Stock Assessment of Targeted Fish Species

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Chapter 4

Stock assessment of targeted fish species

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SUMMARY

- A rapid assessment of reef fish stocks bearing interests for consumption was conducted over an area spanning the communes of Touho to Ponérihouen on the Northeast coast of New Caledonia from the coastal zone to the outer barrier reef.
- A total of 186 species belonging to 67 genera and 23 families was identified over 48 study sites.
- Fish communities were 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.*
- The majority of reefs had community species compositions that indicated good health status.
- The difference in biomass and abundance values observed between "marketed" and "non-marketed" species reflects an unequal fishing pressure (although reduced in all areas sampled).
- Top predators (e.g. 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 (humphead wrasse and bumphead parrotfish).

INTRODUCTION

Province Nord of New Caledonia has reef and lagoon area of approximately 15,500 km² and this province is sparsely populated (45,137 inhabitants or 4.5 per km²) (ISEE 2009). The population growth remains moderate (+1.5% from 2006 to 2009) particularly in the area covered by this study. The fishing pressure on coastal fish species is thus limited (Letourneur et al. 2000) and is exercised mainly through subsistence or recreational fishing (90% according to Labrosse et al. 2000) and to a lower extent through commercial fishing. The human impact appears to be relatively low over the area and resource management measures (e.g. marine protected areas, fisheries regulations) have been already initiated or implemented by Province Nord. Studies by Kulbicki et al. (2000) and Letourneur (2000) provide a complete inventory of species and an assessment of stocks across the northern lagoon. In the process of long-term management, it is also necessary to accurately assess the status of resources over small geographic areas. This chapter lists an inventory of lagoon fish communities bearing consumption or targeted interest through a qualitative and quantitative analysis of their compositions. Exchanges with customary people during this mission, notable issues arose that indicated the local communities have a strong interest in their natural heritage and the desire to understand the elements needed for the establishment of a participatory management plan.

METHODS

The Rapid Assessment Program (RAP) conducted in Province Nord over the 25 day period from November 16th to December 10th 2009, focused on an area spanning from the communes of Touho to those of Poindimié and Ponérihouen. The sampling effort concerns 48 sites in five major habitats from the coast to the outer slope of the barrier reef (Table 4.1).

The underwater survey methods used for this survey are supported by Samoylis and Carlos (2000) and were used in previous RAPs (Cornuet 2006, Grace 2009). This standardized method is frequently used in studies of this type and allows for comparison of results from one study to another.

Species of interest for consumption or marketing are those that are found near coral reefs and likely to be targeted by commercial, recreational or subsistence fishing. Fishing pressure thus is not applied equally among all species and differs depending on the type of fishing practiced and the geographical area. It is thus difficult to accurately define a list of "targeted" species. As the RAPs implemented by Conservation International aim at assessing the biodiversity of an area, the list of species considered was accordingly set to be exhaustive and was defined in agreement with P. Laboute in charge of surveying coral reef fish and based on lists established by the Secretariat of the Pacific Community (Labrosse et al. 2003) or the online FishBase database (www.fishbase.org).

Since the surveyed species are likely to be caught, they may risk fleeing when facing the diver (Kulbicki 1998). To minimize this risk of bias in sampling, the diver enters the water before the rest of the team and the main tape is unwound as the diver progresses (Fowler 1987). Surveying takes place along a belt transect with a length of 50m and a width of 10m. An area of 500m² is thus sampled. Only individuals in front of the diver and already present in the area are counted, individuals arriving from behind the diver are not taken into account to avoid counting the same fish twice. This distinction is sometimes difficult to assess and the count may be slightly overestimated. The fish are counted individually and their size is estimated (to the nearest 1 cm for fish ≤ 10 cm; to the nearest 2cm for fish ≤ 30cm; to the nearest 5cm for fish ≤ 60cm; and to the nearest 10cm for fish ≥ 60 cm). When a group of over 50 individuals is seen, an estimate of the number is given (in increments of 10 to 50 individuals) and an average size is allotted.

On each transect, counting time, depth and visibility are systematically recorded (Table 4.2).

A single count was performed on each site, however, to obtain a more accurate representation of the communities present at each site, a 10 minute random swim was systematically carried out at the end of each count to record species that had not been observed on the transect but were present in the sampling area. Only the species name is then noted, as estimate of the number or size cannot be compared with data obtained during the counting. This method yields significant results on the number of species, genera and families observed at end of mission.

