ASSESSMENT OF COMMERCIAL FISH RESOURCES IN THE LAGOON OF THE NORTHERN PROVINCE, NEW CALEDONIA

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Background

The Northern Province of New Caledonia has in recent years been concerned with implementing rational and sustainable management of lagoon fish resources. In addition, the Province needs to be in a position to respond to various questions raised by fishermen.

These questions mainly concern exploitation levels for certain species or fishing areas, fisheries development and the use of new techniques. Available information and knowledge were, until now, too inadequate and incomplete for the Province to be able to respond.

This situation justified the implementation of an assessment of commercial lagoon fish resources. This study was carried out by ORSTOM (French Research Institute for Development in co-operation) at the request of the Northern Province, as part of the French Government/Northern Province Development Contract. It was completed in August 1997 after two-and-a-half years of work.

A major sampling operation was mounted by the team of four ORSTOM researchers and technicians from the Provincial Government. The work covered almost 300 species, which are, or are likely to become, of commercial interest. Of the 10 000 km² of lagoon in the Northern Province, 7 000 km² were surveyed. For practical reasons, the area was divided into three zones (see Figure 1): the Belep Islands (northern zone), the West Coast (west zone) and the East Coast (east zone). All biotopes were sampled with complementary techniques (reefs, lagoon bottoms, mangroves).

Over the 270 days of work, more than 1,800 underwater visual censuses (dives on the reef), 400 experimental fishing trips with hand-held lines on the reef edges, 210 longline deployments on the lagoon bottoms and 100 net deployments in the estuaries and mangroves were carried out.

From this point of view, this programme is a world-wide first. No sampling effort had ever previously been undertaken on a so great geographical scale and with different techniques in the tropical world.

It has made it possible to collect a very large amount of information concerning the structures of fish populations (diversity, abundance, biomass); species; individuals; and preferred locations, depending on their size and biology (reproduction periods, feeding habits, habitat, etc.).

A large proportion of these data can be consulted through the FISHEYE database accessible by Internet*.

Sampling techniques

Underwater visual census (UVC)

The underwater visual censuses were spread in such a way as to cover all reef geomorphologic types with a minimum sampling frequency of 6 dives for every 4 miles of reef (fringing and barrier reefs) and surveys on both the windward and leeward sides of the middle reefs. UVC's were mainly carried out on inner coral-reef slopes.

The populations were studied by the so-called 'line-transect' method (Buckland et al. 1993). At each site, a 50 m transect was laid out with a 50 m-long measuring tape. Two divers, one on either side of the transect, carried out visual surveys (Figure 2).

They noted all commercial fish seen. For each observation, they identified the species concerned, estimated the number of specimens (n), the size and the perpendicular distance (d) of the fish(es) from the transect.

Along each transect, the special characteristics of the surroundings were noted. In 10 m sections, each of the two divers estimated the relative percentage of each of the different kinds of substrate: i.e. mud, fine sand, coarse sand, debris, blocks, rock, coral heads (Table 1).

In the same way, the observer noted the cover rate of the substrate by living organisms (stringy algae, brown algae, green algae, alcyonarians, coral).

* *http://noumea.orstom.nc/BASE/FISHEYE/presentation.html or 'presentation_en.html' (for the English language version)*

