Coral Reef Fish Diversity of the Northwestern Lagoon of Grande-Terre New Caledonia

Author: Kerr, Vince

Source: A Rapid Marine Biodiversity Assessment of the Coral Reefs of the Northwest Lagoon, between Koumac and Yandé, Province Nord, New Caledonia: 33

Published By: Conservation International

URL: https://doi.org/10.1896/054.053.0106

Chapter 5

Reef Condition

Sheila A. McKenna

SUMMARY

- 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. Nearly half (49%) 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. Debris from mostly fishing or other human related activity was observed on 32.3% of the reef sites surveyed.
- In general damage to the reef sites surveyed from predation by *Acanthaster plancii*, or Crown of Thorns Starfish (COTS) and can be characterized as light and localized except for moderate damage at site 85. No mass (*A. plancii*) feeding aggregations or evidence of a past population outbreaks were noted on any of the reef sites surveyed. Observations included the presence of one to four individuals or feeding scars on coral colonies at 35.5% of the sites surveyed. Breakage to coral colonies from algal feeding activity by the hump head parrotfish, *Bolbometapon muricatum* was light and localized as well. The presence of this species is indicative of a healthy reef.
- 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 Tiebaghi 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 assessed. 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.

INTRODUCTION

The reefs of New Caledonia have been impacted by land-based activities mainly from mining, deforestation and coastal development. Other sources of damage that have been documented include bleaching, crown of thorns starfish (COTS), disease and cyclone events. The most recent major disturbance was from Cyclone Erica (category 5) that struck the west coast of New Caledonia in March 2003 resulting in a reduction in live coral coverage in some areas (Lovell et al.2004). Sulu et al. (2002) reported low live coral coverage for South Noumea due to either large numbers of COTS, coral bleaching or coral disease. Unfortunately, a gap in monitoring for 1999 precluded confirmation of the exact cause.

Assessments of the state or threats to the coral reefs of New Caledonia are available at the coarse (Burke et al. 1998) to site-specific scale. Assessments, workshops and information on the biodiversity and threats of New Caledonia's coral reefs have increased considerably at the national level since the 2004 Mont Panié Marine RAP Survey (e.g. Payri and Forges 2006, Junker 2006, Gabrié et al. 2007). This was spurred in part from the preparation of data and information in support of the World Heritage Nomination and from the Coral Reef InitiativeS for the Pacific (CRISP). At the site scale, studies on the status of coral reefs in New Caledonia have focused mainly in the Province Sud where the majority of the population lives and where the major marine associated institutions can be found (e.g. Institut de recherche pour le dévloppement and Université de Nouvelle-Calédonie). Hence most reports of stressors or disturbances (e.g. bleaching, crown of thorns feeding aggregations and sedimentation) to the reefs are reported from the south.

In 2003 as part of IFRECOR (French Initiative for Coral Reefs), sampling sites were extended to include Province Nord and Province des Iles. Within Province Nord, three sites were monitored at Hienghène, Népoul, and Pouembout. The stations sampled within Hienghène are on the east coast in the vicinity of the previous rapid assessment survey of the Mount Panié area and included Koulnoué, Hiengabat, and Donga Hienga (Wantiez et al.2004). The other two sites, Népoul, and Pouembout, are located off the west coast of Province Nord and lie further south than the area covered during this survey (see Map 1). Other site specific studies within Province Nord include the region of Koné where studies are being and have been conducted to monitor and assess the coral reefs in preparation of a mining project (e.g. Pascale et al. 2006). In the Diahot-Balabio region, just north of the Mont Panié area, an assessment of the reefs and the use of their resources was conducted in 2006 (Gabrié et al. 2007).