Counting was carried out on all sites visited during this mission with the exception of two where the depth and visibility conditions did not allow the methods to be carried out in a satisfactory fashion. Indeed, sites 14 and 48 respectively located in mangrove and seagrass areas were not assessed by transect. The very low number of species sighted on these two sites was taken into account only in providing the total estimated species richness throughout the mission, but no analyses were conducted on the basis of these sightings.

From the data collected, species richness was defined and indices of abundance and biomass were calculated. Species richness is defined by the number of taxa identified during counts. Abundance is the number of individuals recorded for a sampling site. Biomass represents the overall quantity of fish available on a site and is estimated from the number of fish counted and their individual weight on a transect. This

Table 4.2. Descriptive statistical parameters of transects.

	Time (min)	Depth (meters)	Visibility (meters)
Average	26.7	7.1	12.8
Minimum	15	0.8	3
Maximum	49	16	30

Table 4.1. Sites distribution by habitat over the three areas sampled.

Habitat types	Touho zone	Poindimié zone	Ponerihouen zone	Total per habitats
Fringing reef	6, 12, 13, 15,	30, 35	46, 48*	**8**
Mangrove	14*	-	-	**1**
Intermediate reef	4, 5, 8, 9, 16, 17	29, 33, 34, 36	39, 40, 41, 42, 45, 47	**16**
Back reef	3, 7, 11, 18, ,	22, 23, 24, 27	44	**9**
Pass	10	19, 20, 25, 28, 32	43	**7**
Outer reef slope	1, 2	21, 26, 31	37, 38	**7**
Total per zone	18	**18**	**12**	**48**

* sites 14 and 48 were not surveyed by transect

weight is determined from the length of the fish according to the following equation (Letourneur et al. 1998) :

$$W = aL^b$$

Where, W is the weight, L the estimated fork length in cm and the coefficients a and b are species specific and defined by the works of Letourneur et al. (1998). The old cubic formula ($W = 0.05\ L^3$) has a tendency to overestimate the weight of the majority of species and to provide less accurate results so was not used in the analysis of the results. This biomass is expressed in tons per square kilometers (t/km^2), converted from the original expression in gram for $500m^2$.

To best meet the objectives of the RAP (biodiversity inventory, rapid assessment of stocks, use of resources by local communities), the fish fauna was grouped into different categories in the data analysis:

- **Complete community**: includes all species targeted by fisheries and identified in this study. Within this community, a distinction is made between marketed and non-marketed species.
- **Marketed species:** includes species that are found on market stalls and shops throughout the country.
- **Non-marketed species:** includes all non-marketed species but targeted by subsistence or recreational fishing and consumed in the western Pacific. Some species listed are however not consumed in New Caledonia because of their potential toxicity.

Five diets were also defined (Table 4.3) (Randall 2005, Lieske and Myers, 2005) for a more accessible synthesis and better readability of illustrative maps.

RESULTS AND DISSCUSION

General characteristics

Species richness and composition

A total of 185 targeted species belonging to 66 genera and 23 families were observed during the survey with 13,715 individuals sighted. Marketed and non-marketed species respectively represent 42% and 58% of this community, this is equivalent to 78 and 107 species. The number of species, genera and families identified is higher than in the previous RAPs carried out in the reefal areas of Mt Panié (Cornuet 2006) and of Yandé to Koumac (Grace 2009) with an average of 35 species recorded per site. This difference is probably due to a more comprehensively defined list of species to be recorded, more sites and habitats sampled than in 2006, but also due to the sampling technique used. Indeed, the 10 minutes random swim performed routinely after each counting allowed to record a number of species not observed on transects and to significantly increase the total species richness (Student's test significant, $P < 0.01$) (Table 4.4).

The most diverse families observed were the Acanthuridae (27 species), Scaridae (23 species), Serranidae (17 species) and Lutjanidae (14 species).

Scaridae diversity is particularly interesting as 23 of the 28 species known to New Caledonia were observed. In addition, two species reported as rare in this region of the Pacific were recorded: These are *Chlorurus frontalis* and *Chlorurus japanensis.* The species *C. japanensis*, had been already observed during the Mount Panié RAP in 2004 by Richard Evans. The individual was photographed this time by Pierre Laboute. Similarly, it appears that the species *Acanthurus maculiceps* (Acanthuridae), reported in nearby geographical areas (Micronesia and Australia) but never previously recorded in New Caledonia, was observed on three occasions. No photograph or specimen capture however allows for validation of this information.

Table 4.3. Classification of targeted fish families by diet.

