast but still in the Curieuse Marine National Park. At each station 30 m transects were used to assess coral cover and fish abundance (belt transect time and distance restricted). This project (termed the Praslin Rapid Environmental Assessment, REA) was used to identify 6 permanent monitoring stations. At each station 3 permanent quadrats were located and the percentage cover of coral determined (ranging from 8 to 70 %). At all permanent monitoring stations (old and new) fish community structure was assessed (with 111 fish species being recorded across all sites). This objective has been met.

Objective 2

Identify high priority areas for closer inspection in the future on the basis of presence of unusually high species richness, rare species or communities, ecologically sensitive and important areas, and/or endangered habitats

The Praslin-REA identified areas of outstanding coral structure, herein termed the Praslin Acropora beds (Site 6, with up to 70 % coral cover of this branching genus). This area has been fully explored and characterized. It has been identified as an ecological refuge area and fixed monitoring station have been put in place to allow annual assessment. Most importantly we need to ascertain rates of growth and colony fragmentation within these beds whilst also monitor rates of change in cover and incidents of physical as well as biological (e.g. disease) damage. In total 4 monitoring stations have been established immediately around Curieuse Island (mostly eastward) and 6 monitoring stations off the Praslin coast. Each monitoring station consists of 3 permanent quadrats all of which have been assessed to provide an ecological base-line. Monitoring sites were established post a full ecological survey of the Curieuse reefs (2008) and Praslin coastline of the MNP (2009) and are deemed the most important areas to focus future annual assessment. Consequently this objective has been met.

Objective 3

Identify the most appropriate methods to monitor coastal and marine habitats over the long term.

During 2008 fixed monitoring quadrats (herein term data pods) were established and these were re-assessed during 2009. These fixed quadrats allowed large and complete data sets to be produced and have deemed highly appropriate to assess: 1) Standing coral community structure 2) Annual changes to coral reef structure 3) Growth rates of reef building corals 4) Recruitment rates of reef building corals 5) Structure of associated fish communities. The success of the data pods resulted in more being located at other sites so a greater range of habitats could be covered across a wider environmental gradient. Consequently this objective has been met.

Objective 4

Establish a series of natural sites and experimental artificial substrata to monitor long-term coral dynamics

The intertidal team located a number of settlement panels during January 2009. These were located at three sites in one of the key study areas. The coral reef team found 80 % of these panels remaining in August 09. Initial studies (yet to be completed) revealed high levels of invertebrate recruits. All panels were photographed during the August expedition and have been sent to the intertidal team for analysis (results pending).

Objective 5

Evaluate the rates of change in coral and associated intertidal, including mangrove, community characteristics and identify the key drivers of change.

The coral reef data pods have allowed rates of change to be determined. Growth rates for a number of species were calculated. Problems arose in the technique, which does not take into account coral colony fragmentation and consequently the results, theoretically, resulted in negative growth rates for some species. However the replication was large, and meaningful results have been obtained. The data demonstrated a surprising result, that clear water sites were characterized by slower growth as compared to turbid waters (Acropora ranging from 7 – 9 cms per year in clear water sites and 14 to 16 cms per year for turbid environments and Porites ranging from 3-5 cms per year in clear water sites to 5 – 10 cms per year in turbid

sites). The high rates of growth for *Porites lutea* was surprisingly high and warrants further investigation to ensure that high values obtained were not an artifact of the technique used. However the site differences (therefore any errors are standardized leaving a real site affect) can be explained by two, not necessarily mutually exclusive hypotheses raised two hypothesis: 1) corals are adapted to low light environments and make greater use of heterotrophy to sustain growth or 2) so called turbid environments are not so during the maximal growth season (April and May). These hypotheses will be tested directly during the May 2010 expedition when seasonal environmental conditions, will be recorded and metabolic balances of reef building corals characterized through direct assessment of photosynthetic potential and respiration, will be ascertained.

Objective 6

Examine the productivity and metabolism of the key coral taxa existing under the range of environmental conditions that characterize Curieuse Island.