Here, the condition of the 62 reef sites in the northwest lagoon (Yandé to Koumac) is described to provide a snapshot of reef "health" as observed during the period of the survey. Information is presented on the benthic community structure of the reefs surveyed and on incidence or evidence of stress or threats to those sites. Based on a comparative rank of these parameters with the number of species of coral and fish as well as targeted fish counts for the reef sites surveyed, the reef sites can be approximated into three 'health or state" categories: excellent, very good to good, and average. This information is meant to serve as an initial snapshot of the health of the reefs surveyed and to provide an indication of what factors appear to be influencing the reef that suggest further research, monitoring, management and subsequent mitigation activities may be needed.

MATERIALS AND METHODS

At each survey site substrata/biota data of the benthos were collected. Transects were used to sample the benthos as described in English et al. (2000). The following is a brief description of the transects: a 100 meter transect tape was placed along the bottom of the reef as close as possible to the biota/substrata., two 100 m transects were placed at two out of three possible depth zones depending on the reef structure and topography. The three depth zones included <6 m (shallow), 6–10 m (medium) or >12 m (deep). At some sites it was not possible to place and sample transects along two different depth zones either due to weather conditions or limited reef topography. In those cases, one depth zone was sampled. The biota/substrata were sampled at selected 0.5 m intervals (for 40 sample points) along 20 m segments of the 100 m transect. Below each sampling point, the type of substrata/biota is identified or characterized as follows: hard coral (hc), soft coral (sc), sponge (sp), macro algae (ma), calcareous algae (ca), turf algae (ta) rubble (rb), other, mud/silt, and dead coral bare substrata (bs). The category turf algae included filamentous and turf algae as well as bottom dwelling cyano-bacteria. The "other" category includes invertebrates such as tunicates, sea stars, sea cucumbers, etc. After the first 20 of the 100 m was sampled, the diver would skip 5 m and then continue sampling another 20 m (40 points) along the transect. This allowed for replication during sampling, with four 20 m segments of each transect sampled at half-meter intervals per depth.

Any visible signs of damage, threats, or disturbance at each reef site were noted. Evidence of disturbance, damage, or threat was rated according to the relative amount or level of impact/frequency (none, light, moderate, and excessive). The divers looked for evidence of damage from fishing (nets, spear guns, lines,), boating activities (anchor damage, grounding scars, fin marks from snorkelers), and storms or cyclones. Damage from the coral predators *Acanthaster plancii* and *Drupella cornus* on the reef was detected by the presence and number of individuals seen or by feeding scars on the coral. Breakage to coral colonies as a result of grazing activity by the bump-head parrotfish, *Bolbometapon muricatum* was also noted. Other divers of the RAP team supplemented observations on reef condition after the site survey dive had been completed. Charismatic marine fauna and other marine related red-listed species were also noted at each reef site. These include sharks, manta rays, clams, turtles, dugongs, etc.

Bleaching refers to the discoloration of coral tissue color—the more discolored the coral tissue, the more severe the bleaching. Light (or early stages of) bleaching is indicated by a slight discoloration of the coral tissue. Moderate or extreme bleaching is usually indicated by the coral tissue being transparent, opaque, or clear in color with the coral skeleton visible. The number of colonies showing signs of bleaching and the level of tissue discoloration indicates the extent of the bleaching on the reef.

In addition to bleaching, coral pathogens or diseases may be observed on the reef and have been identified to occur on hard and soft coral. Some diseases are identifiable by a distinctive banding or pattern of discoloration on the surface of hard and soft coral. For example, black band disease on hard corals is evident by an obvious black band across the coral head—behind the band the coral skeleton is visible and the coral tissue is dead and gone. On the other side of the band the coral surface looks normal. The incidence of diseases and other pathogens has been more frequently observed and studied in the Caribbean than in the Indo-Pacific (Sutherland et al. 2004). Given the proximity of New Caledonia to the Great Barrier Reef and the need for further etiological studies on coral disease in the Indo –Pacific, any symptoms of disease or pathogens observed during the survey were classified according to the nomenclature used by Australian Institute of Marine Science (http://www.aims.gov.au/pages/research/reef-monitoring/coral-diseases/hcd-gbr-01.html) and in Willis et al. 2004.