Diet	Families	Common names
Carnivore	Carcharhinidae	Sharks
	Haemulidae	Sweetlips
	Holocentridae	Squirrel fishes
	Labridae	Wrasses
	Lethrinidae	Emperors
	Lutjanidae	Snappers, Mangrove jacks, Job fishes
	Mullidae	Goat fishes
	Nemipteridae	Threadfin breams, false snappers
	Priacanthidae	Bigeyes
	Serranidae	Groupers
Herbivore	Acanthuridae	Surgeon fishes, unicorn fishes
	Scaridae	Parrot fishes
	Siganidae	Rabbit fishes
Omnivore	Acanthuridae	Unicorn fishes
	Balistidae	Trigger fishes
	Ephippidae	Bat fishes
	Kyphosidae	Drummers
Piscivore	Carangidae	Trevallies
	Lutjanidae	Snappers
	Scombridae	Spanish mackerels
	Serranidae	Groupers
	Sphyraenidae	Barracudas
Planctophage	Acanthuridae	Surgeon fishes, unicorn fishes
	Caesionidae	Fusiliers
	Holocentridae	Soldier fishes
	Lutjanidae	Snappers

Table 4.4. Number of genera, species and individuals identified by targeted families (decreasing rank by number of species). A distinction is made between genera and species recorded on all transects (transect counts) and those recorded during the systematic random swim (Total).

Families	No. of genera (transect counts)	No. of genera (Total)	No. of species (transect counts)	No. of species (Total)	No. of individuals (transect counts)
Acanthuridae	4	5	26	27	2874
Scaridae	4	5	22	23	1522
Serranidae	7	7	15	17	199
Lutjanidae	4	4	14	14	444
Labridae	6	6	11	12	258
Carangidae	5	7	8	12	94
Lethrinidae	4	4	11	11	382
Mullidae	3	3	10	10	205
Siganidae	1	1	9	9	400
Holocentridae	3	3	7	9	121
Caesionidae	2	2	7	7	6704
Balistidae	5	5	7	8	121
Haemulidae	2	2	8	8	35
Nemipteridae	1	1	4	5	274
Carcharhinidae	2	2	2	3	9
Kyphosidae	1	1	2	2	21
Dasyatidae	0	2	0	2	1
Gerreidae	1	1	1	1	20
Ephippidae	1	1	1	1	18
Priacanthidae	1	1	1	1	5
Scombridae	1	1	1	1	5
Sphyraenidae	1	1	1	1	2
Myliobatidae	0	1	0	1	1
Total : 23	**53**	**66**	**158**	**185**	**13715**

Several species of Acanthuridae (six) Scaridae (five) and Lethrinidae (one) were observed on over 50% of sites. Among these species, a number of them are particularly targeted by fishing activities: Unicornfish (*Naso unicornis*) 75%; Blue parrot fish (*Chlorurus microrhinos*) 50%; Clear headed parrot fish (*Chlorurus sordidus*) 81.3% ; Big eye perch (*Monotaxis grandoculis*) 52%.

Other species characteristic of healthy coral formations were observed also on more than half the sites: Labridae (*Cheilinus trilobatus* 66.7%, *Hemigymnus fasciatus* 56.3%), Siganidae (Blue spotted rabibitfish (*Siganus corallinus*) 62.5%), Nemipteridae (Two-line monocle bream (*Scolopsis bilineata*) 77.1%).

Furthermore, 25 to 50% of sites had a fish community composition classic of coral reef ecosystems (Acanthuridae, Scaridae, Serranidae, Carangidae, Lutjanidae, Mullidae, Labridae, Siganidae, and Balistidae Caesionidae) including some species of high marketing interest (coral trout (*Plectropomus leopardus*) 45.8% (blue-fin Trevally (*Caranx melampygus*) 29.2%).

Much of the observed total species richness (74%) is still composed of species recorded on fewer than 12 of the 48 sites surveyed. These species may be characteristic of other types of habitats and therefore rarely seen on reefs such as. lagoon soft bottom species (Lethrinidae:, pelagic species Carangidae, Scombridae, Sphyraenidae, Caesionidae, Myliobatidae, species difficult to observe when counting Holocentridaeor simply species that are less abundant.

The 78 marketed species represent 42% of the community. Only 26 of them were observed on more than 25% of sites and only eight (Acanthuridae and Scaridae) equivalent to 4% of the total community on over 50% of sites.

Overall quantitative results

The abundance and biomass means recorded over the entire mission are given in Table 4.5 for all families surveyed. The contribution of marketed species in relation to the complete community is expressed as a percentage in the column "contribution of marketed species". The percentage of each

Table 4.5. Mean biomass and abundance of targeted families (in decreasing rank of mean biomasses). The contribution of marketed species to mean biomass and abundance of families is expressed as a percentage.

