Species of Reef Corals Observed in Northwestern Lagoon of Grande Terre, New Caledonia

Authors: Fenner, Doug, and Muir, Paul

Source: A Rapid Marine Biodiversity Assessment of the Coral Reefs of the Northwest Lagoon, between Koumac and Yandé, Province Nord, New Caledonia: 149

Published By: Conservation International

URL: https://doi.org/10.1896/054.053.0122

Executive Summary

INTRODUCTION

Here we report the findings from the Marine Rapid Assessment Survey of the coral reefs of the northwest lagoon (Yandé to Koumac) of Nouvelle Calédonie. 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 tropical lagoons and coral reefs of New Caledonia as a World Heritage Site. Further background information is presented for the two communes of Poum and Koumac 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 results are given and we close with a discussion of conservation 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; and 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°30'S, 165°30'E). The main island "Le 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 in the process of having governmental power and responsibility increasingly transferred from France.

The population of New Caledonia is approximately 230,789 people with a density of 12.4 people per km² (ISSE 2008). 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 (European 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 45% of the inhabitants and 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 coral reefs are of particular note as they comprise the second largest barrier reef in the world (40,000 km²) and are one of the few double barrier reefs found. 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; (x) biological diversity and threatened species. A requirement of the inscription is that the integrity of the site 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-Est and Zone Côtière Ouest.

The area surveyed in this study lies partly within the marine cluster of Zone Côtière Nord & Est (S 20° 24 43 E164° 33 59) that comprises a core area of 371,400 hectares and a buffer zone of 100,200 hectares in Province Nord. It is important to note that the buffer zone is not part of the inscribed site, but designated to protect the integrity of the core area (IUCN 2008). The survey area (Yandé to Koumac) is located off the northwest coast of the communes of Poum and Koumac (Map 1). The northern part of the area surveyed from Récif des Français to Passe de Poum is within the core area of the marine cluster Zone Côtière Nord & Est. The area south of Passe de Poum to Passe de la Gazette is within the buffer. Finally the southernmost portion of the area surveyed, south of Passe de la Gazette to Passe de Koumac is outside the marine cluster of Zone Côtière Nord & Est.

Islands and islets can be found mid-lagoon in the survey area. Of particular note are the islands of Yandé and Néba that are located off of Poum commune. Previous and present mining activities are located onshore in both communes. Poum has a population of 1,390 with population density of 3.0 people per km². There are nine tribes in Poum and these include Baaba, Bouarou, Pangai, Taanio, Tiabet, Tie, Titch, Yande and Yenghebane[4] (ISEE 2008). Within the commune, the surface area of customary lands is 7,291 hectares whereas municipal land is 46,940 (ISEE 2008). The highest point in the commune of Poum is 412m. Mines in Poum are found on the Prequ'ile de Poume. Currently mining activity is taking place in Poum by Société Le Nickel (Directorate of Industry Mines and Energy or DIMENC 2008). Société Le Nickel's Poum mining center opened gradually in 2007 with the operation projected to produce 750 000 tonnes of ore in 2017 (Société Le Nickel 2008).

The commune of Koumac has a population of 3,003 with a population density of 5.5 people per km². The last major city of the northwest coast, Koumac is located here. The commune consists of 3,330 hectares (surface area) of customary lands and 55,000 municipal land area (ISEE 2008). There are five tribes in Koumac and these include Galaaoui, Pagou, Paop, Wanac I and Wanac II4 (ISEE2008). The highest point in Koumac is 823m. A fishing base and port for

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.

4 Spelling of tribal names may vary. Tribe names according to 1996 census (ISEE-INSEE 2008).

pleasure craft is located in Koumac .Approximately 18.5 km north of Koumac is the Tiébaghi mining center (Le Dome Tiébaghi) where Société Le Nickel is actively mining nickel .(Directorate of Industry Mines and Energy or DIMENC 2008)

Survey sites and methods

From November 24, 2007 to December 15, 2007, coral reefs were surveyed off the coast from Yandé to Koumac. The team consisted of local and international scientists. The biological group evaluated the biodiversity of coral and reef fish; targeted marco-invertebrates (sea cucumbers, trochus and giant clams) and fish; and health of 62 reef sites ranging from Recife des Francais and Yandé in the north to Recife de Koumac and Passe de Koumac in the south. Additionally breeding birds of conservation interest were evaluated during the survey as the area includes two Important Bird Areas (IBA) (Spaggiari et al. 2007), identified after a survey by the Société calédonienne d'ornithologie (SCO) (Baudat-Franceschi 2006) mandated by Province Nord. Information presented here on birds mainly comes from the SCO survey with additional data collected during the RAP and during monitoring activities by SCO since May 2006.

