Executive Summary

Source: A Rapid Marine Biodiversity Assessment of the Northeastern Lagoon from Touho to Ponérihouen, Province Nord, New Caledonia: 133

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INTRODUCTION

For the executive summary a brief overview on the Marine Rapid Assessment Program and on New Caledonia is presented first, including general information on the inscription of the Lagoons of New Caledonia: Reef Diversity and Associated Ecosystems on the World Heritage List. Further general background information is presented for the three communes of Touho, Poindimié and Ponérihouen that lie adjacent to the reef sites surveyed. This is followed by general background information on the survey sites and methods used to conduct the study. Finally, highlights of the findings are given and we close with a discussion of conservation and management recommendations based on the findings.

Overview

Marine Rapid Assessment Program (Marine RAP)

The Marine Rapid Assessment Program conducts scientific surveys (Marine RAPS) [1] with local and international scientists to fill in data gaps on marine biodiversity in areas where data is lacking or under threat. Surveys provide data on select species of biological and commercial importance, as well as the "health" of the habitats sampled. The *in situ* fieldwork both underwater and on land identifies threats and documents socioeconomic issues regarding marine resource-use patterns, concerns, and beliefs of coastal residents in the particular region. The specific information collected and methods employed are based on local and regional needs as determined by consultation with all local stakeholders including government and other non-governmental organizations.

The information obtained during the Marine RAP is analyzed, synthesized and geo-spatially mapped with other relevant and available data to: a) pinpoint key sites and issues within the region for implementing realistic mechanisms/activities to conserve species and their habitats (e.g. establishing locally managed marine areas) and for mitigating threats to biodiversity (e.g. curtailing destructive fishing techniques); b) identify data gaps and topics for further study (e.g. stock assessments); c) implement further surveys, activities and studies needed for identified species and regions d) and address questions regarding biodiversity and the design of Marine Protected Areas.

Findings from the surveys enable informed decision making, especially for the creation of Marine Managed/Protected Areas and for implementation of other conservation "tools" (e.g. limitations on extraction). The surveys also provide exchange between national and international scientists to build capacity. Education and awareness on the importance of marine biodiversity and resources is also raised as a result of Marine RAPS.

1 Marine Rapid Assessment Program Survey(s) are commonly referred to by the abbreviated term, Marine RAP(S).

New Caledonia

New Caledonia is a *sui generis* collectively of France situated in Melanesia within the southwestern Pacific Ocean (21^0 30' S, 165^0 30' E). The main island "La Grand Terre" and a number of smaller ones surrounding it comprise New Caledonia with a total land area of 18,575.5 square kilometers and a marine area of 1,740,000 square kilometers. New Caledonia is divided into the three administrative provinces: Province des Îles, Province Nord, and Province Sud. Within these provinces a combined total of thirty-three communes exist.

New Caledonia is currently in a self-determination process in relation to France through the Government of New Caledonia to which certain powers and responsibilities previously managed by the French State are being transferred to this government.

The population of New Caledonia is approximately 245,000 people with a density of 13.2 people per km^2 (ISSE 2010). The majority of the population lives in Province Sud around the capital city of Nouméa. Although a number of different ethnic groups reside in New Caledonia (French and Polynesian among others), the indigenous Melanesian group referred to as the Kanak, has a large presence throughout the island socially and politically. They comprise about 40% of the inhabitants and the majority traditionally live in family oriented tribes. Kanak tradition keeps the people very close to the land and sea as they depend on the land and sea for their food. Kanak culture and religious beliefs acknowledge the importance of the health of their ecosystem, therefore traditionally; they hold utmost respect for the use of their resources.

The economy of New Caledonia is based mainly on nickel and the metallurgy industry as Grand Terre holds 25% of the world's known nickel deposits. Tourism is the second leading industry with agriculture, fishing and aquaculture making some contribution as well. A substantial amount of financial support is also received from France.