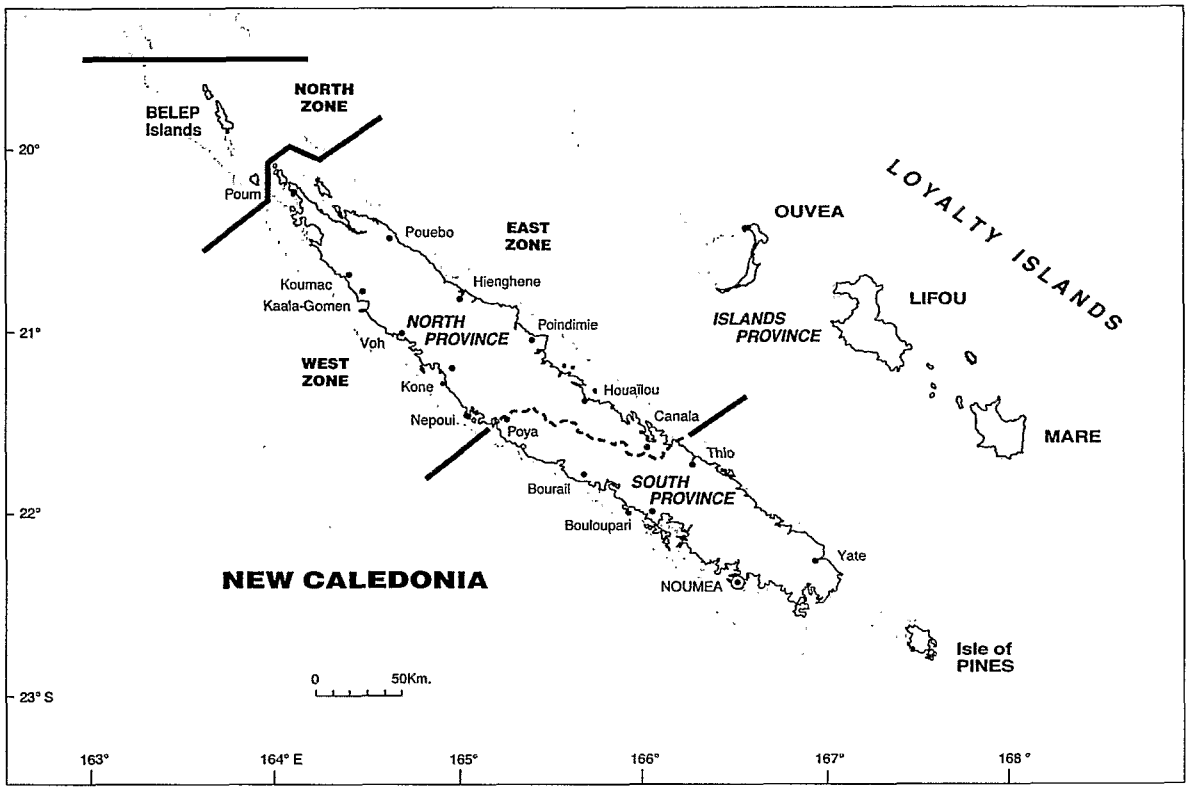

Figure 1: Northern, western and eastern zones of the Northern Province of New Caledonia

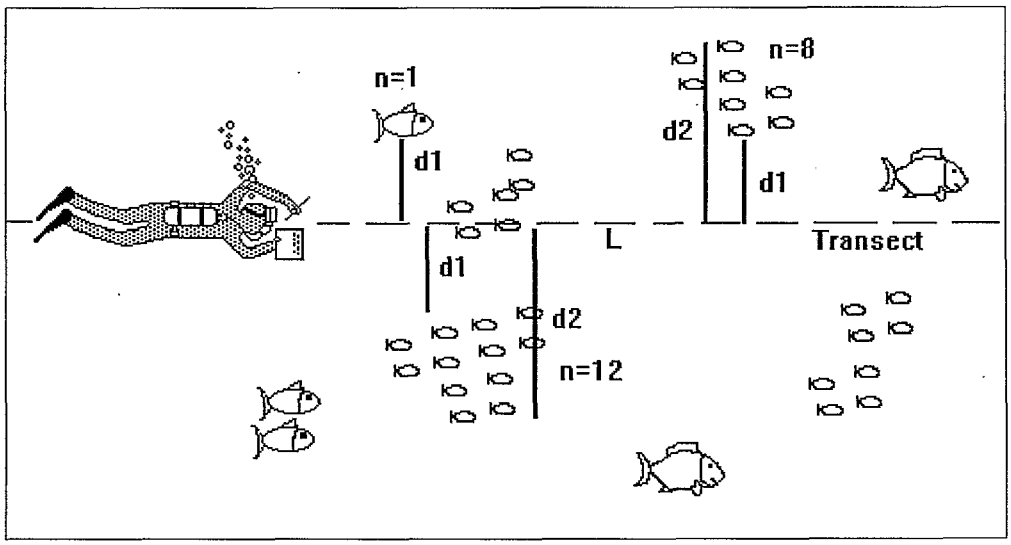

Figure 2: UVC (L = length of transect, d1 = distance from the fish to the transect, n = number of fish)

Fishing experiments using handlines

Handline fishing experiments were spread over the sea-floor, at depths of 3 to 20 m, near the barrier, fringing and middle reefs. Wherever possible, these fishing experiments took place on sites next to those sampled by diving, in order to be able to reveal any possible correlation between fishing and diving. In general, fishing experiments were carried out every 2 to 3 nautical miles.

