Proceedings of the 6th International Coral Reef Symposium, Australia, 1988, Vol. 2

CORRELATION BETWEEN CATCH DATA FROM BOTTOM LONGLINES AND FISH CENSURES IN THE SW LAGOON OF NEW CALEDONIA

M. KULBICKI

Department of Oceanography ORSTOM
BP. A5 Nouméa New Caledonia

ABSTRACT

On a total of 363 bottom longline sets in the SW lagoon of New Caledonia, 45 were surveyed using visual census. Abundance and biomass estimates were derived from these censuses. These estimates were highly correlated to catch per unit effort in numbers and weight. From these relationships were established contour maps of soft bottom fish abundance and biomass. The total biomass of longline catchable fish was estimated between 11800 and 25500 tons with an average of 17700 tons which represents 5.8 tons/km2. It was also estimated that longline catchable fish represented 48 % of the total fish biomass of soft bottoms. Comparisons with other soft bottom fisheries in the region are presented.

INTRODUCTION

The study of coralline fishes is often limited to strictly coralline zones. In most places of the Pacific region a large number of coralline species are found on a variety of habitats, in particular over "soft bottoms" which may represent a very large surface. For instance, nearly 80 % of the S.W. lagoon of New Caledonia is covered by such soft bottoms.

These surfaces are very variable in nature, but they usually support some coralline formations that preclude the use of trawl nets. In most instances the only convenient methods of fishing are by traps or hook and line, either by handline or by longline. The latter method proved to be easier to standardize and comparison of catch with densities are straightforward when using visual censuses.

Underwater surveys of longlines or handlines has been undertaken by a number of authors(High, 1980; Grimes et al., 1982; Ralston et al., 1986; Richards & Schnute, 1986). The two latter related CPUE to densities derived from visual censuses, indicating that in most instances they are proportional. However, no attempt was made to evaluate the biomass of a given area from the CPUE-visual densities relationships.

METHODS

1-VISUAL CENSUSES :

As the longline was set, two divers would take position at the start of the line and wait for the line to lie on the ground. Each diver recorded fish on one side of the line. Only species susceptible of biting on the line were counted. This species list was derived from 220 previous longline sets. Fish size was estimated by 5 cm classes, the accuracy of these visual evaluations being checked on the fish caught on the line. The perpendicular distance of the fish to the line was estimated in meters, fish being recorded at a maximum distance of 15m. In case of several fish seen simultaneously at different distances the nearest and furthest distance were recorded. Fish already caught on the line were not taken into account.

2-BOTTOM LONGLINE :

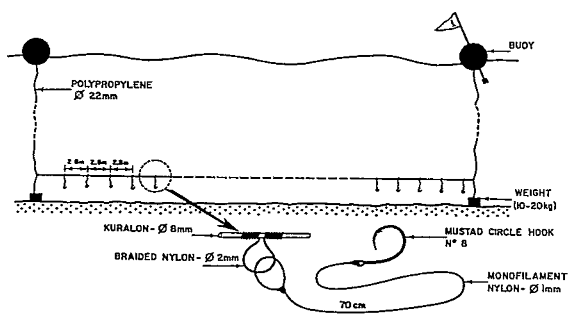


Figure 1. Longline diagramm.

The gear in use is illustrated on figure 1. Each line was 280m long and had 100 hooks. Circular hooks MUSTAD* 3997L (n°7 to 9) or MUSTAD* (n° 8 or 9) were used instead of "straight" hooks, because of their higher yield (Gibson, 1979; ANON., 1982; ANON., 1984a, 1984b). According to Ralston (1982) a 30 % difference in hook size does not induce marked difference in catch. The largest size difference in our experiment did not exceed 18 %.

Hooks were baited with cut pieces of squid (*Notodarious sloanii*). Soaking time was one hour. Species, size and position on the line was recorded for each fish caught.

RESULTS

1-BOTTOM LONGLINE :

1.1-Sampling strategy :

A total of 363 sets were laid which amounts to 41600 hooks. Figure 2 indicates the position of these sets in the S.W. lagoon. There are two sets for every position except for the first 86 sets. The maximum distance between two setting positions does not exceed 3 nautical miles.

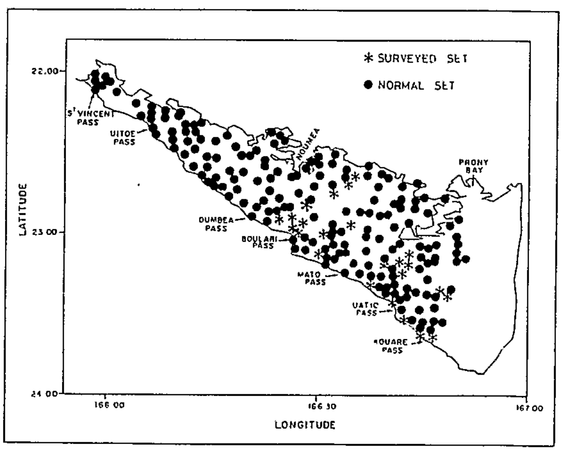


Figure 2. Position of the longline sets.