On land, an extremely rich biodiversity and high endemism is found owing to the origin of Grande Terre from Gondwanaland. The island separated from Gondwanaland (Australia and New Zealand) about 55 million years ago[2] resulting in unique fauna and flora. For example, the island has 21 endemic species of birds, 62 endemic species of reptiles and 2,432 endemic species of vascular plants. Subsequently New Caledonia is one of Conservation International's biodiversity hotspots[3]. Equally impressive are the waters of New Caledonia where a variety of marine species are found in numerous marine habitats such as coral reefs, mangroves, and sea grass beds. The importance of the coral reefs and lagoon is significant as it the largest enclosed lagoon system in the world (40 000 km^2) and comprises the longest cumulated barrier reef system in the world (1 600 km). Further, in some areas there are double barrier reefs' structures (present in the current study area) and in some sections the barrier reef is even triple.

The tropical lagoons and coral reefs of New Caledonia were inscribed as a World Heritage Site in July 2008 under three criterions (vii, ix, and x). These include (vii) superlative natural phenomena or natural beauty; (ix) ongoing biological and ecological processes and; (x) biological diversity and threatened species. A requirement of the inscription is that the integrity of the property be preserved, to this end improvement to and the development of new management and protection plan are underway. Six marine clusters comprise the serial property and include Atolls d'Entrecasteaux, Atolls d'Ouvéa et Beautemps-Beaupré, Grand Lagon Nord, Grand Lagon Sud, Zone Côtière Nord et Est and Zone Côtière Ouest.

Two previous Marine RAP surveys have been conducted in New Caledonia within and surrounding the marine cluster of Zone Côtière Nord et Est. These included the Mt Panié Marine RAP off the northeast coast (McKenna et al. 2006) and the Koumac to Yandé Marine RAP off the northwest coast (McKenna et al. 2009). Here we report on a third Marine RAP conducted just south of the area surveyed during the Mt Panié Marine RAP (McKenna et al. 2006) off the northeast coast of the communes of Touho, Poindimie, and Ponérihouen from Grand Récif Mengalia in the north to Ugué Pass in the south (Map 1). This region surveyed also falls partially within the marine cluster of Zone Côtière Nord et Est, (i.e. encompassing the area between Grand Récif Mengalia and Cap Bayes Pass). The coral reef system off the coastline of these three communes varies considerably in terms of distance from shoreline (e.g. see Grand Récif Mengalia) and formation (number and types of habitat present) (e.g. there are more intermediate reefs found off of Ponérihouen). An unique feature is the double barrier reef found just north of the Passe de Cap Bayes off of Poindimié (Andréfouët et Torres-Pulliza, 2004). Off the coastline of Touho, extensive mangroves can be found. Several uninhabited small islands and cays occur within the mid lagoon area and include the Ilots d' Harcourt, Ilot Agué, Ilot Karu, Ilot St. Ignace, Ilot de Sable, Ilot Bayes and Ilot Tibarama.

The three communes and their corresponding populations with density (#individuals/km^2) are as: Touho 2247, 7.9 ; Poindimié 4818, 7.2 and Ponérihouen 2384, 3.4. There are a total 45 Kanak tribes in these three communes: Touho 11 tribes, Poindimie 21 tribes and Ponérihouen 13 tribes (ISEE 2010). In the most southerly commune of this survey, Ponérihouen, nickel mining activity occurs in Monéo and the neighboring commune of Houaïlou.

2 New Caledonia and New Zealand from Australia 85 million years ago, and from each other 55 million years ago

3 The hotspots concept was first articulated by British ecologist Norman Myers in 1988 and adopted by CI as a priority setting framework in 1989. CI currently focuses on 34 biodiversity hotspot regions worldwide. Together, they cover just 2.3% of the Earth's land surface yet harbor 76% of all the earth's mammals, 82% birds, 71% reptiles, 81% amphibians and 50% all vascular plants.