At each site, there was a boat with two fishermen. Each of them had a hand-line rigged as shown in Figure 3; the line was baited with squid. Fishing began half an hour after the official sunset time and lasted two hours. Every half an hour, the boat was moved about 100 m around the station marker. This procedure made it possible to

Table 1: Granulometric scale used during surveys

Name	Description
Mud	Particles < 0.063 mm in size
Fine sand	Particles 0.063 to 0.25 mm in size
Coarse sand	Particles 0.25 mm to 2 mm in size
Gravel	Particles 2 mm to 1 cm in diameter
Debris	1 to 5 cm in diameter
Small blocks	5 to 30 cm in diameter
Big blocks	30 to 100 cm in diameter
Rock	Rock of organic or non-organic origin
Coral head	Coral head more than 1 m in diameter
Slab	Hardened horizontal layer

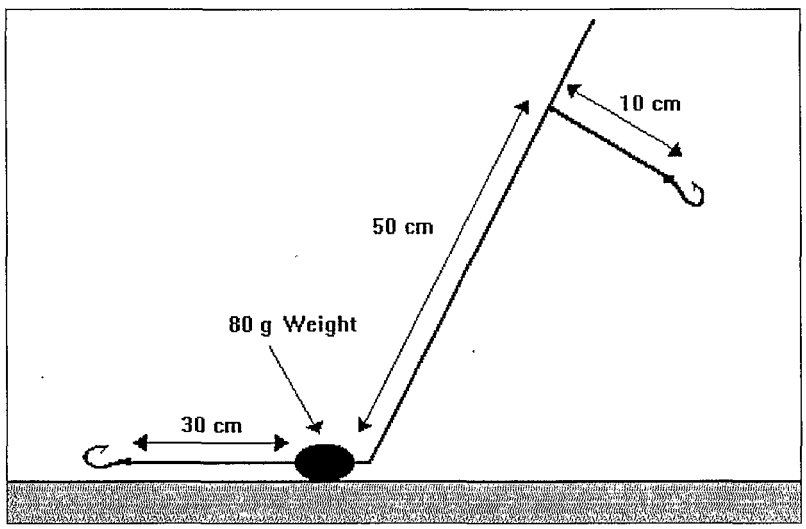

Figure 3: Handline rig for fishing experiments

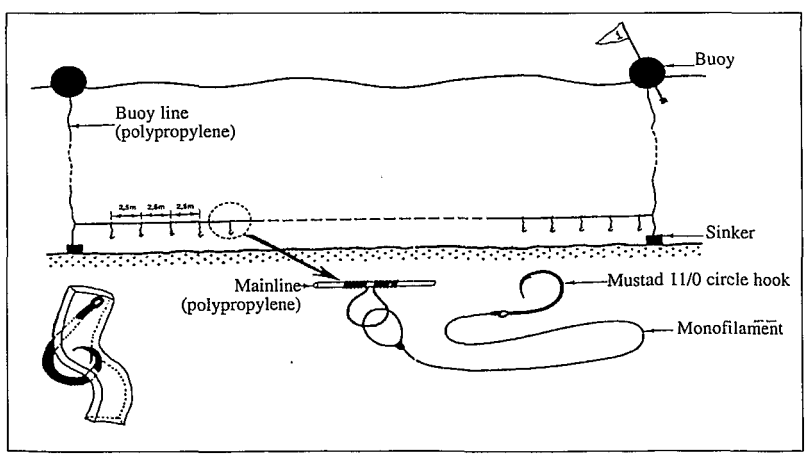

Figure 4: Longline rig for fishing experiments

limit the variability of results caused by the very heterogeneous nature of the surroundings.

Longline fishing experiments

These were spread over the lagoon floor using a sampling grid with a spacing of 3 nautical miles. About 30 visual censuses were carried out using longlines (transect length 250 m) according to the method described above, with only the carnivorous species being recorded.

A longline consists of a mainline made of polypropylene 250 m long. On this line, 100 snoods were spaced 2.5 m apart and equipped with a Mustad 11/0 circle hook baited with squid. Either end of the cord was weighted with ballast and attached to the surface buoy by a rope (Figure 4).

At each site, two longlines were set parallel (i.e. 200 hooks) with a spacing between the two longlines of about 80–100 m. Fishing lasted about two hours (not including setting and reeling in).