This objective is on-going, we have characterized the photosynthetic potential of reef building corals during August-September conditions. However coral growth, as outlined above, which is integrated across the entire year, suggests that there could be changes to metabolism throughout the seasons. Consequently the metabolism of reef building corals will be re-assessed during 2010. Generally metabolic assessment has demonstrated however that corals generally fall in to two camps and most sensitive coral species, to elevated temperature and light, are more dependent on autotrophy whilst more resilient species appear to be more plastic in the metabolic responses being able to capitalize on heterotrophy. Such metabolic plasticity is potentially key to the long term survival of corals particular when put in to the context of environmental change as related to predicted changes in the relative abundance of environmental optima. We further hypothesis that corals that are more dependent on autotrophy do so at the expense of their inherent resilience to elevated temperature and thus are more susceptible to climate change. In the next year we will explore this further and start to address the extent to which the key reef building corals can acclimate to varying environments by changing their metabolic balance (through P:R assessment).

Objective 7

To determine whether coral adaptation across environmental ranges is generic or whether certain species are pre-disposed to survive in the face of climate change.

Both experimental evidence and field-based surveys suggest that some species are better equipped to survive environmental stress events such as predicted ocean warming and increased severity of sporadic events such as El Niño. We have identified two clear mechanisms (herein termed "type") of coral bleaching (type 1 and type 2). We have identified that type 1 bleaching does not allow for colony recovery when environmental conditions (temperature and light) return to ambient, the extent of mortality being dependent on the residual environmental variability (i.e. above ambient in terms of the actual extent, duration and frequency). In contrast we have identified that some species (herein termed type 2) are extremely tolerant to temperature anomalies (a key climate change variable) and although may show small declines in health are able to recover post event. These two mechanisms (i.e. lethal and sub-lethal) are a focus of our laboratory experiments and in particular we aim to enhance our understanding of the actual physiological mechanisms involved. Adaptability of coral species will be further tested in the field during 2010, particular for con-specifics existing

across a range of environmental conditions so we can identify degrees of metabolic plasticity and the role it plays in environmental resilience. Furthermore we hypothesize that differential species responses will lead to alteration in the physical structure of reef systems and consequently the biodiversity they support. There is some evidence to suggest that even corals that typically experience a type 1 bleaching response are buffered from extreme events by ecological refuge environments. We aim to assess the physiology of such corals over a wider range of environments and in particular address the following 1) whether or not species existing in such environments have altered their metabolism (e.g. by becoming less dependent on light) and 2) Whether high light species that are successful in turbid environments due to reduced metabolism. Such questions will help us to identify the relative conservation value of key architectural species and the potential value of marginal (i.e. sub-optimal e.g. turbid) coral environments. At present it would seem that many different species are able to exist across a much wider environmental gradient than was first envisaged but whether this existence is truly successful (competitive growth and fecundity etc.) or in fact the conditions are indeed marginal, remains to be determined.

Objective 8

To assess whether corals living in 'marginal reefs' utilize different acclimation mechanisms to those observed on typical reefs.

This objective has been compounded by results obtained through growth rate assessment. We hypothesized that corals existing in marginal (for the purpose of this study deemed as low light high sediment environments typically considered sub-optimal for coral growth) corals would reduce their energy allocation into growth whilst increasing energy allocation in to maintenance. However results obtained suggest that growth is high if not higher than non-marginal systems (see above objective) suggesting that the systems in question are not in fact marginal at the times of year when growth is maximized. Consequently we need to gain a better understanding of environmental seasonality and in particular how variable coral metabolism is across season (as outlined above). Temporal annual variability in resource allocation and coral metabolism has important consequences for predictive models of coral resilience to future environmental change as it suggests that corals, through seasonal acclimation, will be more / less susceptible to environmental impact events at different times of the year. Furthermore the ability of a coral species to acclimate to environmental variability might provide inherent resilience as compared to corals that are typically located in environments where seasonality is reduced.

Objective 9

To assess the potential of isoprene emission by corals as a mechanism for surviving in extreme environments, and coping with periodic stresses such as El Niño.

Unfortunately the equipment that was bought for this particular objective did not withstand field conditions. The equipment was Beta tested in Indonesia and failed to cope with high humidity and temperature. For this reason this objective was not, and will not, be addressed. It is worth noting that the equipment, although very new, was considered by the manufactures to be appropriate for tropical field environments and was purchased through a UK Research grant – it was not purchased specifically for this project or through project funds.