SURVEY SITES AND METHODS

The survey was conducted in two main phases by a team consisted of local and international scientists. The first or biological phase took place from November 14th to December 7th , 2009 when 48 sites were assessed from Grand Récif Mengalia in the north to Ugué Pass in the south. During this time the biological group evaluated the biodiversity of coral and reef fish as well as select invertebrates. Targeted fish stocks and the condition of the coral reefs were also assessed. At each site, an underwater visual inventory was made of the biodiversity of coral reef fish and benthic invertebrates, mainly scleractinian corals and select invertebrates. Standard underwater visual censuses techniques with transect were used to assess targeted fish stocks and the condition of the coral reefs at each site. Due to scheduling, the reef fish diversity portion was conducted in two parts. The first part took place November 16th to November 29th, 2009 with the main phase for sites 1 to 30. The second part, sites 31 to 48, were evaluated with assistance of Martin Ravana, manager of Tiete Diving Poindimié from January 29th to February 3rd, 2010.

Sites were selected to cover the range of reef types in the area in order to maximize biodiversity and have sufficient coverage for the main reef types in the survey region. Sites of particular interest were also assessed. Ultimately the sites sampled were dependent on weather conditions. The sites sampled for this survey were categorized by reef type as adapted from the geomorphological units (Andréfouët et Torres-Pulliza, 2004) and location off of the three communes (summarized in Table 1). One mangrove site off of Touho was assessed as well. The exact location of these sites is not available in this report; however the general survey area covered can be found on the map.

The second or socioeconomic phase of the survey involved 54 days of field operation, divided into several periods between March 13th and July 2nd, 2010. The study area covered the three communes and the 25 tribes located on the seaside or at river mouths. During this phase, 88 interviews (individual or collective) were conducted. A questionnaire on seafood consumption was given also to primary schools. The approach used was adapted to the local social structure of the target groups.

Table 1: Sites samples for this survey were categorized by a) reef type or habitat and b) location off of commune. One mangrove site was assessed as well.

Type de récif/habitat	Site
Passe (Pass)	10, 19, 20, 25, 28, 32,43
Extérieur /Exterior (Barriére externes/Outer barrier reef)	1, 2, 21, 26, 31, 37, 38
Récif arrière (Back reef)	3, 7, 11, 18, 22, 23, 24, 27
Intermédiaire (Intermediate)	4, 5, 8, 9, 16, 17, 29, 33, 34, 36, 39, 40, 41, 42, 45, 47
Frangeants (Fringing)	6, 12, 13, 15, 30, 35, 46, 48
Palétuvier (Mangrove)	14
Commune	**Site**
Touho	1- 18
Poindimié	19-36
Ponérihouen	37-48

RESULTS

Highlights of the RAP survey are presented below. Detailed results are included in separate chapters for the diversity of Scleractinian corals, select invertebrates and coral reef fish; targeted fish; reef condition and socio-economic issues of the area.

Scleractinian coral diversity

- A total of 333 named coral species was observed during the present survey. The average species diversity per reef site (73.2 species) was higher in this study than in the northwest (63.8) and the southwest (52.7) of New Caledonia, using the same method and recorder (Fenner and Muir 2009). The diversity was similar to that in some areas in the Coral Triangle.
- The number of coral species was correlated with the depth range, as it was in the northwestern RAP (Fenner & Muir 2009). The number of coral species was highest at sites in the lagoon, next highest on the outer barrier reef, followed by passes, then the back reefs of, and finally fringing reefs.
- Five species were observed that are listed as Endangered according to the IUCN Red List (*Acropora rudis*, *Anacropora spinosa, Alveopora minuta*, *Pectinia maxima* and *Millepora tuberosa*) and 68 were listed as Vulnerable.
- A total of 26 species was found that extends the known biogeographic range of the species. The most notable was *Acropora rudis*, a species only reported from the Indian Ocean. The presence of the rare blue coral, *Heliopora coerulea*, was confirmed and compliments the recent discovery of this species in Fiji. The presence of a rare and cryptic fire coral, *Millepora tuberosa*, was also confirmed.

Coral Reef Fish Diversity

- A total of 433 species of fish were identified compared to the 1695 species reported to occur in New Caledonia in the 0-100m zone by Ron Fricke and Michael Kulbicki. The number of fish species recorded during this RAP ranged from 39 to 143 for the least rich to richest site respectively. A mangrove site with only seven species and where reefs were not present was not taken into account in determining an average mean per site. The mean is 83.4 species over 47 sites.
- The greatest diversity of coral reef fish was mainly observed on the outer reef slopes with an average of 113.6 species; passes with 92.6 species; intermediate

reefs with 87.3 species; back reefs with 85.7 species and fringing reefs with 50.2 species per site. Over the study area the three most dominant families present included Labridae with 68 species, Pomacentridae with 61 species and Chaetodontidae with 29 species.