ORSTOM Fonds Documentaire
N° : 31222, ex1
Cote : B
27 JANV. 1991

Forty five sets were surveyed. This represents 4977 hooks, or 12 % of the total number of hooks. Due to poor visibility it was not possible to survey sets nearshore. Diving time being limited, only one set was surveyed below 30m. The position of the surveyed sets are indicated on figure 2.

1.2-Species composition :

Table 1 indicates the species caught during all sets and those caught or seen on the surveyed longline sets. A total of 78 species were caught on all sets of which 31 were present on more than 10 sets (these are referred as "common" species). Thirty five species were taken on the surveyed set of which 26 were common species (80 % of total common species).

1.3-Size and yields :

The average size of fish on all sets and surveyed sets are identical with the exception of three species : Cephalopholis sonnerati and Gymnocranius robertsi which were larger on the selected sets and Echeneis naucrates which was smaller. The average yields are a little higher on the surveyed sets (10.9 kg/100 hooks) than on all sets (7.3 kg/100 hooks) because nearshore sets, which have lower yields, could not be surveyed due to poor visibility.

2-VISUAL CENSUSES :

2.1-Species composition :

A total of 42 species were seen along the longlines (table 1). Only two common species, Saurida undosquamis and Nemipterus peroni were not recorded during these dives. Both of these species are mainly found nearshore in turbid waters. Most families are well represented in the visual censuses except sharks and trevallies. Identification of most species was accurate, only the Gymnocranius spp. and murray eels could not be identified at the species level. Only two of the species caught on the surveyed lines were not observed during the visual censuses.

2.2-Size :

The size of the fish underwater was estimated by eye. The divers performing the counts are well trained in this excercise and the error can be assumed to be of 10-20 % depending on fish size and species (ANON., 1985; Harmelin-Vivien et al., 1985). Average weights were computed from lengthweight relationships.

The estimated size of fish observed by visual census was usually inferior to the fish size in the catch (table 1). This is due to the selectivity of the gear, the hooks being rather large. One should also take into account that the size of large fish tend to be under-estimated by visual censuses (Harmelin-Vivien et al., 1985).

2.3-Distance to the line :

Most underwater censuses using transects do not take into account the distance of the fish to the transect line (Thresher & Gunn, 1986). It is usually assumed that all fish within a given distance to the line (usually 5m) are detected (Harmelin-Vivien et al., 1985). If fish were distributed at random and not affected by either

Table 1. Species composition of catch and visual survey. nb: numbers w: weight (kg) *: species caught on 10 sets or more.

species		all sets		surveyed sets		transets	
		nb	W	nb	W	nb	W
SERRANIDS							
cephalopholis miniatus	•	13	910	-	-	14	400
sonnerati	•	38	1000	3	1540	18	1800
vrodelus		4	135	-	-	-	-
boenack		4	60	2	75	2	150
spiloperca		1	80	1	80	-	-
epinephelus aerolatus	•	72	496	6	520	30	450
cylindricus		4	10980	-	-	4	10000
fasciatus	•	29	270	8	250	46	250
hexagonatus		4	150	-	-	4	100
cyanopodus	•	31	2780	5	2620	33	2100
maculatus	•	145	1070	26	1160	95	600
merra		2	125	1	70	2	80
microdon	•	20	1670	2	1625	1	1400
rivulatus	•	85	430	18	420	18	250
summana		3	400	-	-	-	-
howlandi		7	720	-	-	-	-
malabaricus		3	4830	-	-	-	-
plectopomus leopardus	•	24	2360	2	900	28	1500
variola louti	•	15	2780	2	2150	6	2000
pogonoperca punctata		1	500	-	-	-	-
LUTJANIDS							
lutjanus adetii	•	39	860	4	780	23	900
bohar	•	15	3270	-	-	2	3000
fulviflamma		2	250	-	-	-	-
gibbus		1	420	-	-	-	-
kasmira		1	100	1	100	64	150
sebae		3	6970	-	-	-	-
vitta	•	20	400	-	-	5	600
symphorus nematophorus	•	13	7940	2	5550	4	6700
aprion virescens	•	14	6420	-	-	33	3000
LETHRINIDS							
lethrinus chrysostomus	•	24	1300	1	2200	2	400
lentjan		4	910	-	-	-	-
mahsena	•	83	810	22	770	1	900
miniatus nebulosus	•	256	2350	48	2400	18	1800
rubrioperculatus	•	96	630	18	620	8	750
nemathacanthus	•	11	110	1	80	35	50
gymnocranius robertsi	•	39	2380	16	1680	23	900
japonicus	•	117	1150	46	1000	128	1000
lethrinoides	•	28	1330	24	1380		
NEMIPTERIDS							
nemipterus peroni	•	70	220	6	250		
HAEMULIDS							
diagramma pictum	•	66	3100	19	3130	104	1700
LABRIDS							
bodianus perditio	•	208	1910	57	1870	81	1500
loxozomus		1	700	1	700	5	500
cheilinus chlorovrus		3	480	1	450	6	300
undulatus		5	5920	-	-	1	10000
SYNODONTIDS							
saurida undosquamis	•	84	150	-	-	-	-
TREVALLIES							
caranx sp.		1	1100	-	-	3	500
celetus		2	2425	-	-	-	-
carangoides chrysophrys		7	2270	-	-	-	-
gymnostellus		1	2200	-	-	-	-
orthogrammus		22	590	-	-	-	-
emburyi		1	7700	-	-	2	5000
fulvoguttatus		2	2430	-	-	-	-
gnathanodon speciosus		3	5770	-	-	-	-
seriola aureovittata		2	1450	-	-	-	-
rivoliana		2	500	-	-	-	-
decapterus russeli		2	230	-	-	-	-
MULLIDS							
parupeneus pleurospilos		1	230	-	-	-	-
TRIGGEFISH							
balistes fraenatus	•	17	700	3	870	41	500
fuscus	•	14	2740	3	3670	15	2500
stellatus	•	19	1840	1	1500	3	1400
MURRAY EELS							
gymnothorax sp.		15	150	1	190	6	500
javanicus		1	500	-	-	-	-
xanthostoma		1	800	-	-	-	-
flavimarginatus		1	300	-	-	-	-
TETRODONTIDAE							
gastrophysus sceleratus	•	22	2860	1	5000	1	1800
diodon histrix		11	870	-	-	2	600
ECHENEIDS							
echeneis naucrates	•	110	950	17	710	15	400
RAYS							
dashyatis kuhlii		2	2050	-	-	6	1500
SHARKS							
sphyrna lewini		2	1240	-	-	-	-
carcharinus melanopterus		5	2140	-	-	-	-
amblyrhynchos		7	3460	1	3000	-	-
plumbeus		1	15000	-	-	-	-
limbatus		1	3300	-	-	-	-
albimarginatus		3	4030	-	-	-	-
trianodon obesus		1	10000	-	-	-	-
galeocerdo cuvieri		1	1820	-	-	-	-
stegostoma varium		1	20000	-	-	-	-
total number of species		78		35		42	