Families	Mean biomass (t/Km²)	Contribution of marketed species to mean biomass (%)	Rank	Mean abundance (No. of individuals)	Contribution of marketed species to mean abundance (%)	Rank
Acanthuridae	43.84	70.5%	1	60	43.3%	2
Scaridae	27.92	95.4%	2	32	97.4%	3
Caesionidae	14.09	0.0%	3	140	0.0%	1
Carcharhinidae	9.47	0.0%	4	0.2	0.0%	18
Lethrinidae	8.33	17.1%	5	8	18.8%	6
Lutjanidae	7.39	12.0%	6	9	15.1%	4
Carangidae	4.73	23.6%	7	2	71.3%	13
Serranidae	4.63	70.5%	8	4	71.9%	10
Labridae	2.90	39.4%	9	5	4.7%	8
Siganidae	2.07	75.0%	10	8	70.8%	5
Haemulidae	1.93	0.2%	11	0.7	2.9%	14
Mullidae	129	11.5%	12	4	9.8%	9
Nemipteridae	0.92	0%	13	6	0%	7
Balistidae	0.82	0%	14	2.5	0%	11
Scombridae	0.81	100%	15	0.1	100%	19
Kyphosidae	0.72	100%	16	0.4	100%	15
Holocentridae	0.63	0%	17	2.5	0%	11
Sphyraenidae	0.32	0%	18	0.04	0%	21
Ephippidae	0.27	0%	19	0.4	0%	17
Priacanthidae	0.06	100%	20	0.1	100%	19
Gerreidae	001	100%	21	0.4	100%	16
Total fish fauna	133.16	51,6%	-	286	25.1%	-

family for total biomass and abundance is shown graphically in Figures 4.1 and 4.2.

A mean biomass of 133.16 t/km ² and a mean abundance of 286 individuals were identified per site. The main families observed both in terms of abundance and biomass were the Acanthuridae, Scaridae and Caesionidae.

The Acanthuridae represent a set of species with varying diets (herbivores, omnivores, planktivores), found over a wide range of habitats where some species are relatively common and abundant (*Zebrasoma scopas, Ctenochaetus striatus*). Therefore they largely dominated this group of species, representing over one third of the mean total biomass. The mean size was 26.5 cm for marketed species and 15 cm for non-marketed species. The highest species richness (12 species) and the highest abundance (219 individuals) were observed at site 1.

The Scaridae, main herbivores of coral reefs (Randall 2005), include species that can be found from coastal waters (which are sometimes turbid) up to the outer reef slope affected by oceanic influences. While some species are solitary, others form groups, sometimes of large size, especially during the spawning season as seen during this survey. The mean size of individuals from these groups was evaluated at 25.1 cm, but the presence of many individuals in the initial phase tends to decrease this mean. The mean estimated sizes of the marketed species *Chlorurus microrhinos* and *Hipposcarus longiceps* (yellow parrot fish) were respectively 33cm and 43cm. The highest species richness (12 species) observed was at sites 1, 11 and 38, and the highest abundance (96 individuals) observed was at site 33.

The Caesionidae family combines a variety of pelagic species (planktivores) moving systematically in small to very large schools (10 individuals to 1200 individuals observed). Their size class remains moderate (mean of 14 cm), but their high numbers make up an important biomass.

The Serranidae were of particular attention during two of the previous RAPs (La Tanda 2002, Grace 2009). Indeed, in addition to being of particular interest for subsistence or commercial fisheries, some species are listed on the IUCN Red List (www.IUCNredlist.org): Malabar grouper (*Epinephelus malabaricus* - near threatened (NT)); Blacksaddled coral grouper (*Plectropomus laevis* – Vulnerable (VU)); Coral trout *Plectropomus leopardus* (near threatened (NT)). The average size of marketed species assessed during this mission (28cm) was lower than those estimated on the north-east and north-west coasts during the previous two Marine RAPs (29.3 cm and 32.6 cm) (Cornuet 2006, Grace 2009) but higher than measurements taken in Raja Ampat, Indonesia (about 25cm) (La Tanda 2002), Calamianes Islands, Philippines (Ingles 2000) and the Togian-Banggai Islands, Indonesia (> 20cm) (La Tanda 1998). The estimated average size for all species was lower (24.4 cm), although of the 23 species considered in the inventory, some are small sized as adults (Banded tail coral trout (*Cephalopholis urodeta*); Blue-lined coral trout *Cephalopholis boenak* ; Black-tipped coral trout (*Epinephelus fasciatus*)). The highest species richness (five species) was recorded at sites 1, 2 and 17 and the highest abundances were found on site 8 with 33 individuals recorded on the transect.