Sites were selected from the raw Landsat imagery to cover the range of reef types in the area in order to maximize biodiversity and have sufficient coverage and replicates for the main reef types in the survey region according to Atlas des récifs coralliens de Nouvelle-Calédonie (Andréfouët et Torres-Pulliza 2004 Andréfouët pers. comm.). Sites of particular interest (e.g. table islands and other sites visited frequently) 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 geographic zone (north or south of Baie de Néhoué as summarized in Table 1. The exact location of these sites is not available in this report, however the general survey area covered can be found on the map.

At each site, an underwater visual inventory was made of the biodiversity of coral reef fish and benthic invertebrates, mainly scleractinian corals. Standard underwater visual censuses techniques with transect were used to assess exploited macro-invertebrates, targeted fish stocks and the condition of the coral reefs at each site. For birds, standard methods were used specifically adapted to the ecological characteristics of the species, the surfaces of the survey areas and the type of ecosystem (Bibby et al. 2000).

RESULTS

Highlights of the RAP survey are presented below. Detailed results are included in separate chapters for the diversity of Scleractinian corals and coral reef fish; targeted macro-invertebrates and fish; reef condition and birds.

Scleractinian coral diversity

- A total of 322 named species were observed during the present survey. Species numbers at visually sampled sites ranged from 22 to 117, with an average of 63.8 per site. The highest number of coral species observed per site was recorded on fringing reefs around Yandé Island
- *Acropora*, *Montipora*, *Favia*, and *Porites* were dominant genera on New Caledonia reefs, with 77 (including *Isopora*), 24, and 12 species, respectively; the number of *Acropora* species is very high in relation to other areas.
- A total of 43 species were found that extend the known biogeographic range of the species. The number of species tended to increase significantly northwards, eastwards and away from the mainland which corresponds to a decrease in human impacts such as sediment and nutrient runoff and fishing activity. These trends were statistically significant.

Coral Reef Fish Diversity

- There are currently 1,019 known reef associated reef species. This study observed 526 species in total, representing 52% of the known diversity. Species numbers at the 57 sites for which data was analyzed varied from 46 to 172, with an overall mean value of 117.
- Wrasses (Labridae), Damselfishes (Pomacentridae), and Gobies (Gobiidae) were the dominant groups in the survey area. In these dominant families, 75, 71 and 31 species respectively were observed across the entire survey. Two range extension records for New Caledonia reef fish species were obtained in the survey. These included *Asterropteryx striatus* from the Gobiidae family and *Plectroglyphidodon phoenixensis* from the Pomacentridae family.
- Outer barrier reef front or outer slope sites had the highest fish diversity with a mean of 141 species per site.

Table 1. The sites sampled for this survey were categorized by reef type as adapted from the geomorphological units (Andréfouët et Torres-Pulliza, 2004) and geographic zone (north of Baie de Néhoué and including sites within and south of Baie de Néhoué).

	North	South	Total by reef type
Outer Barrier Reef (outer reef slope, back reef, patch and passes)	6, 7, 9, 10, 11, 12, 13, 14, 16, 17, 58, 59, 60, 61, 62	63, 64, 65, 69, 72, 73, 74, 79, 80, 83, 84	26
Intermediate lagoon reefs (fringing and patch)	1, 2, 3, 4, 36, 37, 38, 40, 41	33, 42, 43, 45, 47, 48, 49, 51, 52, 85, 87	19
Inshore or inner lagoon reefs (patch and fringing)	18, 19, 20, 22, 24,26, 28	29, 30, 31, 32, 34, 56, 57, 85, 86	17
Total Zone	**31**	**31**	**62**

Outer barrier reef back sites had a mean of 117 species per site. Outer barrier reef pass sites had a mean of 124 species, intermediate lagoon reefs had a mean of 127 species and inner lagoon reefs had a mean of 81 species recorded. Fish surveys at most sites on inner lagoon and, to a lesser degree, intermediate lagoon reefs were affected by poor visibility.