Evidence suggesting threat or pressure from pollution/eutrophication, fishing pressure, siltation, and freshwater runoff may be taking place on the reef can be observed, however further testing, monitoring, or experimentation is needed for quantitative data. In some cases, freshwater run-off or siltation may be a "natural" occurrence for a reef site because of its location next to a river mouth where the watershed has not been altered. In other cases theses occurrence are not "natural" and have been altered due to human activities. For example, the source of the damage (e.g., sewage outfall pipe, deforested area along the shoreline, mining activities coastal development, and river outfall) can be seen from the reef site, thereby providing qualitative evidence. An abundance of algae with low coral cover can be an anecdotal indicator of pollution/eutrophication on reefs. However, the population of herbivores and type of algae (macro-algae, turf or filamentous, or calcareous) need to be considered. The presence of fishers actively fishing or a low abundance of target biota (e.g., sea cucumbers or groupers) on the reef site indicates extractive pressure from fishers, but the frequency and extent of marine resource use and abundance of stocks need to be further investigated and monitored to obtain quantitative data. High percent cover of mud or silt on the reef benthos indicates siltation.

These types of threats or disturbance need to be characterized further by direct measurements of specific parameters (e.g., nutrients in the water column, stock abundance and fishers activity, sediments, and percent cover of biota/substrata) over a long sampling period of at least one year or more. The nature of the rapid assessment only allows for initial observations that suggest eutrophication/pollution, fishing pressure, siltation, or runoff is taking place and the relative extent of its impact on the reef site. This provides an important first step in determining stress or threat presence on the reefs sites and what follow up is needed in terms of further study, threat mitigation, monitoring and effective management. Sites where evidence of these threats is noted are indicated in the text and summarized in Table 5.3. The summary table synthesizes the key indicators for state or health of the reef based on biodiversity of the fish and coral species, average percent coral cover and consideration of presence or absence and extent of human impact. The observed values for these key indicators are summed and then ranked according to highest to lowest. The four categories of excellent, good to very good, average and poor are determined by the natural breaks in the determined values. Due to the high variability in targeted fish counts the sites were analyzed a second time with the approximate count of target fish included in the summation for ranking. In cases where percent coral cover and fish counts were obtained from more than one depth for the reef site assessed, the average of the values was used for calculating the sum. Only sites where a complete set of data for fish diversity, coral diversity, percent live coral cover and counts of targeted fish were included in this analysis. Complete data sets were available for 53 sites with incomplete data for nine sites (4, 30, 31, 34, 42, 47, 56, 57 and 64). Targeted macro-invertebrates were not included as this data was collected only for the second half of the survey.

RESULTS

For several reef sites surveyed, sea grass and mangroves were observed to be within the site or in close proximity. These include 13 sites for sea grass (sites 1, 3 floating pieces of seagrass, 4, 18, 19, 20, 22, 28 seagrass towards shore, 29, 33, 34, 36 floating pieces of seagrass and 47) and four sites for mangroves (sites 17, 18, 33 and 34). An additional site 56 contained one mangal tree.

Benthic cover

Percent coverage by hard coral was spatially variable. Mean percentage of hard coral cover in depths less than 6m ranged from 6% at site 72 to 91% at site 49 (Figure 5.1a). At depths between 6m to 10m, mean percentage of live coral coverage ranged from 16% at sites 16 and 63 to 86% at site 24 (Figure 5.1b) while depths greater that 12m ranged from 14% at sites 10 to 58% at site 87 (Figure 5.1c). The mean percent of biota/substrata for all categories cover by site is presented in Appendix 5.