Contribution to biomass and abundance of marketed species is provided as an indication for each family in Table 4.5. Overall, marketed species only represent a quarter (25.1%) of the total mean abundance, but half (51.6%) of the total mean biomass. Biomass and abundance of marketed species

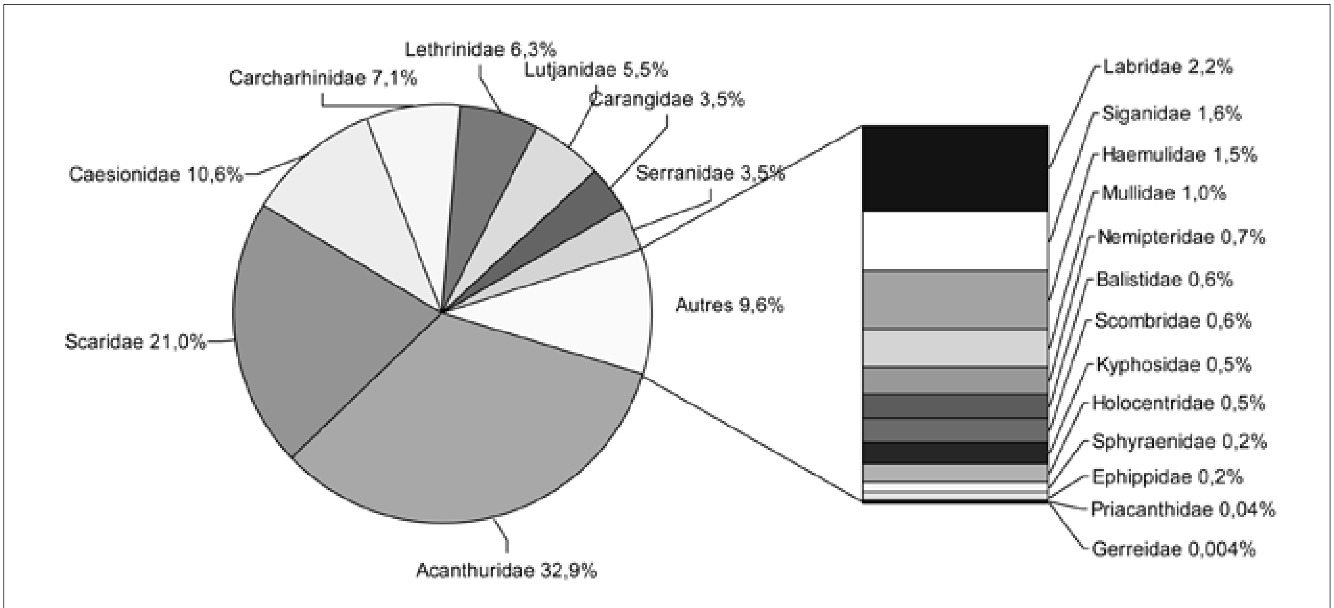

Figure 4.1. Contribution (in percentage) of targeted families to the total biomass.