Targeted Macro Invertebrates

- A total of 28 sites in the southern portion of the survey area (Poum and Koumac) were assessed for targeted marine invertebrate species of sea cucumbers and molluscs (*Trochus niloticus* and giant clams) to a maximal depth of 12 meters.
- Thirteen species of sea cucumbers were recorded and the highest diversity was observed in intermediate type reefs with 11 species. Densities of most harvested species, *Holothuria scabra* and *Holothuria nobilis* were extremely low to nil.
- *Trochus niloticus* were most frequently observed on barrier reefs. Densities were similar between intermediate and fringing reefs. Data from Province Nord shows significant levels of harvesting for this species and a stock assessment would precise the sustainability of *T. niloticus* extraction rate. Only three species of giant clams were recorded along the transects and one *Tridacna derasa* was observed outside the transect. The most recorded species was *T. crocea.*

Targeted Fish

- An initial stock assessment of select targeted coral reef fishes was undertaken with observations made by underwater visual counts while SCUBA diving. From the target list of 164 species, a total of 127 target species from 51 genera and 18 families were recorded on 63 transects (each of 500m^2) at 52 sites.
- The most diverse families observed were Acanthuridae, Scaridae, Serranidae, Lutjanidae and Labridae, but the most abundant species were from the family Caesionidae.
- Caesionids contributed over 60% of fish counted and over 21% of total biomass with *Caesio caerulaurea* being the most abundant species of this family.

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). Of the 62 coral reef sites surveyed, 53 had a full data set for these parameters and were comparatively ranked and rated as excellent, good to very good, fair and poor. Forty-nine percent of the reef sites surveyed were rated as being in a very good to good state.
- The most frequently observed threat or disturbance to the reefs surveyed was from fishing related activity that occurred on 38.7% of the reef sites surveyed. Siltation or sediment stress was noted on 24.2% of the reef sites surveyed and was observed to have the most severe impact on the reefs of all the 'stress' factors examined. Sedimentation stress appeared to be most severe at the inshore fringing reef sites in close proximity of the Tiébaghi mine, especially within the Baie de Néhoué and two fringing reef sites inshore directly adjacent to the mining operations.
- No bleaching was observed at any of the reef sites surveyed, however symptoms of coral disease or pathogens were noted at 8.2% of the sites assesses. These symptoms were indicative of calcioblastic neoplasms or tumors, white syndrome and pigmentation response. Although tumors have been reported previously in New Caledonia, this may be the first report of white syndrome and pigmentation response.
- Numerous red listed species were spotted on 66% of the reef sites we assessed. These include several species of sharks, bony fishes, and sea turtles. This frequency of observation of red listed species at sites was less than that of the previous marine rap survey on the east coast in Mount Panié. However this percentage is still high in comparison to past marine rap surveys undertaken by Conservation International.

Birds

- A new breeding species for the area, the Beach Thick-Knee (*Esacus magnirostris*) was observed (one to two pairs).
- Two lagoon marine Important Bird Areas (IBAs) were identified that included the main breeding area in New Caledonia (about a hundred pairs) for a highly endangered subspecies of Fairy Tern (*Sterna nereis exsul*). Previously, only about 20 pairs had been recorded in New Caledonia.
- A relict population of an endemic subspecies of Island Thrush (*Turdus poliocephalus xanthopus*) was rediscovered on Yandé Island. This subspecies is considered extinct from Grande Terre and had not been observed for 30 years.
- Several first or new reports were recorded during the survey. These included: nine new colonies of Wedge-tailed Shearwaters (*Puffinus pacificus chlororhynchos*); two new nesting sites of Tahiti Petrels (*Pseudobulweria rostrata trouessarti*); confirmation of the presence on Carrey Islet of the only colony of Brown Boobies (*Sula leucogaster plotus*) on the New Caledonian lagoon and of the only two pairs of Masked Boobies (*Sula dactylatra personata*); and the first census of the population of Australian Ospreys (*Pandion haliaetus cristatus*) in the area.