Coral bleaching and pathogens

Although no bleaching was noted, coral disease was observed at five sites or 8.2% of the sites surveyed. One colony of *Acropora* sp was observed at site 43 to have white syndrome (Willis et al. 2004). Calcioblastic neoplasms or coral tumors (Peters et al. 1986) were observed on one colony of *Acropora*

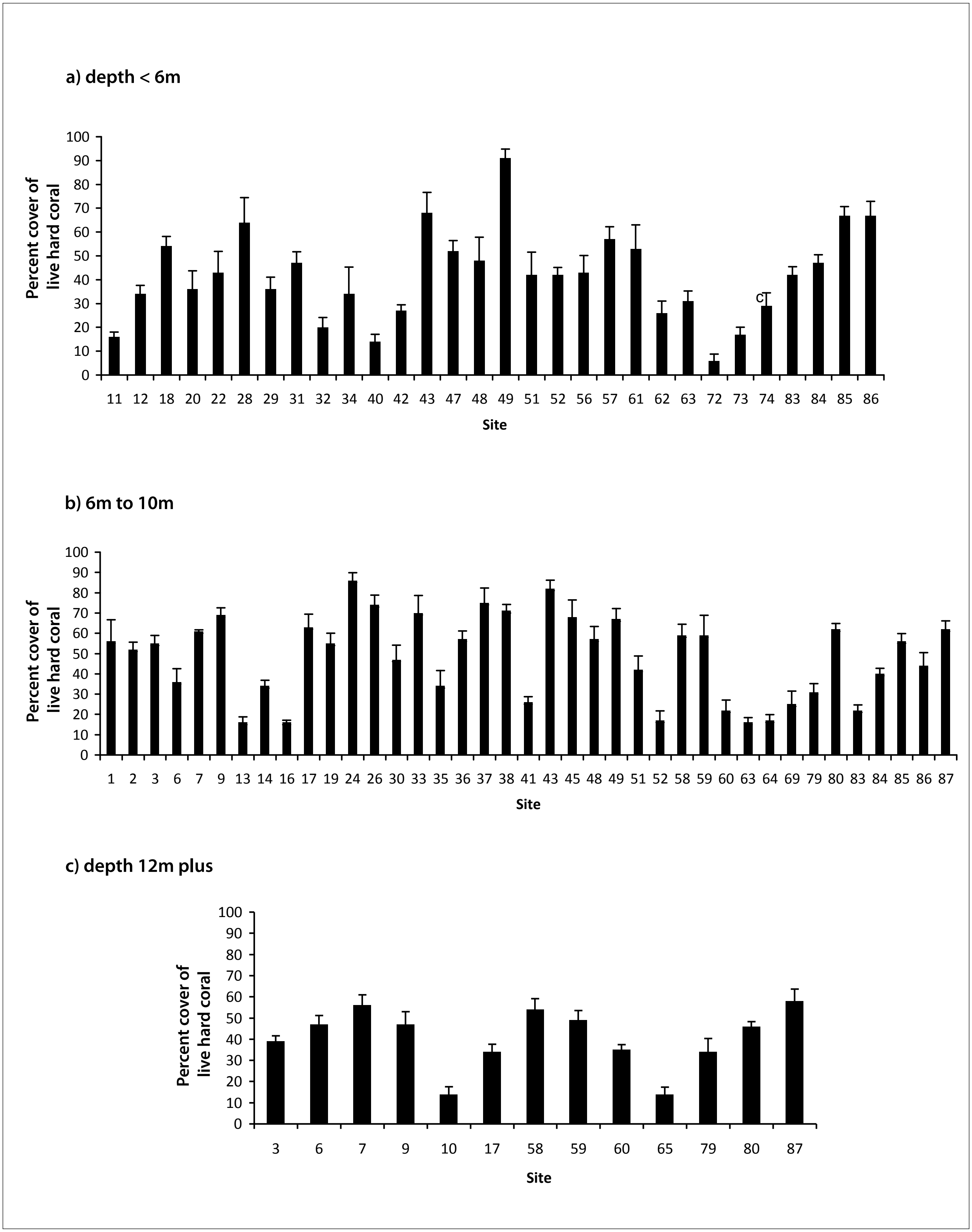

Figure 5.1 (a, b, c). Percent cover of hard coral for sites as numbered at depths of (a) <6 m, (b) 6 m to 10 m, and (c) 12 m plus as determined by the point intercept transect method. For each site, four 20m length transects were sampled (n = 4) except (a) where n = 3 for sites 12 and 62, n = 8 for site 56; (b) where n = 3 for sites 6 and 60; (c) where n = 3 for sites 10 and 60.