- Two species of fish, *Halichoeres richmondi* and *Chlorurus japanensis*, that had been observed during the Hienghene-Pouebo RAP in 2004 are confirmed in this study. They were observed, recorded and photographed. In addition, 10 other fish weren't identified and some of them may be new species.

Select Invertebrates

- Twenty-three species of sea cucumbers were observed, including two rare species, *Actinopyga albonigra* and *Bohadschia maculisparsa*. Eighteen out of these 23 species observed are used in the bêche-de-mer trade. The number of sea cucumber species per site ranged from zero to eight with a mean of 3.6 species per site.
- For gastropods, 192 species were identified including 22 opistobranchs species. The number of species per site ranged from two to 25, with a mean of 9. The diversity of gastropods with shells appeared to be higher in areas under strong oceanic influence.
- Five species of giant clams were observed during the survey and included: *Tridacna maxima*, *T. crocea*, *T. squamosa*, *T. derasa* and *Hippopus hippopus*. The most commonly observed species were *Tridacna maxima* (112 specimens), followed by *T. crocea* (37 specimens) and *T. squamosa* (34 specimens). *Tridacna derasa* was observed to be uncommon with only 6 specimens seen. *Hippopus hippopus* were rare with only one specimen found alive.

Targeted Fish

- A total of 186 species belonging to 67 genera and 23 families was identified over 48 study sites. The fish communities observed during this study are mainly dominated by herbivorous species belonging to the families of Acanthuridae and Scaridae.
- A remarkable variety of parrot fishes (Scaridae) is reported with a total of 23 species observed, including two reported as rare in this area of the Pacific: *Chlorurus frontalis* and *Chlorurus japanensis* .
- Top predators (large size sharks, Spanish mackerels, barracudas, job fishes, groupers and trevallies) were observed in very low numbers. The same can be said of species considered iconic (e.g. humphead wrasse and bumphead parrotfish).

Reef Condition

- Reef condition is a term pertaining to the general "health" of a particular site as determined by assessment of key variables including natural and human-induced damage or stress and biodiversity based on focal species or indicator groups (corals and fishes) and approximate account of targeted fish for the 46 reef sites assessed. These variables were summed by reef site and comparatively ranked from high to low and rated accordingly as: excellent 13%, good to very good 28.3%, fair 45.6% and poor 13%.
- The most frequently observed disturbance was from symptoms indicative of disease mainly for hard corals. Coral disease was observed at 46.8% of the sites surveyed. Other symptoms indicative of diseases were noted at 27.2% of the sites surveyed on several other invertebrates including soft coral, sponges and crustose coralline algae. The incidence of bleaching was very low and minor with one to two colonies with pale tissue coloration observed at three sites.
- Sedimentation stress was observed at 42.5 % of the sites surveyed and varied in extent of observable impact. The fringing reef sites as expected were the reef type where sedimentation stress appeared to be most severe.
- Red listed species were spotted on 55.3% (26 sites) of the reef sites we assessed. These include several species of sharks, bony fish and sea turtles. In cases where the red listed species were observed, only one or two individuals of that species were present on the site except for the coral trout, *Plectropomus leopardus* that was seen in small schools.

Socio-economic

- A field survey, consisting of 88 interviews (individual or collective), was conducted and a questionnaire on seafood consumption was given to primary schools. The methods of surveying the target groups were adapted to the local social structure.
- The study area has about 10,000 inhabitants, of whom 80% are of Melanesian origin and of customary law status. The population is very young, and for the most part lives on the coast. The unemployment rate is high but informal subsistence activities are widespread.
- The marine environment is a place which supports many uses, primarily various types of fishing, which are characterized but remain difficult to quantify. Dependency on fisheries resource for food is very strong. The main anthropogenic pressures are terrigenous runoffs related to land erosion, as well as domestic pollution.
- The public expressed a strong will for environmental management, but the organization of a participatory management project requires taking into account local socio-cultural realities.