CONSERVATION AND MANAGEMENT RECOMMENDATIONS

An overall management framework for the tropical lagoons and coral reefs of New Caledonia World Heritage Site has been developed by the federal and provincial government with the full involvement of all local stakeholders and with respect of customary rights (IUCN 2008). The enhancement of laws and regulations for environmental protection has been taking place and continues to be underway in New Caledonia. Here we make conservation recommendations specific to the area surveyed. The survey area covered reef sites within the World Heritage inscribed core area of the marine cluster Zone Côtière Nord & Est, it's buffer zone and outside of these zones. The following recommendations are discussed by activity heading; however it is important to note many of these are inter-related. This list is not meant to be comprehensive in nature and some conservation and management activities mentioned may be already in the planning process or have begun to take place. More detail concerning the conservation and management recommendations can be found within the specific chapters of this report. Further, it is hoped the information presented will also promote other new ideas and activities, especially by the local stakeholders, to conserve and to improve management practices in their environment. The people who live and work in New Caledonia and depend on its resources are the greatest source to be utilized in restoring in some cases and ensuring the integrity of their environment.

1) Reduce, monitor and mitigate sedimentation as part of an integrated coastal zone management plan for entire watershed of Poum and Koumac communes.
Sedimentation was the most adverse impact on the reefs sites assessed and was implicated as influencing the findings for: coral and fish diversity; targeted invertebrates and fish; and reef condition. Two locales within the survey area are of specific concern. These include the reef sites adjacent to the Tiébaghi mine and the Poum mine. The reef sites adjacent to the Tiébaghi mine are outside the core and buffer zones. The reef sites adjacent to the Poum mine center are within the buffer zone. At the Poum mine center, activity has resumed and is projected to increase. A potential and very likely consequence of the resumed and scheduled increase of mining activity in Poum is that the ability of the buffer zone to function will be compromised.

It is recommended sedimentation be monitored and every effort made to restore the watershed and maintain those watersheds that are intact. Mitigation techniques (e.g. maintaining vegetation or re-vegetating preferably with native species denuded areas, building sedimentation barriers; settlement basins and terrace) should continue and be implementing in sites where these measures are absent (ESCAP 2003). This needs to be considered a cost of doing business. If sediment runoff is not reduced soon, sediment will begin to kill more and more reefs, beginning along the shore and extending farther and farther out into the lagoon. Further, developing new mitigation techniques to lessen the impacts of mining activities on the surrounding environment is critical. The various institutions in New Caledonia have been and can continue to be valuable contributors to this endeavor. Sarrailh and Ayrault (2001) noted that research by the Insitut de recherche pour le développement (IRD) and the International Cooperation Centre on Agrarian Research for Development (CIRAD) has made possible the development of techniques necessary for re-vegetation. For the mining industry, legal mandates to rehabilitate and re-vegetate abandoned mines are reported to be in progress based on a "Mine Resource Valorisation Management Scheme" (DIMENC 2008). Some mining companies have been reported to carry out some re-vegetation programs in parts of New Caledonia by employing private companies, however these appear to have budgetary constraints (Sarrailh and Ayrault 2001).

Reducing the effects from mining is a particularly challenging issue as there is a long history of mining in New Caledonia (since 1870's). Mines that have ceased activity are still contributing to the sedimentation stress in adjacent coastal areas. In the event of heavy rains (e.g. with cyclones) mud slides and eroded soils that may contain heavy metals and other toxins, end up in rivers then the coastal waters. This is reported to be true for very old mining sites as well (Bird et al. 1984). In many cases the soil of previous or existing mines is contaminated whereby re-vegetating areas is not possible. Additionally in some areas, the landscape has been affected as well by fires and cattle ranching activities that also compromise the watershed. Sedimentation is a serious threat to many of the reefs of New Caledonia. If the present trends continue, it appears that the near shore reefs of Northwest Grande-Terre will be dead in a matter of years to at most a few decades. Overall an integrated coastal zone management plan needs to be instituted that would restore, maintain and monitor the watersheds of Poum and Koumac communes. It is recommended that efforts to restore the watershed include all local stakeholders including the mining companies. Costs (money, time and effort) associated with restoring the watershed of past and present mines as well as sites comprised by fires and cattle ranching could be covered in a variety of ways. This would include but be not limited to the government, non-government organizations, the mining companies, customary land owners, cattle ranches, schools, community groups and tourists.