humulis at site 48, one table colony of *Acropora* at site 56 and on two colonies (one table *Acropora* and a colony of *Turbinaria*) at site 57. A pink pigmentation response of one to two massive *Porites* coral colonies in total per site was observed at four sites. (48, 52, 56 and 57) (Aeby 1991; Willis et al.2004).

Coral predators and damage from fish grazing activity

The presence or evidence of predation by Crown of Thorns (COTS) or *Acanthaster plancii* was observed at a total of 22 sites or 35.5% of the sites surveyed. Individuals of COTS were noted at 13 sites (6, 10, 14, 32, 33, 37, 38, 56, 62, 83 and 85–87). The majority of sightings were of one to two individuals, with the maximum of four individuals seen at only one site (32). At an additional eight reef sites (36, 43, 45, 59, 61, 69, 79 and 84) surveyed, feeding scars were seen providing anecdotal evidence of COTS however no individuals were observed. Feeding scars were noted on the coral species, *Acropora* sp, *Acropora humulis*, *Pocillopora* sp. and *Stylophora mordax*. With the exception of one site (85) where moderate damage occurred as evidenced by numerous feeding scars and two individuals, the frequency of feeding scars or damage on the other reefs were low with two or less colonies affected per site. No population outbreaks, mass feeding aggregations or evidence of their occurrence were noted. There were no individuals seen of the coral predator, *Drupella cornus* (gastropod or snail) nor scars from its feeding activity observed at any of the sites surveyed.

Damage was observed on the surface of the coral colonies, *Acropora humilis*, *A. digitifera*, *Pocillopora verucosa* at 8 sites (7, 9, 10, 13, 60, 64, 65 and 83). Characteristics of the damage to the colony were indicative of the feeding activity by *Bolbometapon muricatum*. This fish is not considered a coral predator and its presence is indicative of a healthy reef.

Debris

Several types of debris were noted on 22 sites or 32.3% of the reef sites surveyed. The most frequently observed debris was from fishing activity. This included fishing line at 18 sites (2, 19, 20, 24, 26, 33, 36, 38, 40, 41, 43, 45, 49, 52, 61, 83, 85, 86 and 87), a spear gun at two sites (83 and 84), fishing net at one site (17), and rope at one site (37). Other debris included one tin can (site 36) and a glass bottle (site 87).

Fishing and reef gleaning activity

Evidence of marine resource extraction as noted by fishing debris on the reef as reported in the previous section or by the presence of actual fishers on the reef was observed at 24 sites (2, 3, 17, 18, 19, 20, 24, 26, 36, 38, 40, 41, 43, 45, 49, 52, 61, 62, 63, 83, 84, 85, 86, and 87) or 38.7% of the reef sites surveyed.

Sedimentation

Sedimentation stress was observed at 14 sites (or 22.6% of the sites surveyed) and varied in extent of observable impact (i.e. turbidity and amount of silt covering reef organisms or substrata). At two of the more northern reef sites assessed (18 and 20) silt was noted to be covering the sand on the reef. Sites 2 and 3 of Yandé appeared to be naturally silty. These four sites (2, 3, 18, and 20) can be categorized as having light sedimentation. Moderate sedimentation stress was noted on 4 sites (34, 35, 45, and 86). Sedimentation stress was most severe or extensive at inshore fringing sites off of Grande Terre within the Baie de Néhoué (29, 30, and 31) and further south (56 and 57). Site 32 situated off a small islet at the mouth of Baie de Néhoué also was observed to be subject to high sedimentation stress.