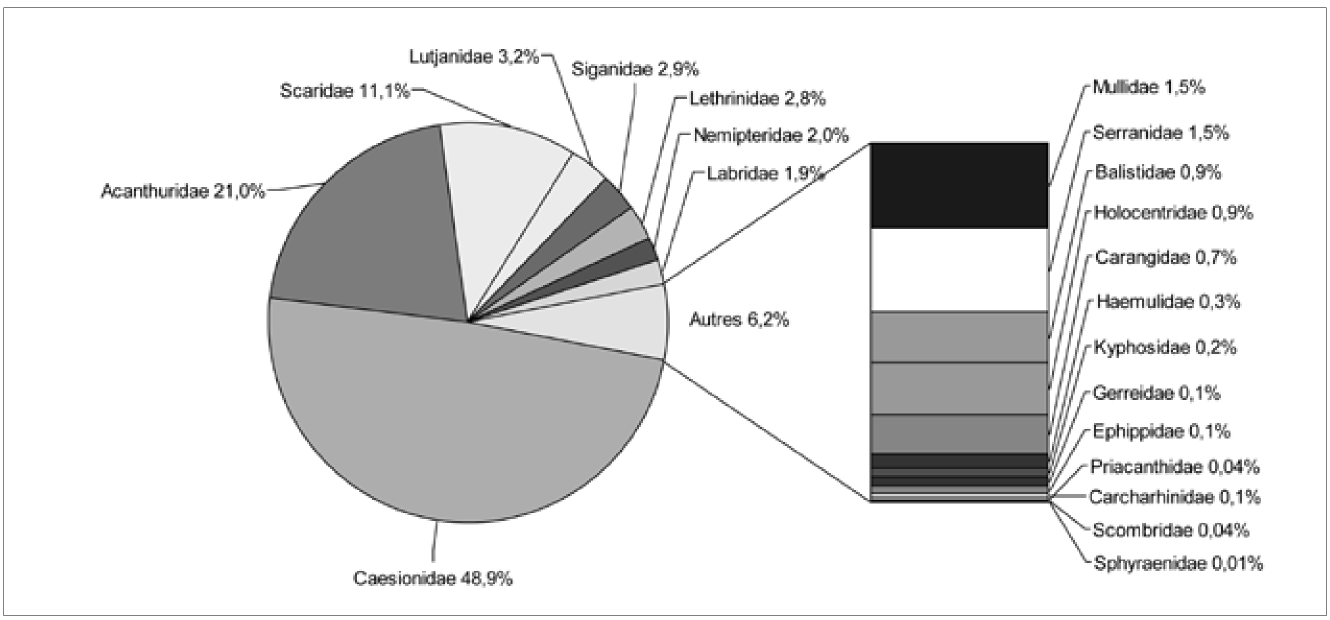

Figure 4.2. Contribution (in percentage) of targeted families to the total abundance.

are once again largely dominated by the Scaridae and Acanthuridae with respectively 43% and 36% of the total market abundance and 45% and 39% of the total market biomass.

Comparative study:

Habitat analysis

A habitat is a homogeneous area characterized by a set of abiotic parameters (currents, turbidity, physical and chemical water characteristics etc.) to which corresponds an associated flora and fauna. The composition of fish communities as well as indices of abundance and biomass thus varies from the coastal areas under the influence of catchments to the barrier reefs under oceanic influence. The results by habitat type are expressed in Table 4.6. The contribution of marketed species in relation to the complete community is expressed as a percentage in the column "contribution of targeted species".

Sites located on the outer slopes of the exterior barrier reefs had species richness, biomass and abundance values superior to other habitats. As the oceanic influence allows for the establishment of a complex trophic structure characterized by the presence of many types of diets (herbivore, omnivore, carnivore, piscivore and planktivore), the diversity and abundance of species is important. The communities observed were dominated by the Acanthuridae, Scaridae and Caesionidae representing over 60% of the total biomass including the important biomass of some marketed Acanthuridae species (*Naso unicornis*; Bulbnose unicornfish (*N. tonganus*); Spotted unicornfish (*N. brevirostris*); Sleek unicornfish (*N. hexacanthus*) and Scaridae (*Hipposcarus longiceps*; *Chlorurus microrhinos*). The Caesionidae communities were observed to be dominated by blue and gold fusiliers (*Caesio caerulaurea*).

Sites located in the passes, back reefs and intermediate reefs present were observed to have relatively similar characteristics in terms of species richness and biomass, however with higher biomasses around intermediate reefs and generally higher abundances in passes. Again, the Acanthuridae (dominant species: *Naso brevirostris*, *N. hexacanthus*, *N. tonganus*, *N. unicornis*) and Scaridae (dominant species: *Scarus longiceps*, *S. microrhinos*, *S. rivulatus*) families were the ones that contributed the most to the mean biomass in passes (52%), intermediate reefs (57%) and back reefs (46%). The Caesionidae (*Caesio caerulaurea*) represented the third most important family in passes and intermediate reefs. Moreover, the species of Lethrinidae *Monotaxis grandoculis* that sometimes form large groups constituted an interesting part of the biomass on the intermediate reefs and pass sites. Back reef areas in turn presented significant biomasses (23% of the mean biomass) for the Lethrinidae and Lutjanidae.

Fringing reefs are influenced by specific environmental conditions (high turbidity, moderate currents, and influence of estuarine water), are probably more exposed to human impact, and have the lowest species richness, biomass and abundance values. Community composition remains dominated by the Acanthuridae (*Acanthurus dussumieri*) and Scaridae (*Scarus rivulatus*) contributing 22% and 19% to the mean biomass. Communities are however more homogeneous where Lutjanidae, Mullidae and Kyphosidae families contributed together 33% to the mean biomass. As the average visibility on these sites is low (mean = 5.39 m) it is quite likely that all measured indices may be underestimated to the actual values, identification or measurement of some individuals often was difficult.