line or divers one would expect a distribution pattern as indicates figure 3 (Burnham et al., 1980). Our data (figure 3) suggest that one can not assume such a random distribution. There is at first a "heaping" phenomenum which is fairly common to transect data (Burnham et al., 1980), certain distances being preferentially recorded. Grouping the data smooths such bias. Most fish tend to avoid either the line or the divers as indicates the depressed distribution at distance 0. This phenomenum varies with species and with size. Thus, small fish are seen at closer distances and large fish tend to be more shy and stay further away from the divers. Figure 4 indicates a number of different types of distance distributions. These illustrate the bias that would be introduced by using fixed width transect counts.

2.4-Density estimates :

Knowing the distance distribution of species i to the line, it is possible, using FOURRIER series (Burnham et al., 1978), to calculate $f(\hat{o})i$, which is the estimate of the probability density function at distance zero. This estimate is needed for the calculation of the density $\hat{D}i$ of species i along the longline, using the following equation :

$$\hat{D}i = ni * f(\hat{o})i/2L \qquad (1)$$

where ni : number of fish of species i seen along the line

L : length of the line

The $f(\hat{o})$ estimates were calculated from the pooled data of all 45 surveys. When there was insufficient data for a given species, the $f(\hat{o})$ estimate of its family or the overall $f(\hat{o})$ estimate was attributed. These estimates are indicated on table 2.

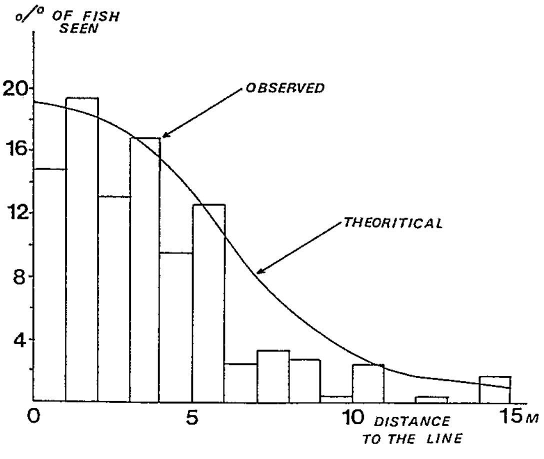


Figure 3. Theoretical and observed distribution of the distance of the fish to the longline.

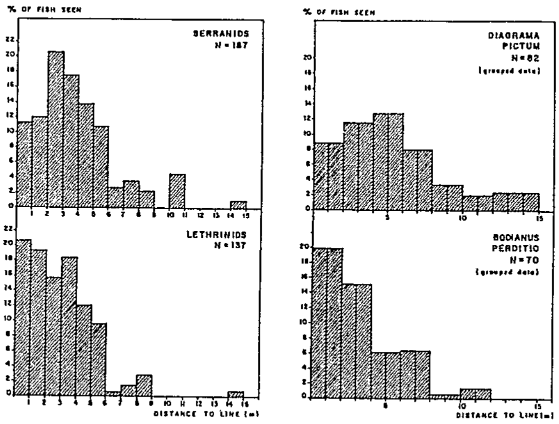


Figure 4. Observed distance distribution for Serranids, Lethrinids, Diagramma pictum and Bodianus perditio.