Fishing trials with gillnets

Gillnet fishing was carried out at the edges of the mangroves and estuary regions. Each site was sampled with two types of net (large and small mesh).

Each net was 50 m long and 1.5 m high. Mesh sizes were 47 mm (small) and 57 mm (large). At each site, 4 nets (a total of 200 linear metres) were set perpendicular to the edge of the mangrove or the coastline.

They were spaced every 100 m approximately, alternating small and large mesh sizes. They were set at high tide and caught fish at low tide for about four to six hours.

Population structure

The average density figures for fish from the coral reefs of the East Coast lagoon and the Belep Islands were equivalent and slightly higher than those from the West Coast (Table 2).

On the other hand, biomasses in the Belep area were among the highest recorded in the Indo-Pacific region. They were twice those on the East Coast and a third higher than those on the West Coast. This means that average specimen weights for fish in the East and West Coast lagoons were less than those in the Belep Islands, especially for long-lived species. In general, the biomass figures obtained were relatively high in comparison to data and literature (Table 2).

Study of the demographic structure shows that long-lived species accounted for a large proportion of total biomass, particularly in the Belep area. Analysis of size structures confirms the differences observed between the northern, eastern and western areas for these fish.

Given population characteristics, and negligible fishing pressure, stocks of bottom fish of commercial interest in the Belep zone could be considered untouched. By contrast, those in the East and West Coast lagoons show the characteristics of stocks under exploitation.

Table 2: Assessment of densities (spec/m²) and biomass (g/m²) for fish in some Indo-Pacific reefs. The figures concern all species, unless otherwise stated.

Location	Surroundings	Density	Biomass	Source
East Coast lagoon, Northern Province, New Caledonia	Barrier + fringing +middle	0.48 (1)	158 (1)	Letourneur et al., 1997
West Coast lagoon, Northern Province, New Caledonia	Barrier + fringing +middle	0.62 (1)	258 (1)	Labrosse et al., 1997
Northern lagoon, Northern Province, New Caledonia	Fringing +middle	0.54 (1)	339 (1)	Labrosse et al., 1996
Hawaii	Fringing	3.1	106	Brock et al., 1979
Hawaii	Coral heads	2.6	102	Wass, 1967
Chesterfield, New Caledonia	Fringing	2.0–3.2	37–43	Kulbicki et al., 1990
Australia	Fringing	7.0	92	Williams and Hatcher, 1983
Australia	Outer reef	3.2	156	Williams and Hatcher, 1983
Mayotte	Barrier reef	3.7	202 (1)	Letourneur, 1996
La Réunion Island	Coral slope	3.0	161	Letourneur, in prep.
La Réunion Island	Isolated coral	1.1	34	Letourneur, in prep.
New Caledonia	Barrier	3.4	244	Kulbicki et al., 1991
New Caledonia	Middle	3.4	301	Kulbicki et al., 1991
Aboré (Noumea), New Caledonia	Barrier	7.9	253	Kulbicki et al., 1995
Aboré (Noumea), New Caledonia	Barrier	0.7 (1)	182 (1)	Kulbicki et al., 1995
Ouvea, New Caledonia	Barrier	3.70	260	Kulbicki et al., 1994
Ouvea, New Caledonia	Barrier	0.5 (1)	187 (1)	Kulbicki et al., 1994

(1) commercial species only

Yields for the fishing trials carried out on other biotopes corroborate these results (Tables 3 and 4). In the Belep Islands, the figures observed for handline fishing were among the highest in the Indo-Pacific region, while those from East and West Coast lagoons were comparable with those from areas under exploitation.

Status of total stock

Total stock was estimated at 138 000 tonnes of commercial bottom-dwelling fish over all the biotopes studied, except for the estuaries and mangroves for which an estimate was not possible. It is interesting to note that half of this total stock is located in the Belep Islands region (Figure 5).

The rest is divided between the East and West Coasts. In general, a little less than half of the total stock is located on the reefs (principally on the barrier reefs), with the other half on the lagoon floor (Figure 5). This latter part is difficult to exploit and can be considered as a biomass reserve for the resource, especially for lethrinidae (emperors and breams).

More than two-thirds of the total stock (about 70 per cent) is formed of six families of fish which can be classified into two groups.

'Line-caught fish' included the Serranidae (cod and trout), Lutjanidae (snapper) and the Lethrinidae (emperor and bream) which made up slightly less than 50 per cent of the total stock. About half of this group was located on the lagoon floor.