Red-listed species sightings

Numerous red listed species were spotted on 66% or 36 of the reef sites we assessed. These include such species as Maori Wrasses, sharks, rays, sea turtles, coral trout and other groupers. A brief recap of these findings is provided here with detailed information on the non-fish red listed species, sea turtles and dugongs. For more details on the red-listed fish species observed, please refer to chapter 2. For the red-listed giant clam species, no *Tridacna gigas* was observed during the survey as expected since they are only known from fossil record (Wells 1997) and only one *T. deresa* was observed. For more details on giant clam species observed during the survey, please refer to chapter 3. Sea turtles (green, loggerhead and hawksbill) were observed at eleven of the reef sites surveyed or 21% of the sites (Table 5.1).

Other red-listed species not observed during the survey, but reported from New Caledonia are species of whales, great white sharks, tiger sharks, other shark species, dugongs and sea horses. For more background on the red list and an up-to-date list of species evaluated from New Caledonia the reader is referred to their website, http://www.iucnredlist.org.

Synthesis of factors

Based on the number of fish and coral species observed with percent coral cover and consideration of presence or absence of human use, most sites were comparative ranked as very good to good. When the approximate count of target fish was included the sites predominantly were rated as fair (Table 5.2). A summary of values for these factors and relative scale of impact for each reef site visited (n = 62) can be found in Table 5.3.

Table 5.1. Turtle species and sites where observed during survey.

Species	SITES
Caretta caretta (Loggerhead)	60 (en route), 63, 69
Chelonia mydas (Green)	1, 14, 17 (en route), 22, 33, 37, 38, 57, 58, 63, 83
Eretmochelys imbricata (Hawksbill)	83

DISCUSSION AND CONSERVATION RECOMMENDATIONS

Based on coral and fish diversity, percent live coral cover

Table 5.2. Comparative categories for the state of reef sites (n = 53) surveyed based on rank cumulative total of number of fish species observed (FS), number of coral species observed (CS), and average percent live coral cover recorded (PLC) and consideration of presence or absence of human use. The second column lists the sites with approximate count of target fish (TFC) included in the summation for the comparison. The percentage of sites within that rating appears in parentheses.

Rating	FS + CS+PLC	FS + CS+PC+TFC
Excellent	1–3, 6, 7, 9, 17, 36–38, 49, 58, 59 (24.5%)	36, 83, 87 (5.6%)
Very good to good	11, 14, 16, 19, 24, 26, 28, 33, 41, 43, 45, 48, 52, 60, 61, 62, 63, 69, 74, 79, 80, 83, 84, 85, 86, 87 (49%)	3, 7, 9, 17, 43, 48, 49, 52, 58, 59, 61, 79, 80, 84, 85, 86 (30.2%)
Fair	10, 13, 18, 20, 22, 32, 35, 40, 51, 73 (19%)	1, 2, 6, 11, 13, 14, 16, 18, 19, 24, 26, 28, 32, 37, 38, 40, 41, 45, 60, 62, 63, 69, 73, 74 (45.3%)
Poor	29, 34, 65, 72 (7.5%)	10, 20, 22, 29, 33, 34, 35, 51, 65, 72 (18.9%)

and frequency and relative impact of observed stress or disturbance, 49% of the reef sites surveyed (n = 53 sites where complete data sets were available) were in very good to good health. No coral bleaching was observed on any reef sites assessed during the survey. Bleaching was reported to occur on reefs by scientists from IRD on the east coast in Province Nord, north of Poindimé in February 2008 (Spaggiari pers. comm.).

What appeared to be coral pathogens or disease was infrequently noted (8.2%) on the reefs surveyed. However the observed symptoms or responses indicative of white syndrome and pink pigmentation response may be the first ones reported for New Caledonia. No previous records of pink pigmentation response nor white syndrome were found in the literature or on internet data bases (i.e. Reefbase of Tupper et al. 2008 and coral disease mapping site of UNEP and WCMC 2006). Tumors on one *Acropora* species was noted during the Mont Panié marine rap survey (McKenna et al. 2006) and reports of tumors on one colony of *Acropora formosa* appear on reefbase and coral disease mapping site of UNEP and WCMC (2006). 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 stakeholder) may prove helpful. This would include a way to report such sightings for further examination by scientists, managers and the marine regulatory/protection entities in the region.