The total density along a longline is given by the summ of the $\hat{D}i$:

$$\hat{D} = \sum_{i=1}^{k} \hat{D}i \qquad (2)$$

where k : number of species seen along the line. Knowing the variance of $f(\hat{o})$ it is possible to calculate the variance of $\hat{D}i$. The total variance for $\hat{D}$ was estimated as the weighted summ of the variances of the $\hat{D}i$:

$$\mathrm{var}\,(\hat{D}) = \left(\sum_{i=1}^{k} ni * \mathrm{var}(\hat{D}i)\right) / \left(\sum_{i=1}^{k} ni\right) \qquad (3)$$

This estimate is biased because the variances of the $\hat{D}i$ are not independent. This will result in a conservative value of var $(\hat{D})$.

The biomass density estimate for species i along a longline is calculated from :

$$\hat{B}i = \hat{D}i * \hat{w}i \qquad (4)$$

where $\hat{w}i$: average weight of species i along the line.

Table 2. Probability density function estimates at distance 0 for species observed along longline sets.

species	f (0)	var (f 0)) x 10^{-3}
ALL SERRANIDS	0.1403	0.6043
cephalopholis spp.	0.1284	0.8121
epinephelus aerolatus	0.2840	1.756
fasciatus	0.1678	0.1594
maculatus	0.1944	0.2551
plectropomus leopardus	0.1493	0.4315
ALL LUTJANIDS	0.1740	1.451
LETHRINUS SPP.	0.2995	3.898
GYMNOCRANIUS SPP.	0.3663	2.855
DIAGRAMMA PICTUM	0.1403	0.1041
ALL LABRIDS	0.2551	0.9146
ALL TRIGGERFISH	0.1781	0.6043
ALL OTHER FISH	0.2249	0.1727

The value of $\hat{w}i$ is evaluated from the visual length estimate. The variance of $\hat{B}i$ was estimated from :

$$var(\hat{B}i) = \hat{w}i \bullet var(\hat{D}i) \qquad (5)$$

and for $\hat{B}$ we have :

$$var(\hat{B}) = (\sum_{i=1}^{k} ni \bullet var(\hat{B}i))/(\sum_{i=1}^{k} ni)$$

2.5-Correlation between density estimates and CPUE

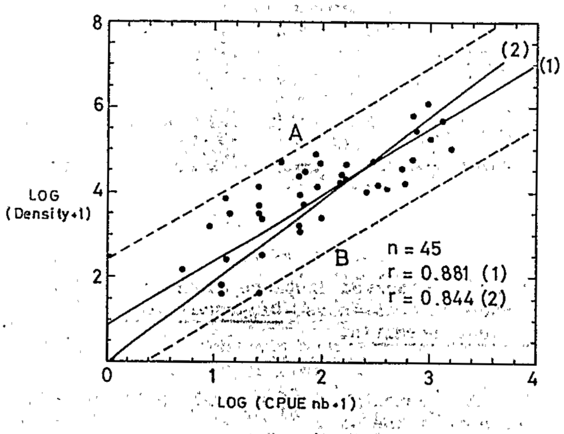


Figure 5. Relationship between density estimates and CPUE in numbers.
(1) : normal regression (2) : regression through origin. line A & B indicate the 95 % confidence intervals on (1).

Density estimates and CPUE by numbers were best correlated after a log-log transformation (figure 5). From previous work (Kulbicki et al., 1987) it was demonstrated that depth and distance to the coast were the most important factors affecting CPUE. These variables were added to the previous model, but their contribution being of respectively 3 % and 1 % of the fit, they were not kept. In order to make predictions on densities from catch data it was necessary to have a model that went through the origin.

The intercept not being significantly different from 0 ($\alpha = 0.05$) (figure 5) such a model was conceivable (equation 6) :

$$Log(\hat{D} + 1) = A \bullet Log(CPUE + 1) \qquad (6)$$

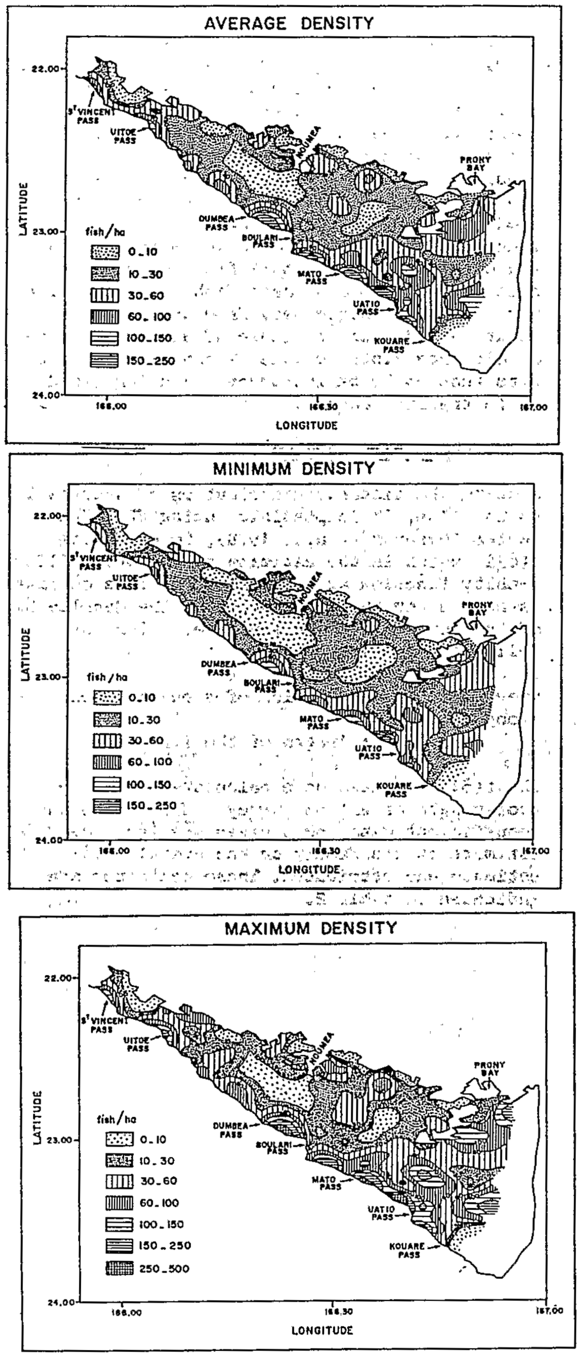
This regression through the origin resulted in a drop in the correlation coefficient from r = 0.881 to r = 0.844. From this relationship it was possible to estimate densities from the CPUE data for each 363 sets. The resulting densities were contoured on a map (figure 6a). In order to have a confidence interval on these density estimates two other values of $\hat{D}$ were used :