CONSERVATION AND MANAGEMENT RECOMMENDATIONS

As part of the 2008 World Heritage inscription of the site, Lagoons of New Caledonia: Reef Diversity and Associated Ecosystems, an overall management framework that respects customary rights has been developed by the federal and provincial government with the involvement of all local stakeholders (IUCN 2008). Several laws and regulations,

mainly fisheries legislation, exist and are undergoing further examination to ensure and improve effectiveness. Further within each of the six clusters, management and conservation plans are being developed with full stakeholder involvement, including co-management arrangements with the Kanak (UNESCO 2011). This participatory process has begun with the establishment of management committees for the communes of Touho and Poindimié. The adjacent lagoon area off these communes is within the inscribed core area of the marine cluster Zone Côtière Nord et Est, (i.e. encompassing the area between Grand Récif Mengalia and Cap Bayes Pass). Although not part of the inscription, areas adjacent to the core area include buffer zones and the bordering zones just outside the buffer zones off the commune of Ponérihouen. These zones (buffer and adjacent) are critical to ensuring the resilience and vitality of the inscribed zone areas so their proper management is of concern as well.

The conservation and management recommendations are based on the findings from this survey that assessed the biodiversity, reef condition and marine resources of reef sites in the core, buffer, and outside or adjacent zones. Data also collected from the people who use the resources, including 25 tribes located on the seaside or at river mouths, were also taken into account to formulate these recommendations.

For ease of review and clarity, the recommendations are numbered and listed under activity heading and are interrelated. In some cases related activities are listed under the activity heading. These recommendations are not meant to be comprehensive and hopefully will help stimulate other ideas for actions to take and the best way to effectively implement them to ensure the longevity and health of the area. Some of these recommendations are similar in scope to what was recommended during the past two rap surveys (Mount Panié and Yandé to Koumac). This is not surprising as some of the same issues and concerns, especially regarding sedimentation, are a prevalent threat throughout New Caledonia.

1) The meaning of the World Heritage Inscription of Sites for New Caledonia: Global, Regional and Local Context clarified with management goals and project framework articulated and widely communicated to inhabitants of all three Communes

Based on the interviews collected from the socioeconomic portion of the study, there appears to be some lack of clarity in terms of what the inscription means for some inhabitants. The inclusion of the reefs as part of the World Heritage inscription in 2008 is well known by the stakeholders; however the management goals and project framework are not explicit to the population. As a result some of those interviewed were wary regarding the results of the listing and what it means for them in terms of use (e.g. more regulations and restrictions). More information on the management goals and project framework for the World Heritage site listing needs to be disseminated with the method or means of explanations tailored to the local context of the targeted user groups (recreational, sports and subsistence fishers, tribes and tourists etc) and widely disseminated.

2) Mapping of marine resource use in conjunction with rules and regulations regarding use of the area regardless of compliance level from user groups (e.g. gap analysis).

Compounding the lack of clarity for what the inscription means, there is a lack of clarity in terms of what the current rules and regulations are that currently exist. This is complicated even further by the socio-cultural realities. There is information in terms of whom uses what part of the marine resources and the location for lagoon areas adjacent to the three communes (e.g. see socioeconomic chapter). Further analysis of who does what where, how it is regulated if at all and by whom in reality or on paper needs to be determined. Does the locality (e.g. fringing reef or islet) and resource used (e.g. species of fish) in actuality fall under any customary practice or federal/provincial government regulation and legislation or both? If there is no ultimate authority responsible for regulating a place or activity then obviously it needs to be developed and appointed as agreed upon thru full consultation of all local stakeholders/those concerned in the communities. This would help mitigate current and potential conflicts among user groups (e.g. recreational and sports fishers versus subsistence fishers). Who uses what, where is the locality, how it is regulated if at all, and level of compliance for that activity needs to be determined so that a firm foundation for participatory systematic conservation and management planning can take place.