Sarrailh and Ayrault (2001) reported that older abandoned or orphaned mines have been rehabilitated by local communities. For example in 2000, local communities completely rehabilitated the 10 hectares at the Odette mine in Province Sud. Therefore this approach may prove feasible in the communes of Koumac and Poum.

2) Further studies to better elucidate the biodiversity and other dynamic processes (e.g. water flow patterns, movements of species) in the area are necessary for effective systematic conservation planning and management.
The nature of the rapid assessment survey renders the data limited spatially and temporally. It is intended as a snap shot and a step towards data for informed decision making. Even though every effort was made to sample a wide range of habitats with robust replication of the reef habitats and types, there is no perfect or comprehensive dataset. The need to improve and implement management and conservation activities cannot wait. As more information is obtained, the management and conservation activities can be adapted, the process is iterative. Therefore more studies are needed to document the biodiversity not only of the focal groups examined here (e.g. sea cucumbers), but other focal groups (e.g. algae) and habitats (e.g., sea grass beds, mangroves and soft sediments or inter-reefal areas). Although many items can be identified for further study, the realty is further research of some may not be feasible for several reasons. Therefore it is suggested that data need be prioritized according to conservation or management objective, ecological role (e.g. architectural or habitat forming species such as corals, seagrass and mangroves) and impending threat. More sampling dives within an area usually results in an increase in the number of species reported from an area. Thus, New Caledonia is likely to have many species not yet found. The physical characteristics (e.g. currents, water flow patterns, and bathymetry) and other dynamic processes (e.g. larval supply and species movements) would prove extremely valuable for effective planning and management especially to maximize connectivity of the marine managed and protected area.

Coral, a focal group examined in the present survey is well known as being difficult to identify and there may be a significant number of local variations of species or even new species. Many colonies could not be identified easily during the survey, especially on the reefs sampled that had a high diversity of *Acropora* species. Additionally, the number of species found is likely to depend heavily on the habitats sampled as some coral species are restricted to particular types of habitats or are more common in particular types of habitats. This is also true for coral reef fish species. Having sites assessed at nite would add to the species observed as the chances of observing nocturnal fish would increase.

3) Comprehensive stock assessment and continued monitoring of targeted marine invertebrates and commercial fish
A comprehensive stock assessment is urgently needed for sea cucumbers. This assessment would include sites deeper than 12 meters as well as sites not covered in the present survey lying north of Poum. Similar assessments are needed for giant clams and trochus as well as regular monitoring of the stocks and the pursuit of regular monitoring of catches for these three invertebrates. There is a lack of data on both invertebrate stocks and fishing effort for subsistence or commercial purposes. The sites surveyed during this assessment have shown general low numbers of high cash value species of sea cucumbers and giant clams underpinning a possible over-harvesting trend. However, it is important to mention that not all habitats suitable for invertebrates have been sampled extensively, such as embayments or seagrass beds. In all types of habitats, stock assessments and monitoring of the targeted invertebrates needs to be undertaken. Further the amount caught per unit effort for particular species (as indicated by low population densities and or of high commercial value) needs to be pursued.

Based on the general low densities of high value sea cucumbers, a limitation of their harvesting is recommended to be put in place as a precautionary approach and more accurate quotas could be implemented after a comprehensive stock assessment. The current legislation does not mention any restriction on species of giant clams to be collected. As numbers of rare giant clam species such as *Tridacna derasa* and *Hippopus hippopus* ranged from extremely low to nil, it may be necessary to put a ban on these species and educate fishermen on their identification. Moreover, *Tridacna derasa* has been evaluated on the IUCN Red List as a vulnerable species with updating of its status needed. Similar stock assessment needs to be undertaken for trochus populations considering that numbers were low in lagoon sites and catch rate are at a high level.

The nature of this rapid protocol of assessing targeted fish renders this study spatially and temporally limited as 52 sites were visited once with data collected on one or two transects. This precludes us from making specific targeted fish conservation recommendations. Further work by Province Nord is in progress to assess, adaptively manage and conserve targeted fish stocks in the region of the survey. In both cases, targeted invertebrates and fish, data on the catch per unit effort as well as incorporating the fishers and other stakeholders into the effort is critical for effectiveness. The nature of stock assessments requires the data be collected over a long and continuous time period and measures adapted as indicated by the data.