Where 'browsing fish' are concerned, the Acanthuridae (clown fish), Scaridae (parrot fish) and the Siganidae (rabbit fish) make up about 25 per cent of the total stock.

They were almost always concentrated on the coral reef where they made up 75 per cent of the commercial fish resource.

Table 3: Yields observed for handline fishing in the tropical reef setting (yields are shown in kg/hour/fishermen)

Location	Yields	Source
East Coast lagoon, Northern Province	1.70	Letourneur et al., 1997
West Coast lagoon, Northern Province	1.55	Labrosse et al., 1996
Northern lagoon, Northern Province	6.80	Labrosse et al., 1996
Ouvea	6.90	Kulbicki et al., 1994
South West lagoon, New Caledonia	10.00	Loubens, 1978
South West lagoon, New Caledonia	2.60	Kulbicki et al., 1987
Chuuk	2.30	Diplock and Dalzell, 1991
Guam (lagoon)	0.90	Hosmer and Kami, 1980
Guam (lagoon)	1.50	Molina, 1982
Nauru	5.80	Dalzell, unpublished
Norfolk	13.60	Grant, 1981
Palau (reef)	3.49	Anon, 1990, 1991
PNG (exploited lagoon)	1.20	Wright & Richard, 1985
PNG (untouched lagoon)	3.90	Wright & Richard, 1985
PNG (Port Moresby)	2.50	Lock, 1986
Samoa (lagoon)	0.90	Wass, 1982
Yap	1.70	Anon., 1987
North West Australia	15.60	Stehouwer, 1981
American Samoa	0.54	Sauceman, 1994
Tuvalu (Funafuti)	2.35	Patiale and Dalzell, 1990
Wallis	1.30	Taumaia and Cusack, 1988
Tonga	0.44	Munro, 1990
Guam	0.55	Katnick, 1982
Caribbean (10 to 20 m)	1.70	Munro, 1983
Caribbean (20 to 30 m)	1.60	Munro, 1983
Caribbean (30 to 40 m)	2.60	Munro, 1983
Caribbean (40 to 60 m)	1.10	Munro, 1983

Table 4: Yields observed from longline fishing in tropical areas. Yields are shown in kg/100 hooks.

Location	Depth and type of zone	Average weight (kg)	Yield (kg/100 hooks)	Source
East Coast lagoon, Northern Province	20–50 m, lagoon floor	1.6	9.80	Letourneur et al., 1997
West Coast lagoon, Northern Province	20–40 m, lagoon floor	2.1	8.80	Labrosse et al., 1997
South West lagoon, New Caledonia	5–70 m, lagoon floor	1.6	7.50	Kulbicki et al., 1987
Maldives, Shaviyani Atoll	Atoll	–	16.70	Anderson et al., 1991
Maldives, Alifu Atoll	Atoll	–	24.00	Anderson et al., 1991
Maldives, Laamu Atoll	Atoll	–	9.80	Anderson et al., 1991
Maldives, N. Malé	Atoll	–	20.00	Anderson et al., 1991
Sri Lanka	10–180 m, reef flat	2.6	5.90	Anon., 1982
Vanuatu	120–440 m, outer reef slope	3.9	39.50	Brouard and Grandperrin, 1984
Kenya	200 m, continental shelf	–	23.00	Anon., 1979
Caribbean	32–450 m, fringing reefs	2.2	8.30	Kawaguchi, 1974
Caribbean (commercial trial)	30–300 m, fringing reefs	–	3.00	Kawaguchi, 1974
Guyana and Surinam	160–400 m, continental shelf	6.0	22.70	Wolf and Ratjen, 1974
Gulf of Mexico	50–550 m, continental reef flat	–	15.00	Nelson and Carpentier, 1968
New Caledonia	100–500 m, outer reef slope	–	24.00	Grandperrin, pers. Comm.
Hawaii	200–500 m, seamounts	4.5	30.30	Anon., 1984