$$\hat{D}min = \hat{D} - t(\alpha = 0.05, n - 2) \bullet s\hat{D}$$
$$\hat{D}max = \hat{D} + t(\alpha = 0.05, n - 2) \bullet s\hat{D}$$

where $s\hat{D}$: standard error of $\hat{D}$
n : number of species used to calculate $\hat{D}$.

This allowed to calculate a minimum and a maximum regression between density and CPUE by numbers (Table 2). These relationships permitted the contouring of minimum and maximum density maps (figure 6b & 6c). These results are more conservative than if one had used the minimum and maximum values of A (equation 6) :

$$Amin = A - t(\ = 0.05, n - 2) \bullet sA$$
$$Amax = A - t(\ = 0;05, n - 2) * sA$$



Figures 6 a, b, c. Maps indicating the density of catchable bottom longline fish in the SW lagoon of New Caledonia.

2.6-Correlations between biomass density estimates and CPUE

Biomass density estimates and CPUE by weight were best correlated after a log-log transformation. Figure 7 and table 2 indicate a high correlation between these two variables. Using these relationships it was possible to draw the maps illustrated by figures 8a, 8b and 8c. An evaluation of the standing stock (table 3) was then calculted as follow from figure 12a :

$$S = \Sigma \hat{B}i \bullet ai$$

where $\hat{B}i$: mean value of the biomass density for the strata i

ai : surface of strata i (km2)

Similar calculations from figures 8b and 8c resulted in a minimum and maximum value of the standing stock (table 3). These values are only indicative, since we have sofar no method to estimate the type I error (α) level for S, but they are likely to be conservative.

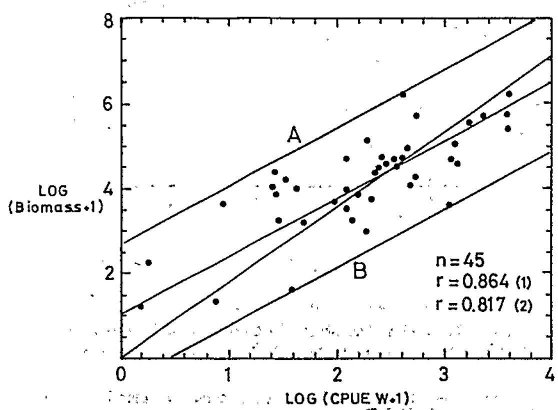


Figure 7. Relationship between biomass density estimates and CPUE by weight (1) normal regression (2) regression through the origin - lines A & B indicate the 95 % confidence interval for (1).

DISCUSSION

To our knowledge this is the first work correlating catch data from bottom longlines to visual census data in tropical waters. One of the advantages of the present method is that censusing and fishing were conducted at the same time and the same place, which was not the case with two other similar surveys (Ralston et al., 1986; Richards & Schnute, 1986). Preliminary analysis of our catch data (Kulbicki et al., 1987) indicates that there is little variation in CPUE with time of day.

Table 3. Relationships between average, minimum and maximum estimates of density or biomass and CPUE in numbers or weight.

1st variable (Y)	2nd variable (X)	equation	N	a	b	r
density	c.p.u.e in numbers	LogY = aLogX + b	45	0.88	1.54	0.881
density	c.p.u.e in numbers	LogY = aLogX	45	1.94	-	0.844
minimum density	c.p.u.e in numbers	LogY = aLogX	45	1.75	-	0.867
maximum density	c.p.u.e in numbers	LogY = aLogX	45	2.07	-	0.765
biomass density	c.p.u.e in weight	LogY = aLogX + b	45	1.04	1.37	0.864
biomass density	c.p.u.e in weight	LogY = aLogX	45	1.78	-	0.817
minimum biomass d.	c.p.u.e in weight	LogY = aLogX	45	1.61	-	0.851
maximum biomass d.	c.p.u.e in weight	LogY = aLogX	45	1.89	-	0.745