In general, the highest biomasses for the familes of Lutjanidae, Lethrinidae, Haemulidae, Mullidae, Kyphosidae, Nemipteridae and Carcharhinidae were found on the back reefs ; the highest biomasses of Siganidae, Carangidae, Serranidae, Scombridae and Ephippidae were on on the intermediate reefs ; the highest biomasses of Acanthuridae, Scaridae, Caesionidae, Holocentridae and Balistidae were on the outer reef slopes, the highest biomasses of Labridae were in the passes.

Site analysis

Table 4.7 provides a ranking of the 10 sites with the highest values for indices of species richness, biomass and abundance. The Caesionidae were excluded from this analysis, their high numbers in certain areas (with a limited consumption interest) largely biased comparisons between sites.

Three sites stand out from this analysis with the 10 highest values for each of the measured indices found . Sites 1 (located on the barrier reef in front of the township of

Table 4.6. Mean species richness, biomass, and abundance by habitat type. The proportion of marketed species for each index is given as a percentage.

Habitat types	No. of sites	Mean species richness	Contribution of marketed species to the mean species richness (%)	Mean biomass (t/Km²)	Contribution of marketed species to the mean biomass (%)	Mean abundance (No. of individuals)	Contribution of marketed species to the mean abundance (%)
Fringing reef	7	18	44 %	37.75	62 %	94	48 %
Intermediate reef	16	36	47 %	14224	65 %	284	40 %
Back reef	9	35	46 %	127.28	49 %	234	35 %
Pass	7	38	50 %	127.93	51 %	339	30 %
Outer reef slope	7	49	45 %	258.57	51 %	560	20 %

Touho) and 17 (located on an intermediate site within the lagoon close proximity to the back reef) 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 (Touho zone: 2 and 9; Poindimié zone: 20, 23 and 33; Ponérihouen zone: 37and 38) stand out with values that fall within the 10 highest for at least two of the measured indices.

Apex predators and iconic species

The term apex predator applies to large size piscivore species with slow growth rate at the top of the food web and with a very low rate of predation. These species (e.g sharks, large groupers, barracuda, spanish mackerels, large trevallies, and jobfishes) therefore contribute significantly to coral reef ecosystem functioning by structuring fish communities.

On all sites studied during this mission, only small numbers of these predators were recorded.

Only two species of sharks were encountered: 18 *Carcharhinus amblyrhyncos* (Gray shark) individuals (average size: 150cm, Maximum: 180cm - Minimum: 120cm) and 8 *Triaenodon obesus* (whitetip reef shark) individuals (average size: 110cm, Maximum: 120cm - Minimum: 100cm) were mainly observed on the outer reef slopes and intermediate reefs (*C. amblyrhyncos*) and on the back reefs (*T. obesus*). No observations of the species *C. melanopterus* (black tip reef shark), although generally common, were recorded. Table 4.8 presents the data recorded for the main apex predators encountered in the study.

A small number of individuals was counted and the recorded sizes were modest in comparison to the maximum sizes that can be observed for these species. This table is however provided as an indication since the chosen methodology makes it difficult to observe the majority of these species that are pelagic.

In addition, two other large sized iconic species, particularly sensitive to fishing and unfortunately often viewed as "trophy" fishes were recorded only in small quantities. Only two bumphead parrotfish (*Bolbometopon muricatum*, IUCN Status: Vulnerable) were observed. These observations were of isolated individuals, although the species usually form large groups. Nine humphead wrasses (IUCN Status: Endangered) were observed for size classes corresponding to young individuals (average size: 70cm, Maximum: 90cm - Minimum: 45cm), according to the literature adult individuals can reache sizes up to 200cm.

The spatial variability observed over the entire area is mainly structured along a coast to ocean gradient. A set of

Table 4.7. Ranking of the 10 sites for each of the indices measured (species richness, abundance and biomass). Sites 1, 11 and 17 (underlined in the table) show high values for each index measured.