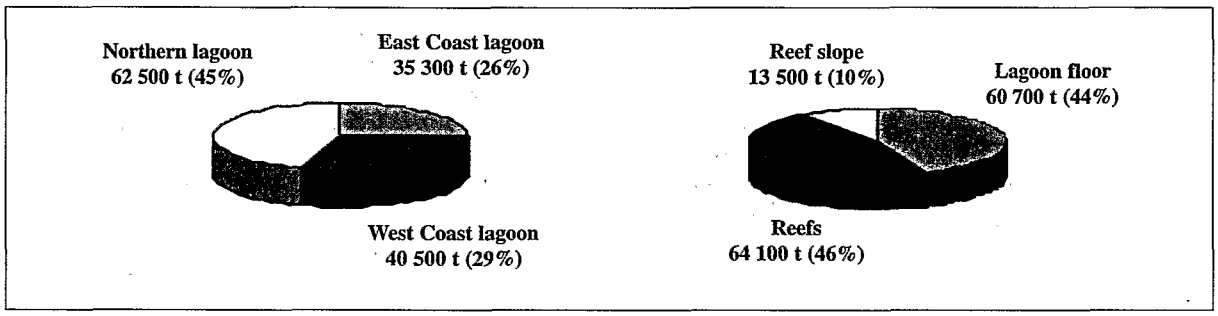

Figure 5: Distribution of total stocks by geographical area and biotope. Stock figures are given in metric tonnes.

Fishing pressure and exploitable stocks

Assessment of the quantity of fish which can be exploited without danger to the resources and the lagoons of the East and West Coast must include fishing mortality, in contrast with the Belep Islands where the stocks are considered untouched. At the beginning of the study, the only data about lagoon fishing related solely to the activities of a few commercial fishermen. Subsistence fishing catches had never been calculated.

On the basis of statements by commercial fishermen, and subsistence quantities estimated from a study of household consumption budgets carried out by the ITSEE (Institute of Statistics and Economic Research) in 1991 (28.6 kg/inhabitant in the Northern Province), fishing pressure was assessed in the various areas and geographical sectors studied (Labrosse et al., 1996).

In 1996, catch amounts in the Northern Province were estimated at 1 330 t. It is important to note that subsistence fishing accounts for 90% of this total (Figure 6), i.e. almost all catches. It is higher on the East Coast. The foreseeable growth of the amount of fish caught seems, for the moment, to be mainly determined by subsistence fishing, and consequently, by the demography of the fish populations.

Catches in the Belep Islands represent 0.003% of the total estimated stock in this area. The same calculations made for the West and East Coasts yield figures of 0.3 and 0.1% respectively, that is to say 100 and 300 times higher than in the Northern area. These exploitation percentages for the resource remain low overall.

A significant relationship between total stocks and fishing pressure, as estimated in the various Northern Province locations, shows that catches are higher in certain habitats and for certain species.

Therefore, on the East and West Coasts, handlined fish are sub-

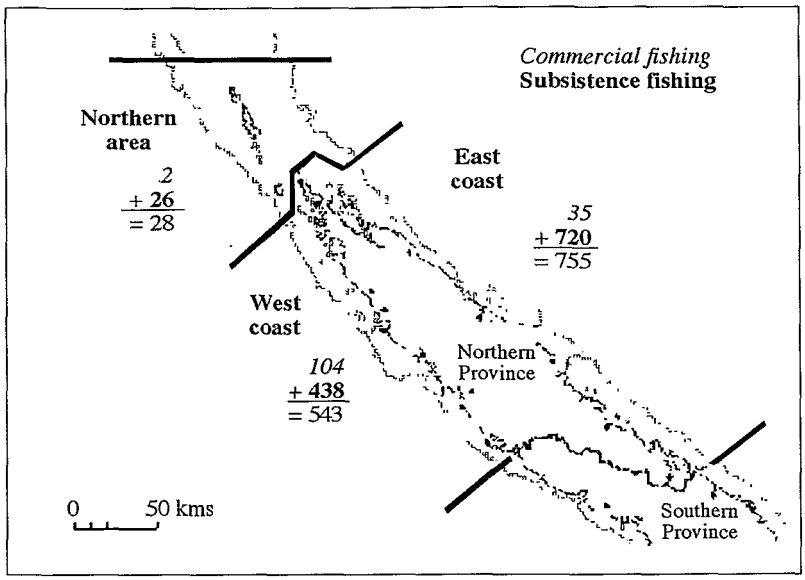

Figure 6: Distribution of commercial and subsistence fishing catches in the Northern Province in the various zones studied in 1996. Catch figures are given in metric tonnes.

ject to higher fishing pressure which mainly occurs on and around the reefs.

All of these results confirm that fishing has an effect on the populations of the West and East Coasts.