Our bottom longline is characterized by the large number of species caught. Each species has a particular behaviour towards the line and the divers. Richards and Schnute (1986) have presented a number of possible relationships between CPUE from handlining and visual census depending on species and densities. Most often the number

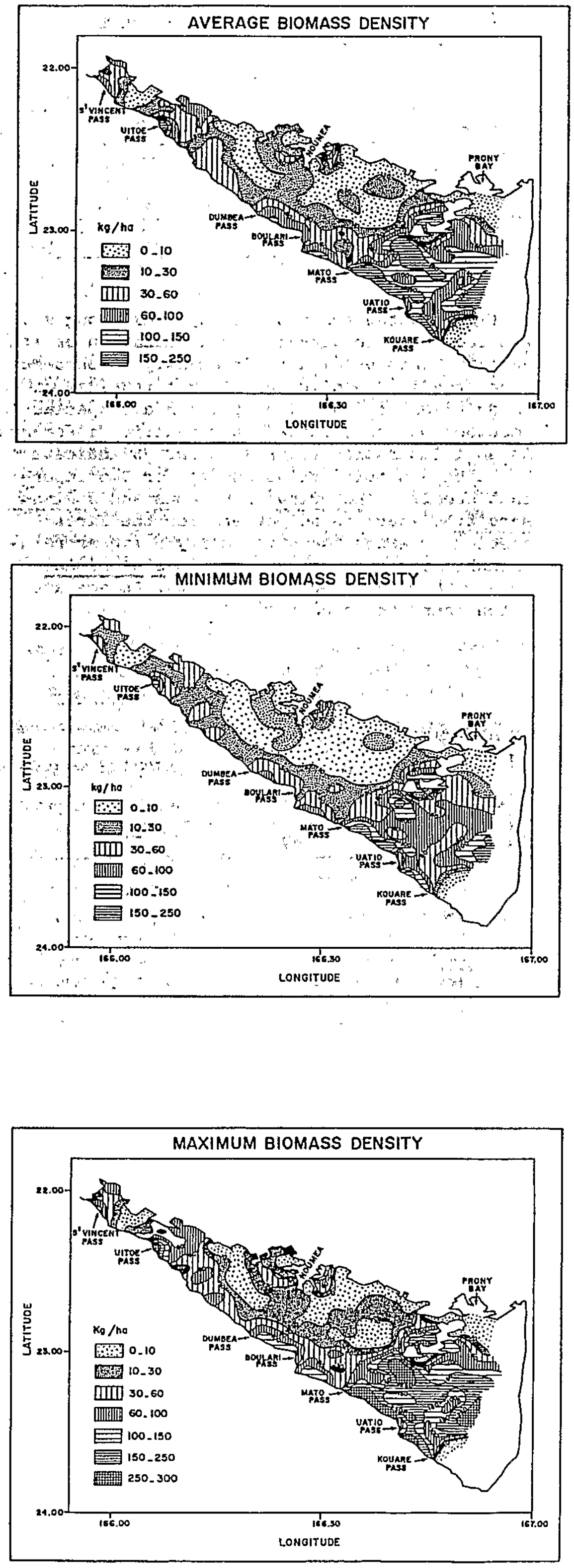


Figure 8 a, b, c. Maps indicating the biomass density distribution of catchable bottom longline fish in the SW lagoon.

Table 4. Data used to estimate standing stocks from biomass density maps.

biomass map		biomass density (t/km^2) 0-1	1-3	3-6	6-10	10-15	15-25	25-50	TOTAL
minimum	area (km^2)	1042	857	621	435	147	72	-	3180
	tons	521	1715	2794	3485	1844	1441	-	11800
average	area	785	751	556	484	367	240	-	3180
	tons	393	1502	2500	3869	4588	4900	-	17750
maximum	area	696	665	466	412	271	357	199	3180
	tons	364	1392	2192	3430	3516	7134	7460	25490

of fish counted for a single species along a line was too small to warrant the calculation of its density. This problem is frequently encountered when studying carnivorous fish in tropical waters using visual censuses. By pooling all species one smoothes out some large interspecific differences. As an illustration figures 9a and 9b indicate the CPUE - Density relationship for two important species : Lethrinus nebulosus and Bodianus perditio. There is no pattern for the first species, whereas there is nearly a linear relationship for the second. Lethrinus nebulosus is a rather shy species, difficult to see and often found in schools.

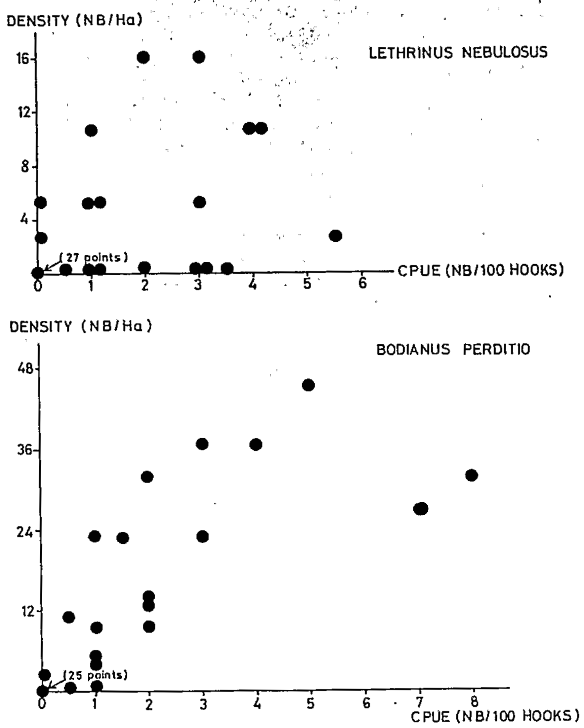


Figure 9a, b. Relationship between estimated density and CPUE in numbers for Lethrinus nebulosus and Bodianus perditio.