When targeted fish counts were included as a factor in the comparative cumulative rank analysis, a shift in the majority of reefs to fair occurred. This is logical given that fishing appeared to be the most frequently observed (i.e. fishers) or detected activity (e.g. fishing gear on site) for all the reefs surveyed (n = 62). Further the region surveyed, especially those sites in the southern area of the assessment, is close to the yacht and fishing harbor base in Koumac. As a consequence fishing related items left on the reef constituted the majority of the debris observed. Observations of fishing activity occurred more frequently at sites more easily accessible by humans. These observations of high incidence of fishing and numerous fishing line on the sites are consistent with previous studies that suggested reef habitats (near reef areas) or fish species caught by line were intensively fished in this area (Labrousse et al. 2000).

Given these observations, it is recommended that targeted fish populations be studied and monitored in more depth especially at sites most frequently visited. Examining and monitoring (e.g. catch per unit effort, landings, number and type of gear and areas fished) all fishers activity whether for commercial or subsistence purposes may prove useful as well.

As suggested previously (Labrousse et al. 2000) diversification of fishing methods may prove helpful to displace some of the fishing pressure off the line caught fish species. To reduce the amount of debris especially the fishing line on the reef sites, increased education and awareness of the need to dispose of items properly may be useful. For example more postings or signage concerning the need to be careful with unwanted items and special receptacles near docks and boat ramps for the collection of monofilament/fishing line etc.

The findings regarding fishing activity need to be taken with caution as reef fish communities can be highly variable on spatial and temporal scales. The work presented here is only a snapshot and each site was only visited once during different times of the day.

Although sedimentation stress was observed less frequently (24.2%) in comparison to fishing activity (38.7%) and COTS (35.5%), the level or extent of its impact observed on the reef sites affected was the highest. This is not surprising as previous and present mining activities are located onshore in Poum (Presqu'ile de Poume) and Tiébaghi (Le Dome Tiébaghi). Moreover the sites (29, 30, and 31) observed to have high sedimentation stress are situated in the Baie de Néhoué. This Bay is subject to the effluent from the Néhoué river and its tributaries that are impacted by the activities of Tiébaghi mine (Bird et al. 1984). Site 32 that is located at the entrance of Baie de Néhoué also was observed to have high sedimentation stress. The other two sites (56 and 57) noted to have high sedimentation stress were fringing reefs adjacent to the Tiébaghi mine and subject to river effluent as

Table 5.3. Summary of reef condition. The reef condition table provides the syntheses of species diversity, percents of hard coral cover and damage and threat observations for each reef site surveyed. Where values are not available due to issing data, "no data" is used. Threats or levels of damage are rated as L = light, M = moderate, and E = excessive (listed next to letter A for COTS in parentheses and alone for damage or threat observation). In cases where no damage was observed but Acanthaster plancii was seen, the letter P for "present" follows the letter A notation. Feeding scar is noted next to predator as FS. If no threat or damage was observed the corresponding cell for that site is empty. The approximate counts of targeted fish have been omitted from the table intentionally.