3) Capturing of the tribal traditional knowledge and management practices for the area; integrating this information as appropriate with the public maritime domain rules and regulations to develop an adaptive management plan that is effectively communicated.

Given that customary and administrative legitimacies overlap, a related recommendation following from the previous one is to capture the tribal traditional knowledge and management practices of the area. This information can be then taken into account and integrated as appropriate with the public maritime domain for co-management purposes. Collecting and capturing this information will help raise awareness and build support for more effective management and conservation activities. Additionally this information may contribute to a better understanding of the current condition of the reef sites within the lagoon and perhaps provide insight to improving management and conservation activities. It is recognized that this task has to be done with the utmost care and respect given the local socio-cultural realities of the area and by a means that is agreeable to all, (e.g. government, tribes, inhabitants and all people concerned). Once this information is gathered, it needs to be synthesized and integrated or adapted into the management plan (i.e. marine spatial planning) with the full participation of all those concerned. The resulting management plan needs to be widely communicated and disseminated through meetings, posting of signage at various localities (e.g. market, docks, post office, schools,

meeting places) and handed out. A communication strategy developed and tailored to the targeted users would help ensure effectiveness. This would contribute to increasing environmental education and raising awareness as well.

4) No-take or fully protected status for sites of outstanding biodiversity value or sites thought/known to be used for spawning aggregations, migratory roots or corridors, nesting sites, feeding or nursery areas.

The spatial variability observed over the entire area is mainly structured along a coast to ocean gradient. Numerous environmental (e.g. topography and types of reefs, hydrodynamics, turbidity etc.) and anthropogenic factors (e.g. proximity and accessibility of reefs, terrigenous runoffs) combine to influence the community structure of the flora and fauna. Moreover this survey was carried out over a short time period providing only a snap shot. Nevertheless, several sites stood out compared to the others in terms of their biodiversity (hard corals and reef fish), targeted fish, and overall condition of the reef and are recommended for designation as a no take or fully protected area. Key sites included the outer slope of the exterior barrier sites of Récif Mengalia, Recif de Poindimié, the intermediate reefs off of Ilots d' Harcourt, and Ilot Tibarama. More details can be found in the chapters of this report on each parameter observed. A brief background on key sites of note is provided below.

In terms of species richness for coral, the greatest numbers observed were at site 32 located on the northern side of the pass Du Cap Bayes and sites 40, 41, and 45 located off of Ilots d' Harcourt. Additionally, five other noteworthy sites as identified by the two indices of coral replenishment and rarity included the intermediate reef sites of 9 (behind Récif Mengalia), 29 (mid-lagoon off of Touho commune) and 36 (off Ilot Tibarama) as well pass site 19 (located in the passe de la Fourmi) and one fringing reef site (35) off of Cap du Bayes.

Based on the richness for reef fish species, the outer slopes of the exterior barrier reefs located off of Grand Récif Mengalia (1, 2,) were observed to have the highest values during the assessment. Additional outer slope exterior barier reef sites included were: 38, 21, and 37. Other noteworthy sites included an intermediate reef within the lagoon in close proximity to the back reef (site 17) and a back reef site, 22. Regionally, the entire area surveyed had comparatively a very good number of fish species.

For targeted fish, three exceptional sites of note included 1, 11, and 17. Sites 1 and 17 had the five highest values for species richness, abundance and biomass. Site 11 (located on back reef near the pass in front of Touho) had observed species richness and abundance values within the five highest and a biomass value within the 10 highest. In general, seven other sites (2, 9, 20, 23, 33, 37and 38) stand out with values that fall within the 10 highest for at least two of the measured indices of reef fish communities.

Combining the previous parameters with reef condition, the outer slopes of the exterior barrier sites (1, 2, 26, 31, and 38) and reef pass sites (10, 19, and 32) were noteworthy. Additionally, some intermediate reef sites (9, 10, 17, 36, and 41) ranked in the two categories of good to very good and excellent condition. These sites tended to be the ones located in the lagoon closer to the barrier reefs and passes. Notably, one fringing reef site off of Cap Bayes (site 35) was assessed to be in good to very good condition (with targeted fish counts not included). Despite the deposition of sediment on many surfaces, the coverage of soft and hard coral was high.