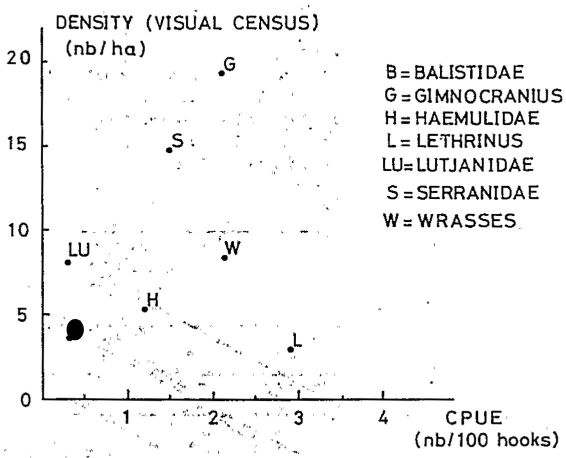


Figure 10. Relationship between estimated density and CPUE by numbers for 7 families or genera.

Bodianus perditio is conspicuous, normally not a shy fish except in heavily fished areas and usually found solitary or in small groups. Figure 10 indicates the relationship between the density estimated from visual census and CPUE for the major families. Thus, at similar densities, Wrasses are more vulnerable to the longline than Haemulidae or Lutjanidae. Lethrinus spp. stand aside, being either very sensitive to this gear or largely underestimated by visual censuses.

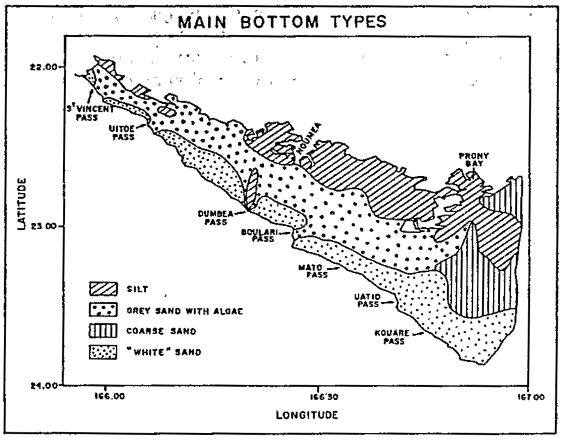


Figure 11. Main bottom type in the SW lagoon of New Caledonia.

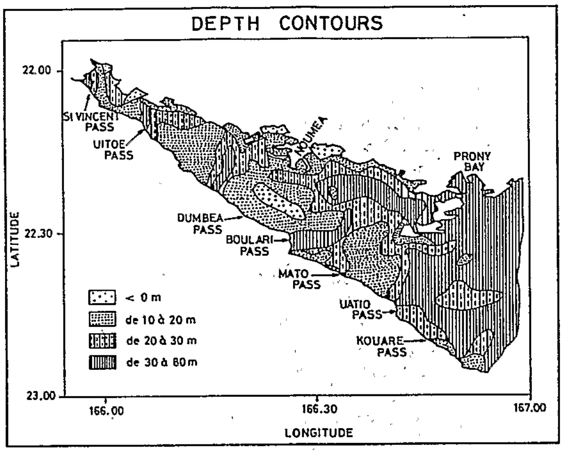


Figure 12. Bathymetrical map of the SW lagoon of New Caledonia

The density and biomass density maps (figures 6 and 8) show that the lowest concentrations of fish are near the coast and the largest concentrations near the barrier reef and in the eastern part of the lagoon. This distribution can be correlated to a great extent to the sedimentological and bathymetrical maps of our lagoon (figures 11 and 12), the highest concentrations being found in the deeper parts where the sand is the coarsest.

In order to have a first approximation of the relative importance of the total biomass (17700 tons, table 3) of large carnivores in our soft bottom fish fauna, the data from 59 soft bottom total fish counts were analyzed. These fish counts are 100m visual transects during which all major species are taken into account. By major species one understands fish over 10 cm or relatively abundant (i.e. Apogonids, Anthias and Pomacentrids). A total of 263 species were recorded of which only 40 were catchable by longline. These latter species accounted for 48 % of the estimated biomass. Therefore, one can estimate that the total soft bottom fish biomass in the SW lagoon is approximatively 35 000 tons. Knowing that this lagoon covers 3200km2 this implies an average of 11 tons/km2. This is much lower than reported standing stocks on coral reefs (38 - 209 tons/km2 according to Stevenson & Marshall (1974), Alcala (1981) cites several authors reporting levels of 120 to 195 tons/km2).