4) Long –term monitoring of the coral reefs
To ensure the integrity of the coral reefs, monitoring is necessary. When events (e.g. bleaching or crown of thorn outbreaks) that compromise the state of the reef occur then appropriate research and mitigation measures can be instituted if possible. The goals for the monitoring program and best methods to achieve them need to be clearly determined from the onset. Findings from this report suggest that the rate of sedimentation (especially sites adjacent to the former and present mining sites), cover of benthic substrata (e.g. algae, live and dead coral cover) as well as a suite of other standard indicators need to be observed over time in the area surveyed. Examining the sedimentation rates in particular will also provide a way to test whether the restoration (e.g. re-vegetating the mining scar) or mitigation (e.g. building sedimentation barriers) techniques on the former and pres-

ent mining sites are effective. As much of the sediment from mining activities includes heavy metals and other toxins, water quality should be checked and regularly monitored as well. Some species can be used as bioindicators for monitoring. Two species of oysters and one species of clam have been identified as useful bioindicators for monitoring the status of Ni contamination in New Caledonia (Hédouin et al. 2007). Perhaps implementing a bioindicator study on reef sites throughout the zones in the survey area would be useful way to determine nickel contamination existing in the core, buffer and outside zones and track improvements in environmental quality as the mining industry come under enhanced laws and regulation of their activities.

As this survey may provide the first report of white syndrome and pink pigmentation response in corals on the reefs of New Caledonia, the incidences of symptoms indicative of these diseases as well as others needs to be examined. With global climate change, bleaching is expected to increase in severity and extent therefore incidence of bleaching needs to be watched as well. Increasingly studies have shown that coral reefs subject to less stress (e.g. pollutants, sediments etc) are more resilient to bleaching events. It is critical that stressors to the reefs are mitigated and the reefs kept as healthy as possible to allow them to be more resilient.

The current monitoring and research activities already within New Caledonia will prove helpful in getting a better handle on the extent of coral disease and bleaching. Pending funding availability, it is recommended that more sites be included for monitoring and study. Given the reality that funding needs for such endeavors are usually more than what can be accommodated, perhaps increased awareness and educational activities for those who frequent the reef (e.g. SCUBA diving clubs, tribes with traditional marine areas, fishers and other local stakeholders) may prove helpful. This would include a way to report such sightings of possible bleaching and symptoms of coral disease for further examination by scientists, managers and the marine regulatory/protection entities in the region.

5) No-take or fully protected status for sites of outstanding biodiversity value or sites thought/known to be used for spawning aggregations, migratory routes or corridors, nesting sites, feeding or nursery areas.
Findings from the focal groups (coral, fish and birds) indicate sites of outstanding biodiversity value and it is recommended these sites be designated no-take or fully protected. In terms of coral diversity, the reefs in the far northern section, particularly around the island of Yandé, contained the highest diversity of corals and a wide range of coral reef community types in a relatively small geographic area. Many unusual coral species were only found in this area and some quite unusual communities were present. This area is certainly worthy of high protection and is presently relatively remote from large human populations and relatively pristine. This area in the north is part of the inscribed or core zone of the marine cluster Zone Côtière Nord & Est.

The north core area was also noteworthy for the diversity of fish observed. Specifically, Yandé Island together with the Passe de Yandé are recommended for no-take or full protected status. In our survey the sites around the Yandé Island and Passe de Yandé occupied the most positions in the top ten sites ranked by fish diversity. Outside the core and buffer zone, the Passe de Koumac was observed to have high diversity of fish species and as such is recommended for full protection.

For birds, both Yandé Island and the Koumac sector are two important bird areas (IBA) (Spaggiari et al. 2007). The Yandé Island could form an integrated conservation project including control and/or eradication of introduced predators, monitoring of populations of Island Thrushes and Tahiti Petrels, and restoration of the dry forest ecosystem. In the Koumac area, 14 out of the 19 islets of the IBA are found in the RAP survey area. This area should be placed under a concerted management for its islets, including regulation of human frequentation and eradication of introduced predators. Creation of a network of small natural reserves protecting the richest islets is recommended. Management recommendations are to implement monitoring protocols for seabirds' populations, to eradicate invasive species (introduced predators are a priority), and to manage human frequentation.