Several nesting sites for green and logger head turtles reveal the interest of the Touho-Ponérihouen area, especially on the islets. It is recommended that an improved assessment of the nesting sites and their location be conducted to allow for the establishment of appropriate safeguards (e.g. protection status and restriction of visitors to islets during nesting season) Currently, none of the islets in the area of the RAP are part of a marine protected area or have any particular protection status.

5) Further research and monitoring to better elucidate the biodiversity, other dynamic processes (e.g. water flow patterns, movements of species) and events (e.g. bleaching, disease and crown-of-thorn outbreaks) in the area are necessary for effective systematic conservation planning and management.

Given the spatial and temporal limitations of this survey, more studies are needed to uncover the biodiversity present within the focal groups already studied as well as others of interest (e.g. algae). Within New Caledonia, monitoring and research activities on the coral reefs are already in place, it is suggested that the locations currently being studied and monitored are assessed to ensure adequate representation and coverage of the coral reefs around all three provinces and especially the area of the six marine clusters.

Specifically within the area surveyed (core, buffer and adjacent zones of the marine cluster Zone Côtière Nord et Est) observations suggest that follow up may be important in regards to diseases of corals and other benthic invertebrates. The frequency and incidence of disease should be monitored closely. Other items or events normally monitored should be followed as well such as bleaching and outbreaks of crown of thorns star fish.

As funding is usually limited for such activity, a way to increase coverage of the reefs given limited resources is to enlist the help of stakeholders who frequent the reef (e.g. SCUBA diving clubs, tribes with traditional marine areas, tourists, fishers etc). An awareness and education campaign on what to look for in terms of signs of stress on the reef (e.g. coral diseases, bleaching, Crown-of-Thorns outbreaks) can be launched that would include a way to report such sightings for further examination by scientists, managers and the marine regulatory/protection entities in the region. Sightings of other species of special interest (e.g. whales, dolphins, sea turtles, Napolean wrasse, and dugongs) and areas thought or known to be spawning aggregations and nesting sites could be reported as well. Some of this info may be captured from the local stakeholders (e.g. traditional knowledge). Monitoring sediment loading on the reefs through some type of low tech method may also prove helpful.

6) Specific monitoring of targeted species stocks over time for accurate assessment of the populations and to ensure sustainable use.

Further study is recommended for several taxa (e.g. sea cucumbers, trochus, clams, fish) to provide better estimates of species population over time (e.g. five years or more) and density to ensure sustainability of the populations. The nature of the Marine RAP does not allow for the accurate assessment of targeted stocks. Further the coverage of habitat types during the rap most likely influenced the number of sea cucumbers and trochus observed as their preferred habitats were not frequently censured. Several commercial fishers specifically commented that they noticed a decline in sea cucumbers and trochus. Similarly many people expressed concern that clams were being overfished. Findings from the inventory of the benthic macro-invertebrates suggest that the clams, *Tridacna derasa* and *Hippopus hippopus* may be of limited abundances.

Several fish species were mentioned by stakeholders to be of concern for perceived declining population numbers. These species included sardines, anchovies and especially Spanish mackerel as it is fished during their breeding season (October to December). Tribes along the river specifically mentioned an observed decline of "Black mullet" while commercial deep sea snapper fishers commented on a decline in snapper stocks.

Determining stocks of targeted species is strongly recommended. This appears to be urgently required not only due to the stakeholder's concerns, but also given the proposed Koniambo mining development to the Voh-Kone-Poumbout communes (VKP) area that may lead to increasing number of recreational and sport fishers off the communes of Touho, Poindimié and Ponérihouen. Another related recommendation is to see if an accurate estimate of fishing effort and catch per unit effort can be determined for the area. It is recognized that given the characteristics of the reef fisheries, this is a challenge (Pascal, 2010). The potential options for other methods (e.g. mandatory reporting of all landings) to be instituted that may help estimate fishing effort can be explored.