Species richness			Abundance (no. of individuals)			Biomass (t/km²)		
Habitat types	**Sites**	**Values**	**Habitat types**	**Sites**	**Values**	**Habitat types**	**Sites**	**Values**
Outer reef slope	2	**66**	Outer reef slope	<u>1</u>	**330**	Intermediate reef	<u>17</u>	**422.23**
Outer reef slope	<u>1</u>	**65**	Intermediate reef	<u>17</u>	**315**	Outer reef slope	37	**396.71**
Intermediate reef	<u>17</u>	**59**	Back reef	44	**269**	Outer reef slope	38	**392.42**
Outer reef slope	38	**52**	Back reef	<u>11</u>	**248**	Intermediate reef	9	**378.21**
Back reef	<u>11</u>	**49**	Back reef	23	**248**	Outer reef slope	<u>1</u>	**343.22**
Outer reef slope	37	**45**	Intermediate reef	9	**231**	Intermediate reef	33	**285.65**
Back reef	22	**43**	Outer reef slope	2	**222**	Back reef	<u>11</u>	**277.68**
Pass	32	**43**	Intermediate reef	33	**220**	Outer reef slope	26	**228.03**
Pass	20	**42**	Back reef	24	**219**	Back reef	23	**199.49**
Outer reef slope	21	**42**	Back reef	3	**203**	Pass	20	**171.70**

Table 4.8. Number of individuals, and average sizes observed for apex predators with corresponding values reported in the literature.

Species	Common name	Number of individuals	Average size (cm)	Maximum size observed (cm)	Maximum size recorded in the literature (cm)
Caranx ignobilis	Giant trevally	2	80	90	**170**
Scomberomorus commerson	Spanish mackerel	5	75	90	**120**
Epinephelus malabaricus	Malabar grouper	1	90	90	**200**
Sphyraena barracuda	Barracuda	2	78	100	**140**
Aprion virescens	Jobfish	1	70	70	**100**

combined environmental factors (topography and types of reefs, hydrodynamics, turbidity, coral cover etc.) intervene on the structuring of reef fish communities. Moreover, other local anthropogenic factors such as terrigenous runoffs due to erosion of catchment areas (e.g. forest fires, farming, mining), organic pollution (e.g. environmental enrichment due to wastewater discharges and algal development), fishing (e.g. proximity and accessibility of reefs) impact significantly on fish communities either by habitat modification (changing the species composition and coral and algal community structures (McClanahan and Obura 1997, Aronson et al. 2004, Fulton and Bellwood 2008) or by direct action on the stocks of exploited species. All these elements must be taken into account to properly analyze the data presented in this report.

CONCLUSION

Targeted fish populations in the area between Touho and Ponérihouen seem somewhat little impacted overall or at least were observed to have a significant diversity and quantitative values in agreement with previous RAPs. The great varieties of Acanthuridae and Scaridae including the presence in the lagoon of uncommon species are particularly interesting elements.

In coral reef environments, the relationship between algae and corals is characterized by intense competition in terms of space (Knowlton 2001). The composition of the communities mainly dominated by Acanthuridae and Scaridae (mostly herbivores) across the habitats studied is an important point as the grazing action of herbivores regulates algal development and promotes growth and occupation of space by corals (Crossman et al. 2001, Polsenberg and McManus 2004, Wismer et al. 2009). A review by Carassou et al. (2009) provides knowledge about the importance of herbivorous fish in structuring coral and algal communities.

Several families representative of healthy reefs were also present on many sites and it would be interesting to cross the data from this study with the results of the reef fish species studies, including the community structuring of "indicator" species such as the Chaetodontidae that are mostly corallivores. These ichthyological data and the results of the substrata composition would provide a fairly accurate vision of the health of the reefs in the area.

However, it is necessary to emphasize other elements that can influence community structure. When analyzing the data, the targeted species were treated separately in order to evaluate the existence of a greater fishing pressure on them in comparison to the rest of the community. Indeed, intensive exploitation of fishing stocks can be assessed by the considerable number of deleterious effects, such exploitation can cause on the natural populations: decreased densities and abundances and hence the number of catches per fishing effort or frequency of observation, decreased mean sizes of catches, depletion of the genetic stock and reduced fertility (Gell and Roberts 2003).

In this case, the results obtained here for targeted species highlight signs of a greater fishing pressure than for non-marketed species:

- a low abundance, since it is only a quarter of individuals counted during the mission,
- a low frequency of observation with only one third of marketed species present in at least 12 sites (or one quarter of all sites) and only 1/10th of marketed species present in at least 24 sites (half of all the sites),
- only a small number of apex predators was observed and the maximum sizes observed for so called large species remain modest.

It is difficult to develop this argument without conducting further studies, but these initial analyses tend to suggest that fishing pressure, as small as it is, is exercised unevenly upon marketed species in the lagoon.

Rapid assessments programs including the methodology used do not allow and are not intended to accurately determine the status of the stock of resources in the area sampled. However, they provide a fairly accurate representation of biodiversity and pose a scientific foundation for the establishment of a long term heritage management scheme. The involvement of local communities in this process appears to be a prerequisite for the preservation of this heritage.

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