The present estimate is higher than densities from tropical trawl surveys in the region (table 5). This is certainly due to the fact that in the present case habitat is more diverse, including some coralline formations.

Table 5. Biomass density estimates from several trawl fisheries in the region.

zones	estimated densities	authors
NW AUSTRALIAN SHELF	2.1 - 3.1*	Sainsbury (1987)
SAMAR SEA (PHILIPPINES)	2.36	Villoso & Hermosa (1982)
SOUTH CHINA SEA	1.0 - 5.0	Aoyama (1973)
BENGLADESH	2.9 - 7.9	Lamboeuf (1987)

* Exploitable fish

The contribution of the soft bottom fish biomass to the total fish biomass of the SW lagoon is likely to be very large. Coral reefs cover less than 200 km2 in that zone. Therefore, even if these reefs supported 200 tons/km2 they would have a standing stock of 40 000 tons which is of the same magnitude than the soft bottoms. This indicates that in future research, more attention should be devoted to non trawlable soft bottom fish in tropical fisheries.

REFERENCES

Alcala, A.C. 1981. Fish yields of coral reef of Sulimon Island, central Philippines. Nat. Res. Counc. Philip. Bull. 36(1) : 1-7.

Anonymous. 1982. Further fishing trials with bottom set longlines in Sri Lanka. FAO-BOBP W.P. 16 : 25 pp.

Anonymous. 1984a. Ancient circle hooks rediscovered Aust. Fish. June 1984 : 34-35.

Anonymous. 1984b. Why do circle hooks work so well ? Aust. Fish. Oct. 1984 : 34-36.

Anonymous. 1985. Workshop on coral trout assessment techniques. Great Barrier Reef Marine Park Authority. Workshop Series n° 3 : 85 pp.

Aoyama, T. 1973. The demersal fish stocks and fisheries of the South China Sea. FAO/UNDP SCS/DEV/73/3 : 80 pp.

Burnham, K.P., Anderson D.R. & Laake, J.L. 1980. Estimation of density from line transect sampling of biological population. Wildlife Monographs 72.202 pp.

Gibson, D. 1979. What hook should I use ? Catch'79 6(5) : 3-5.

Grimes, C.B., Able, K.W. & Turners, S.C. 1982. Direct observation from a submersible vessel of commercial longlines for tilefish. Trans. Am. Fish. Soc. 111 : 94-98.

Harmelin-Vivien, M.L., Harmelin J.G., Chauvet, C., Duval, C., Galzin, R., Lejeune, P., Barnabe,G., Blanc, F., Chevalier, R., Duclerc, J. & Lasserre, G. 1985. Evaluation visuelle des peuplements et populations de poissons : méthodes et problèmes. Rev. Ecol. (Terre Vie) 40 : 467-539.

High, W. 1980. Bait loss from halibut longline gear observed from a submersible. Mar. Fish. Rev. 42(2) : 26-29.

Kulbicki, M., Mou-Tham, G., Bargibant, G., Menou, J.L. & Tirard, P. 1987. Résultats préliminaires des pêches expérimentales à la palangre dans le lagon sud-ouest de Nouvelle Calédonie. Rapports Scientifiques et Techniques ORSTOM Nouméa Océanographie 49 : 104 pp.

Lamboeuf, M. 1987. Bangladesh demersal fish resources of the continental shelf. FAO/UNDP FI:DP/BGD/80/025 : 75 pp.

Ralston, S. 1982. Influence of hook size in the Hawaiian deep-sea handline fishery. Can. J. Fish. Aquat. Sci. 39: 1297-1305 pp.

Ralston, S., Gooding, R.M. & Ludwig, G.M. 1986. An ecological survey and comparaison of bottom fish resource assessments (submersible versus handline fishing) at Johnston Atoll. Fish. Bull. 84(1): 141-155.

Richards, L.J. & Schnute J.T. 1986. An experimental and statistical approach to the question: is CPUE an index of abundance ? Can. J. Fish. Aquat. Sci. 43: 1214-1227.

Richer de Forges, B., Bargibant, G., Menou, J.L. & Garrigues, C. 1987. Le lagon de la Nouvelle Calédonie. Observations préalables à la cartographie bionomique des fonds. Rapports Scientifiques et Techniques ORSTOM Nouméa Océanographie 45: 110 pp.

Sainsbury, K.S. 1987. Assessment and management of the demersal fishery on the continental shelf of northwestern Australia. In: Tropical snappers and groupers. Biology and Fisheries management Polovina, J.J. & Ralston, S. (ed.) Westview Press, Boulder & London, pp. 465-503.

Stevenson, D.K. & Marshall, N. 1974. Generalization on the fisheries potential of coral reefs and adjacent shallow water environments. Proc. 2nd Intern. Coral Reef Symp. 1: 147-156.

Thresher, R.E. & Gunn, J.S. 1986. Comparative analysis of visual census techniques for highly mobile reef-associated piscivores (Carangidae). Env. Biol. Fish. 17(2): 93-116.

Villoso, E.P. & Hermosa, G.V. 1982. Demersal trawl fish resources of Samar Sea and Carigara Bay Philippines. Fish. Res. J. Philip. 7(2): 57-78.