7) Reduce, monitor and mitigate sedimentation as part of an integrated coastal zone management plan (iczmp) for the entire watershed of the three communes. Ensure plan is adapted to projected effects from climate change and that stakeholders are educated on coastal erosion and climate change.

Although sediment loading did not appear to be as severe on the reef sites here as that observed during the Yandé to Koumac Marine RAP (McKenna et al 2009), the need to undertake activities to mitigate land erosion and land run-off is certainly required. During the socioeconomic study, terrigenous run-off was voiced as a major concern by stakeholders and was identified by the biological team as a negative factor for the biological portion of the survey as well. Although mining is less developed on the east coast than the west coast of Grande Terre, mining does occur in the most southerly commune of this survey, Ponérihouen where nickel mining activity occurs in Monéo and the neighboring commune of Houaïlou (DIMENC 2008). Further some mines in Poya on the west coast may spill over into catchment areas linked to the east coast thereby partially affecting them.

Restoring the watershed by replanting native plants where possible is a recommended start. Sediment from road based work was also mentioned by the stakeholders as contributing to the problem. This can be lessened by placing sediment screens as a barrier to collect the sediment before it reaches the reefs. Erosion due to the presence of invasive species (deer and pig) and to bush fires occurs, but has not been assessed fully in the area. Such an assessment is recommended and would provide useful information for curtailing run-off. Some coastal development can also cause a significant and localized terrigenous runoff, which can strongly affect the reefs nearby.

Studies to determine the exact source and the routing of the sediments and the other possible accompanying compounds (e.g. pesticides) or items (household garbage) by which it reaches the reefs would be useful information for mitigating the impact from the run-off. Additional study into the processes involved in erosion (land or coastal) may prove useful. Restoring, maintaining and monitoring the watersheds of the three communes as part of an integrated adaptive coastal zone management plan would be most beneficial especially with projected changes climate change. Further as part of implementing such a plan, widespread education on the dynamics of land erosion especially coastal erosion and how this interplays with global climate change appears to be needed. Coastal erosion is a concern and some stakeholders appear to lack information on this factor and on climate change.

8) Study and plan for other identified and potential stressors or source of disturbance to the marine, terrestrial, or freshwater areas for the three communes so these threats can be mitgated.

Other identified sources of stressors to the environment in the three communes were from domestic pollution including untreated sewage. The communes have limited equipment and means to deal with household waste. Collection takes place by private companies that require payment. In some instances, some stakeholders do not agree with paying for this service. Not all the tribes are serviced by the private collection companies so people are required to bring their own waste to the landfill. Areas with no collection either burn their garbage in gardens or discard it outdoors and some end up in mangroves. Waste that does go into landfills is just stacked not treated with some of the landfills located directly in mangroves such as in the commune of Touho. Moreover, waste waters from some tribes is not always treated and is directly discharged into rivers that flow into the lagoon. Therefore, it is strongly recommended that a waste management plan be developed to address this issue for the three communes. This is especially important with the potential population increase projected for the area from tourism

(e.g. development of the VKP area may lead to more fishers and visitors) and migration.

The infrastructure required to maintain the existing and projected larger population needs to be carefully thought out as part of the iczmp. As tourism is likely to increase, measures to maintain the integrity of the area and leaving the least impact while allowing for visitors to enjoy the environment should be pursued. For diving or other boating activities that occur already or may be promoted, installing moorings to prevent anchor damage may be advisable as well as instituting user fees for dive tourists visiting the area. Anchor damage to the reef sites was noted by the stakeholders during the socioeconomic phase of the study.

9) Patrols for enforcement and compliance to the laws and regulations of the marine managed areas and central locality to report activities (accidental and intentional) that may be compromising the integrity of the environment.

The lack of knowledge or understanding of the laws and regulations is compounded by little to no enforcement as well. Some cases of poaching (e.g. turtle, tuna, and clams) were mentioned by stakeholders. Even with extensive education, awareness, and outreach programs, inevitably there is an issue of compliance in any marine managed or protected area. Some type of physical enforcement (e.g. presence of marine patrols) would help ensure people obey.

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