Fishing pressure and the biological characteristics of each species (e.g. growth, mortality) have made it possible to estimate than 13 000 t per annum could currently be caught without endangering the resources in all of the lagoons in the Northern Province, i.e. about 10% of the total stock. These resources mainly consist of, in order of importance, Lethrinidae (emperors and breams), Acanthuridae (clown fish), Scaridae (parrot fish), Serranidae (cods), Lutjanidae (snappers), and Siganidae (rabbit fish). For each one of these families, the maximum sustained catch also represents about 10% of the estimated total stock.

When considering overall fishing pressure, stocks seem far from being threatened, and it is possible to significantly increase fishing effort. However, it must be considered that, on a smaller geographical scale, some specific reef habitats and geographical locations (Figure 7) already sustain a significant amount of fishing activity.

In some cases, the exploitation limit seems to have already been reached, and even exceeded, as in Koné (Figure 5). However, it must be understood that fishing pressure takes into

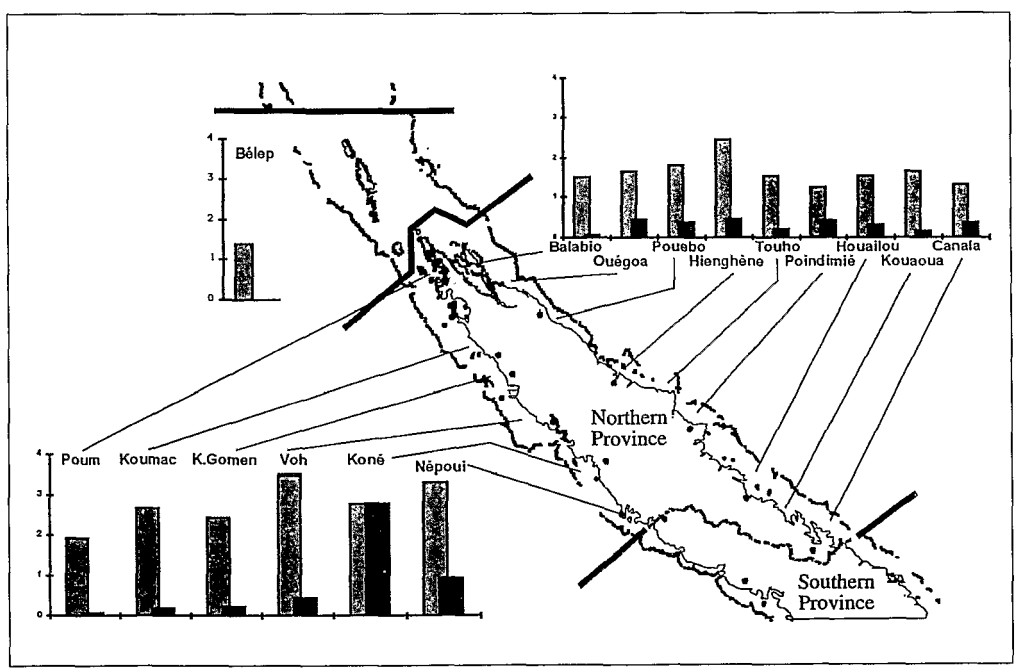

Figure 7: Comparison of fishing pressure and exploitable stocks in 1996 in the various geographical locations studied. Fishing pressure (in dark grey) and exploitable stocks (in light grey) are given in metric tonnes per km².

account all species, including those from estuaries and mangroves, which have not been subject to a stock assessment.

Recommendations and prospects

Some recommendations can be made, based on the data collected in this study. They also take into consideration projections that fishing pressure in the lagoon will double over the next ten years in the Northern Province. They target sustainable management of this resource, whose importance is vital for the people of the Northern Province.

Firstly, the system for assessing fishing activities in the Northern Province should be modified. Until now, it has only been based on the declarations made by local commercial fishermen, whose activity remains marginal. This is likely to have led to an under-assessment of catches for this activity. This assessment needs to be made more precise. Also, given their demonstrated importance, subsistence fishing catches must be assessed.

Secondly, the study which has just been completed is in some ways 'a snapshot' of the population of fish at a given moment in time. A plan to monitor the stock over time needs to be made, especially in areas most sensitive to fishing pressure, in order to study longer-term trends.

A joint analysis of fishing pressure and standing stocks would allow monitoring of exploitation levels of populations and their probable impacts on the resource. This should help prepare for the possible implementation of management measures aimed at preservation of the resource, especially if new fisheries are to be started.

