Deep-Sea Bottom Handline Fishery In Papua New Guinea, a Pilot Study.

by

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ABSTRACT.

Bottom handlining was performed in three areas: Port Moresby, Milne Bay and Manus. Variance ratio test (X^2), show that the catch rates are not Poisson distributed, i.e. random. No differences in catch rates could be found between the three areas, the time of day or between different depths in the range fished, 70 - 270m (Kruskal-Wallis one-way analysis of variance, ANOVA, p=0.05). It is concluded that the contagious distribution of the catch rates is probably due to different bait or by fishing at different sites or both.

Differences in mean weight were found for different depths (ANOVA, p 0.01). There is a general trend for fish weight to increase with depth. The mean weight at 200-210m is significantly higher than at depths 140-150m and mean weight at 220-270m is significantly higher than at depths 80-110m and 140-190m.

Depth distribution are given for the 15 most common species encountered: *Gnathodentex mossambicus, Lutjanus argentimaculatus, Pristipomoides multidens, P. flavipinnis, Etelis carbunculus, E. oculatus, E. radiosus, Tropidinus zonatus, T. argyrogramicus, Tangia sp., Epinephelus compressus, E. magniscuttis, E. morrhua and Epinephelus sp.* The depth associations between these species are described by cluster analyses based on a similarity matrix, where association is expressed with a combination of Jaccard's and Bray-Curtis' coefficients.

INTRODUCTION.

Interest in the deep water resources of the South Pacific is increasing for three reasons: First, demersal fish stocks are limited because of the almost complete absence of continental shelf; second, the overfishing of demersal stocks in those areas where they exists, and third, the problem of ciguatera poisoning does not exist with the deep water fish.

The South Pacific Commission (S.P.C.) has been involved in deep water projects since 1974 (Crossland & Grandperrin, 1980), and has endeavoured to both teach and encourage handline bottom fishing.

In early 1982, S.P.C. staff visited Papua New Guinea to carry out a training programme in deep water handlining. Information on catch rates and catch composition was collected during this training programme and was analysed to describe the differences in catch-rates between the three areas fished (Port Moresby, Milne Bay and Manus), the distribution of catch rates with respect to depth and time of day, and the depth distribution for the most common species. The depth and abundance associations between these species were also analysed.

This paper deals only with teleost fish. In some areas however, a substantial part of the catch consists of elasmobranchs.

MATERIAL AND METHODS.

Fishing.

Three areas were fished: Port Moresby (seven trips, 41 hours fishing), Milne Bay (four trips, 65 hours fishing) and Manus (four trips, 61 hours fishing) (Figure 1). Fishing trips lasted from between two hours and three days and depths ranged from 70 to 270m. Small launches (6-8m) were used on all trips except one where fishing was undertaken from a 10m research vessel.

Fishing in Milne Bay and Manus was carried out on the slopes of fringing reefs, while in Port Moresby the outer slope of a barrier reef was fished. All fishing occurred from anchored positions; the anchor was dropped in shallow water and the rope paid out until a suitable depth was reached. Depths were determined with a Japan Marina Co., model 707 A/B echosounder.

Fish were hauled by hand-reels of the Samoan type, equipped with over 300m monofilament line (125kg test) and a wire terminal rig with three Mustad hooks, sizes 5, 6 and 7. A detailed description of this fishing gear, is given by Fusimalohi & Crossland, 1980.