Site #	Biodiversity of focal groups		Approximate count of target fishes per 500m² sampled		Percent mean hard coral coverage by depth			Presence of COTS	Marine resource extraction	Disease	Debris	Sedimentation
	# of coral species	Fish species	# individuals shallow (10–12 m)	# individuals deep (15–24 m)	Deep (>12m)	Medium (6–10m)	Shallow (<6m)					
1	109	143				56						
2	91	151				52			yes		fishing line	L
3	99	138			39	55			yes			L
4	45	46			No data	No data	No data					
6	93	148			47	36		A (P)				
7	107	154			56	61						
9	100	147			47	69						
10	51	104			14 (n=3)			A(L)				
11	82	126					16					
12	61	97					34 (n=3)					
13	68	93				16						
14	68	93				34		A(L)				
16	78	130				16						
17	111	135			34	63			yes		fishing net	
18	71	56					54		yes			L
19	73	77				55		A(L)	yes		fishing line	
20	62	76					37		yes		fishing line	L
22	50	82					43					
24	75	84				86			yes		fishing line	
26	95	79				74			yes		fishing line	
28	53	84					64					
29	27	78					36					E
30	22					47						E
31	34						47					E
32	61	104					20	A(L)				E
33	76	108				70		A(L)	yes		fishing line	
34	45	39					34					M
35	64	64				34						M
36	105	133				57		A (FS/L)	yes		fishing line and tin can	

Table 5.3. continued on next page

Table 5.3. Summary of reef condition. *Continued from previous page.*

Site #	Biodiversity of focal groups		Approximate count of target fishes per 500m² sampled		Percent mean hard coral coverage by depth			Presence of COTS	Marine resource extraction	Disease	Debris	Sedimentation
	# of coral species	Fish species	# individuals shallow (10–12 m)	# individuals deep (15–24 m)	Deep (>12m)	Medium (6–10m)	Shallow (<6m)					
37	117	158				75		A (L)			rope	
38	94	135				71		A (FS/L)	yes		fishing line	
40	37	136					14		yes		fishing line	
41	63	117				26			yes		fishing line	
42	60	141					27					
43	63	134				82	68	A (FS/L)	yes	white syndrome (L)	fishing line	
45	69	105				68		A (FS/L)	yes		fishing line	M
47	53						52					
48	53	119				57	47			tumor (L)		
49	72	139				67	91		yes			
51	54	95					42					
52	49	128				17	42		yes	pigmentation response (L)	fishing line	
56	60	70					43 (n=8)	A(L)		tumor and pigmentation response (L)		E
57	67	33					57			tumors and pigmentation response (L)		E
58	93	136			54	59						
59	100	139			49	59		A (FS/L)				
60	80	136			35 (n=3)	22						
61	66	147					53	A (FS/L)	yes		fishing line	
62	67	106					26 (n=3)	A (FS/L)	yes			
63	47	163				16	31		yes			
64	33	86				17						
65	41	83			14	Nd						
69	73	139				25		A (FS/L)				
72	30	94					6					
73	33	113					17					
74	49	121					29					
79	76	130			34	31		A (FS/L)				
80	78	143			46	62						
83	64	172				22	42	A (FS/L)	yes		fishing line and spear	
84	56	134				40	47	A (FS/L)	yes		fishing line and spear	
85	74	139				56	67	A (FS/M)				
86	60	121				44	67	A (L)	yes		fishing line	M
87	42	142			58	62		A (L)	yes		fishing line and bottle	

well. These reef sites were so close to the mining activity that trucks transporting materials on the dirt roads could be seen during the survey. Consequently the sites (34, 35, 45, 85, 86) with moderate sedimentation stress were in close proximity to the high sedimentation sites.

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 denuded areas, building sedimentation barriers; settlement basins and terrace) should continue and be implemented in sites where these measures are absent (ESCAP 2003). Further, developing new mitigation techniques to lessen the impacts of mining activities on the surrounding environment is critical. This 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.

During this survey, the percent of reef sites (66%) where red listed species observed is less than that observed 76.2% during the Mount Panié survey (McKenna et al. 2006). The percent of sites where sharks were observed was similar for both surveys and is a positive sign given the global over-exploitation of sharks. In comparison to past surveys conducted closer to and within the renowned coral triangle in the Pacific Ocean by Conservation International using similar methods (e.g. Raja Ampat, Togean Bangaii, and Calamianes), the sightings of red listed species in New Caledonia are presently the highest observed. As these percentages are observational and based on limited spatial and temporal scale, it is important that continued quantitative study and monitoring occur. This will contribute to ensuring the viability of these populations and recovery of the threatened red-listed species in the future.

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