Objective 10

Insofar as is possible, initiate evaluation of the rate of recovery of the mangrove fauna after the devastation of the Baie Laraie mangrove caused by the December 2004 tsunami.

Results from the mangrove surveys are pending

Objective 11

To undertake a pilot study to assess the possibility of implementing a socio-economic centric research study aimed at identifying key stakeholders, levels of ecological knowledge and environmental awareness, and dependency on marine resources whilst also identifying possible areas of conflict between user groups and conservation managers.

Initial steps were made to address this objective. The Principle Investigator visited a local stakeholder group (Curieuse Marine Park Community Management Initiative) and discussed resource requirements and conflicts. The meeting stimulated further interest in the need to balance conservation with user requirements and the SNPA partners continue to meet with the local user group. Social-economic resource usage data is now being collected by our Seychelles collaborators but we are yet receive an update. It is uncertain whether or not this objective will be feasible in the long term and it is highly dependent on the requirements of the Seychelles collaborators and resources availability. However the potential continues to be explored and is certainly valid within the holistic context of the main project i.e. the resilience of Seychelles coral reef systems and consequences of environmental change for dependent society, but successful implementation of the objective would most probably require additional resources.

Objective 12

Generate material to engage the Seychelles government, local community and conservation groups in understanding the importance of the coastal habitats of the Seychelles.

This objective has been directly assessed through the production of the rapid environmental assessment report. During this survey, agreed upon and in fact instigated through the SNPA partnership, areas of outstanding coral abundance was recorded (as reported above) and these sites (through joint field visits, through video and photography) has been reported back to the partnership and local user group. Other material (media based – videos mainly) have been given to the partnership to highlight the impact of sedimentation on approximately half of the Praslin coast. Video evidence demonstrated that very high coral mortality occurs northwards of a new development and that the said mortality is most likely due to the amount of sediment entering the system. The use of targeted video was deemed extremely appropriate and a very visual way to engage local authorities, national agencies and the local stakeholders. We are awaiting response from our collaborators on how this information and material has been used and what the outcomes were. Passing the information to our Seychelles partners was deemed a more appropriate way of engaging with government and local user groups as they could do so through their already existing formal and informal networks.

2. PARTNERSHIPS

The key to this successful project was the excellent relations with our Seychelles collaborators from the Seychelles National Parks Authorities (SNPA). SNPA arranged logistics and all aspects of camp management. However some SNPA staff were also heavily involved with data collection, in instigating discussion between the researchers and local community networks whilst also providing incredibly useful information on local environments. SNPA staff also identified the need for the rapid environmental assessment of the Praslin coast. Their active inclusion in the project is essential to ensure future success and sustainability and this relationship needs to be carefully fostered. Other than that administrative and logistical support was provided by Earthwatch field management teams and again the project would not be possible without such support.

3. PROJECT DEVELOPMENT

One objective has been removed due to technological failure (as outlined in objective 9 progress above). No other objectives have been added but the remit of several have been expanded (as outlined in the object progress report above). However we do not feel that this represents a change in the objective and represents an opportunity to increase the quality and relevance of our research.

4. DISSEMINATION

Printed:

2009 and / or in press

Suggett D.J. & Smith D.J. (In Press). Interpreting the signs of bleaching as friend or foe. *Global Change Biology*

Barnes, D.K.A., Barnes, R.S.K., Smith D.J., Rothery, P. (2009). Littoral biodiversity across scales in the Seychelles, Indian Ocean. *Marine Biodiversity* **39**:109 – 119.

Barnes, R.S.K. (2010) Regional and latitudinal variation in the diversity, dominance and abundance of microphagous microgastropods and other benthos in intertidal beds of dwarf eelgrass, *Nanozostera* spp. *Marine Biodiversity* **40(2)**:95-106

Smith, D.J., Pretty, J.N., Etienne, M., Spring, N. & Suggett, D.J. (2009). Using Coral Reefs to Examine the Threats of Climate Change to Marine Biodiversity. National Biological Symposium Book chapter.

Hennige S.J., Suggett D.J., Warner M.E., McDougall K.E., Smith D.J. (2009) Unravelling coral photoacclimation: *Symbiodinium* strategy and host modification. Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida

National Geographic Japan National Geographic Explorer (Sept 09) New Scientist

Webcast Numerous websites (USA Today etc) Numerous local publications (university etc)

Meetings and conferences: 2009 only:

Hennige S.J., Suggett D.J., Etienne M., Spring N., Barnes R., Barnes D. & Smith D.J. (2009) Talk: Alternative bleaching mechanisms drive long-term changes in coral community structure. American Society of Limnology and Oceanography, Nice, France.