From now on, it would seem advisable to re-direct part of the fishing effort towards groups of species (rabbit fish, parrot fish, etc.) and biotopes (lagoon floors especially) which are less exploited. This could be done by using different fishing techniques (fish corrals, traps). Also, this would allow lagoon fisheries to expand into new potential markets, such as those for live fish and aquarium species.

These additional aspects are part of a supplementary study which began in October 1997 and will last six months. It is principally designed to define and implement monitoring methods for fishing pressure and populations, and transfer these methods to the Province's technical services.

To help with this supplementary study, a survey of fish consumption is being carried out and will be repeated at regular intervals. It will record the amounts and main species caught for subsistence fishing. It will also contribute to clarifying exploitable stock figures. In addition, fishermen's landed catches will be recorded on a routine basis, in order to determine the quantities and qualities of fish caught.

The planned population monitoring work only concerns those coral reefs (barrier, middle and fringing) which are the most subject and sensitive to exploitation. In order to be able to make comparisons with the sites already surveyed, a single sampling method has been chosen.

This involves UVC work through diving using the transect method, which has the advantage of being a proven technique. This will make it possible to quantify the changes in populations and correlate these data with fishing pressure. It will be carried out once a year in four geographic sectors, Koumac and Koné on the West Coast, Hienghène and Poindimié on the East Coast.

Finally, diversification of fishing techniques will be investigated, to see if they are technically and economically viable.

At the end of the study, the Northern Province will have the basic skills and information needed to formulate and implement a policy for the sustainable and balanced development of lagoon fishing resources and their exploitation.

The diversity of lagoon environments and the species that live there, and the local socio-economic characteristics of the people (especially social structure), justify the identification of homogenous units (such as villages, districts, communes).

Inhabitants of these units will be educated about taking responsibility for the management of their own units. On the basis of biological, ecological and technical data from current and future work, fishery officers will be able to guide them more efficiently in the research of rational solutions appropriate to their environmental context.

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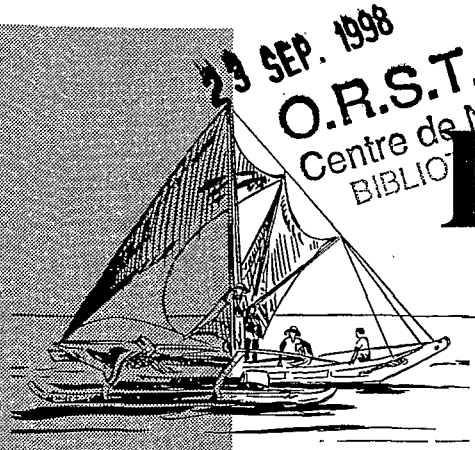

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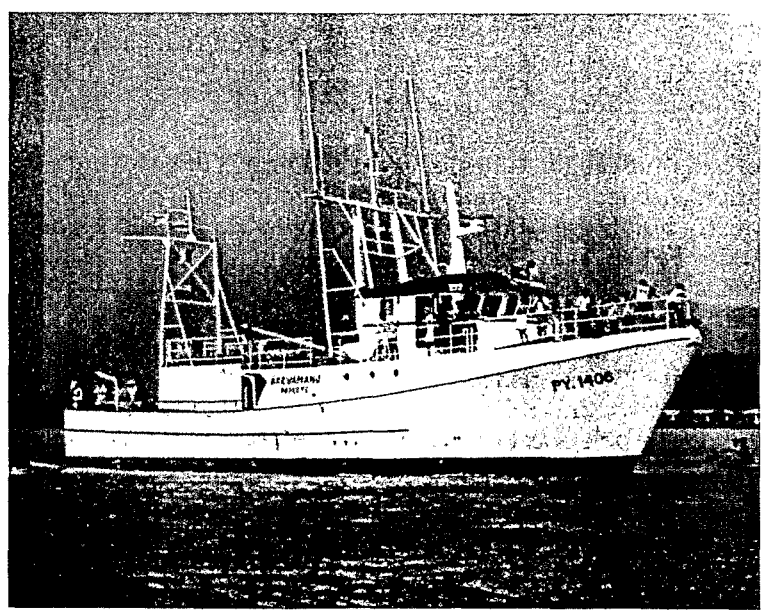

Masterfisherman Steve Beverly spent two weeks in April fishing aboard the 26 m longline vessel, F/V *Arevamanu*.

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