6) Increase environmental education and awareness: Build local capacity and promote community participation in conservation planning and management.
Rules and regulations regarding use of the marine managed areas need to be clearly communicated with information widely dissemination. Information can be readily made available to schools, community centers and posted publically. Maps depicting areas or zones of no take, what activities are permissible in what areas and regulations concerning extraction of marine species (e.g. minimal size required to take certain species of fish or mollusk and permissible means of fishing can be made and distributed. Further signage and postings of these rules and regulations at marinas, docks and other boat slips can be effective. Now that the New Caledonia has been inscribed, it is important to ensure everyone understands what this means and what they can do to ensure the integrity of the site. Moreover, the importance of managing and conserving their marine environment as a whole whether within or outside the inscribed zones should be communicated. Information on new or enhanced legislation for environmental protection such as those in progress for the mining industry can also be included as part of the initiative to increase education and awareness.

7) Promotion and development of conservation-oriented marine ecotourism for the benefit of local communities.
Several activities to promote tourism while maintaining the integrity of the area are possible. These options need to be carefully thought out, well planned and balanced in the interest of leaving the least impact on the surrounding

environment. For example, diving, hiking and camping may be feasible activities for the area. If diving or other boating activities are promoted then installing mooring to prevent anchor damage may be advisable as well as instituting user fees for dive tourists visiting the area. In terms of hiking or camping, it is important that IBAs be removed from such activity and the foliage is not destroyed. The use of the environment whether marine terrestrial or freshwater for recreational activities needs to be regulated as well and can be included in the development of the conservation and management plan. It is recommended that employment associated with these potential tourism activities be local individuals from the communes of Poum and Koumac.

REFERENCES

Andréfouët S. et D. Torres-Pulliza. 2004. Atlas des récifs coralliens de Nouvelle-Calédonie, IFRECOR Nouvelle-Calédonie, IRD, Noumea.

Beauvais, M.L., A. Coléno and H. Jourdan (eds). 2006. Les espèces envahissantes dans l'archipel néo-calédonien: un risque environnemental et économique majeur. IRD Editions. Paris.

Bibby C.J., N.D. Burgess, D.A. Hill and S.H. Mustoe. 2000. Bird census techniques. 2nd edition. Academic Press. San Diego, CA.

Bird, E.C.F., J-P Dubois, and J.A. Iltis. 1984. The Impacts of Opencast Mining on the Rivers and Coasts of New Caledonia.The United Nations University. Pp1–64 Toyko, Japan.

Direction de l'Industrie des Mines et de l'Energie Directorate of Industry Mines and Energy (DIMENC)2008. Retrieved on 20 January 2009. http://www.gouv.nc/portal/page/portal/gouv/annuaire_administration/administration/dimenc

ESCAP. 2003. Integrating Environmental Considerations in Economic Decision Making Processes Synthesis B Modalities for Environmental Assessment-Pacific Islands Subregion Pacific Island case studies. Mining activities in New Caledonia. (*Unpublished*) http://www.unescap.org/drpad/vc/conference/bg_nc_147_man.htm

Hédouin L., O. Pringault, M. Metain, P. Bustamante, M. Warnau. 2007. Nickel bioaccumulation in bivalves form the New Caldonia lagoon: Seawater and food exposure. Chemosphere 1449–1457.

Institut de la statistique et des études économiques de Nouvelle-Calédonie (ISEE) 2008. (figures updated 11-25-08). Retrieved on 13 January 2009. http://www.isee.nc/anglais/

International Union for Conservation of Nature (IUCN) 2008. World Heritage Nomination – IUCN Technical Evaluation, The lagoons of New Caledonia: Reef diversity and associated ecosystems (France) - ID No. 115 p 1–12.

Sarrailh J.M and N.Ayrault. 2001. Rehabilitation of nickel mining sites in New Caledonia Unasylva - No. 207 - Rehabiliation of degarded sites. FAO - Food and Agriculture Organization of the United Nations. FAO Corporate Document Repository. Retireved on 20 January 2009. http://www.fao.org/docrep/004/y2795e/y2795e05.htm#e

Société Le Nickel - Les centres miniers 2008. Retrieved on 20 January 2009. http://www.sln.nc/content/view/67/42/lang,french/

Spaggiari J., V. Chartendrault, and N. Barré. 2007. Zones Importantes pour la Conservation des Oiseaux de Nouvelle-Calédonie. SCO/BirdLife International.