Smith D.J. & Suggett D.J. (2009). Oceans Priority Research, New York Academy of Science event.

Smith D.J., Spring N.S., Etienne M. & Suggett D.J. (2009). Coral reefs and climate change, resilience, refuge and recovery. Indonesia.

Smith D.J. (2009). Coral reefs and climate change: lessons from the Seychelles. Federal University of Bahia, Salvador, Brazil.

Smith D.J. & Suggett D.J. (2010). Coral Bleaching: the future of earths reef systems. Association of Tropical Biology and Conservation (ATBS), Bali July 2010.

5. CAPACITY DEVELOPMENT AND EDUCATION

Six staff of the Seychelles National Parks Authority have acted as staff on the expeditions in the past year. Each staff have been given formal and informal training in research design, implementation, data collection, analysis and output.

Numerous African fellows have joined the capacity building programme, particularly building skills in intertidal, including mangrove, research.

Teachers have also joined the project, as a development opportunity in environmental research and issues

6.1. CONTRIBUTIONS TO INTERNATIONAL CONVENTIONS, AGENDAS, POLICIES, MANAGEMENT PLANS

None as yet but steps are being made to ensure that research output is used by Seychelles partners during international symposium (Western African Regional Programmes) to highlight the need of detailed research when designing marine park management programmes and also to highlight the plight of reefs. The results have been placed in to a management context for this purpose. Several meetings between SNPA and the Earthwatch team have highlighted the need to examine national policy to ensure that conflicts between user groups and management authorities are resolved through potential changes in policy. It is our understanding that these ideas will be implemented as a case study to be put forward to other western African nations. However this will be dependent on our partners taking it forward.

6.2. CONTRIBUTIONS TO LOCAL, NATIONAL AND REGIONAL CONVENTIONS, AGENDAS, POLICIES, MANAGEMENT PLANS

Our research is fed directly back to our collaborators who are tasked with management of national parks of the Seychelles. Therefore our research feeds directly in to future management plans. Of particular note are the findings from the Praslin Rapid Environmental

Assessment which clearly demonstrated that landuse adjacent to the park are having a detrimental impact on reef systems. Initial meetings with local stakeholders are also relevant as the aim was to provide advice on how to formalize regulations for natural resource usage. The outcomes of meetings and their influence on policy is pending, also see above).

7. ACTIONS OR ACTIVITIES THAT ENHANCE NATURAL AND SOCIAL CAPITAL

Enhancement of natural capital is core to the entire research project. The production of base-line ecological data, the evaluation of system dynamics and identification of ecological refuge environments will result in greater awareness of those areas of specific scientific interest and conservation value. Our Seychelles partners have engaged with project and have already instigated actions to protect natural capital e.g. the establishment of more mooring buoys within the ecological refuge environments. Active enhancement actions will be dependent on how the Seychelles partners use the data. Social capital has been increased through researchers meeting with the local community along side SNPA staff and discussing conflicts and issues. Potential resolutions were identified and actions suggested, however implementation again is dependent on the marine park authorities rather than not native researchers.

8. LONG TERM IMPACT OF PROJECT

This project has highlighted the sensitivity of a key coral architect genera (the most diverse and within the Indo-Pacific abundant coral genus) and furthermore has identified natural systems that can buffer impacts of environmental change thereby increasing the conservation value of these ecological refuge habitats. Also the research has highlighted the key fact that abundant coral species are able to survive climatic events by being abundant and having wide dispersion across environmental gradients. Consequently it has highlighted the need to consider the fact that commonality and high abundance itself is a survival strategy and an important characteristic that should be taken in to account when considering the sensitivity of species and resilience of an ecosystems.

The key and most obvious outcome that can be considered central to this theme is the identification that turbid systems, which have traditionally been of low conservation value, are in fact extremely important systems that could buffer species against environmental change (i.e temperature anomalies). Consequently such systems have been given higher priority in terms of conservation efforts and further effort is being made to identify such refuge environments.