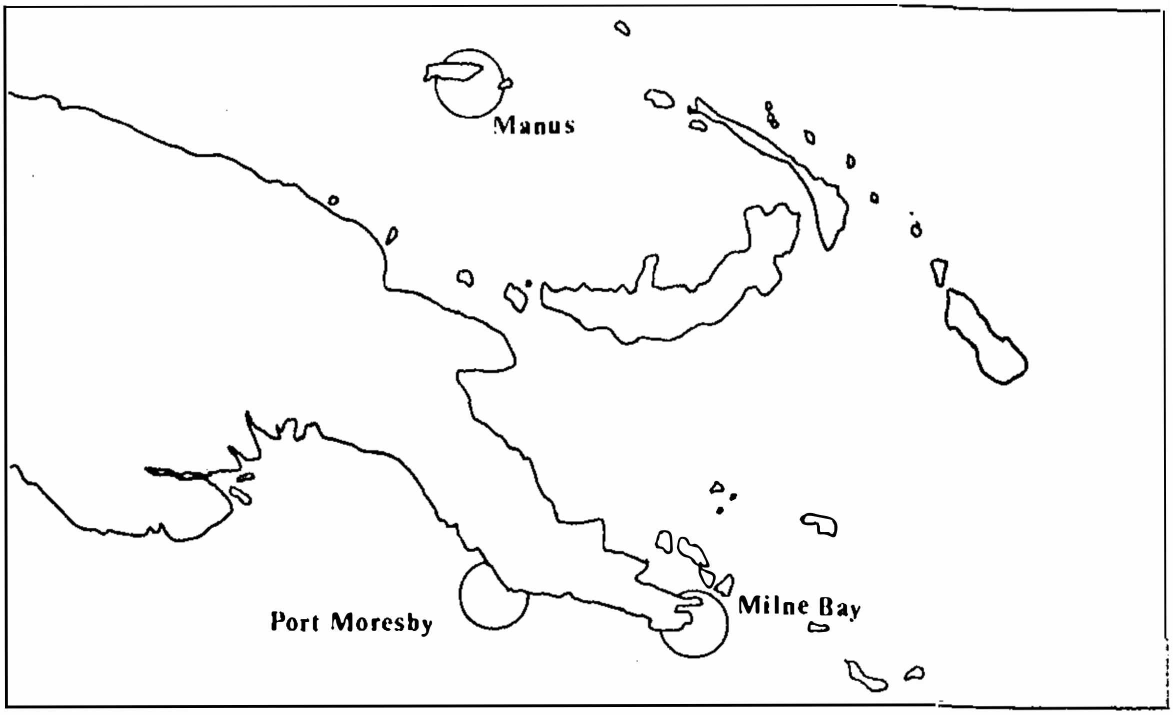


Fig.1. A map of Papua New Guinea, showing the three fishing areas, Port Moresby, Milne Bay and Manus.

The bait varied accoring to availability: skipjack tuna (*Katsuwonus pelamis*), dogtooth tuna (*Gymnosarda nuda*) and different mackerels being the main bait. It was either used fresh or toughened with rock salt.

Analyses.

If catch rates are randomly distributed the ratio variance/mean value should equal one. If the ratio exceeds one in a statistically significant way, then the distribution is considered contagious (Elliot, 1971). To test this, the ratio $s^2(n-1) / \bar{x}$ is used, where s^2 is the variance of the catch rates, $\bar{x}$ the mean value, and n is the sample size. This ratio is approximately x^2 distributed with n - 1 degrees of freedom (d.f.).

Catch rates used in this analysis are in kg of ungutted fish caught per line and hour. Differences in the catch rates between areas, time of day and depths, together with differences in the mean weight of fish for different depths, were analysed by the non-parametric Kruskal-Wallis one-way analysis of variance (ANOVA) (Daniel, 1978). A non-parametric test was used instead of a parametric test since the data do not fulfil the assumptions underlying the latter. When significant differences were found, an *a posteriori* comparison was made by the procedure proposed by Dunn (1976), and described in Daniel (*op. cit.*). An experimentwise error of 0.15 was used (Daniel, *op. cit.*).

The justification for using an experimentwise error rate is discussed by Kurtz *et al* (1965).

Ecological associations with respect to depth distribution and abundance were analysed using the two cluster analysis techniques: unweighted pair-group method using arithmetic averages (UPGMA) (Sokal & Michener . 1958; Sneath & Sokal, 1973), and single linkage clustering (Sneath, 1957; Sneath & Sokal, 1973). The cluster analyses were based on the similarity coefficient S, where $S=1/2\ (A/(A+B+C) + 2W/T)$. In this equation, A is all the depths where species x and y occur together, B is where x, but not y, is present, C is where y, but not x, is present, W is the sum of the lesser number of specimens for the species common to both depths, and T is the total number of specimens for x and y.

This coefficient (S) is a combination of the Jaccard (1908) and Bray-Curtis (1957) coefficients. The reason for combining them is that the former does not take into account abundance and will give high similarity even if some of the species are rare, whilst the Bray-Curtis coefficient, underestimates the ecological important fact that two species do occur together, even though their abundances are low.

RESULTS AND DISCUSSION.

Catch rates and species composition.

TABLE 1. Mean catch rates for the three areas fished.

Area	Mean catch rate (kg/hr x no. of lines)	95% confidence interval	sample size (hours of fishing	line hours
Port Moresby	3.99	2.07	41	72
Milne Bay	2.50	0.74	65	114
Manus Island	4.55	1.74	61	126
Pooled	3.68	0.85	167	312

Catch rates and species composition.

The mean catch rates are given in Table 1 and the species encountered are listed in Table 2. Table 2 also lists where these species have been caught elsewhere in the South Pacific. The most common species are *Etelis carbunculus*, *Epinephelus morrhua*, *Tropidinius zonatus* and *Lutjanus bohar*.

The catch rates are not statistically different between the three areas (ANOVA, p=0.05). For comparison, some other catch rates obtained by the same method of fishing in the South Pacific region are listed in Table 3.

TABLE 2.

List of the species encountered in Papua New Guinea and elsewhere in the South Pacific.

Species	No of fish	% per weight	Mean weight	A	B	C	D	E	F
Etelis carbunculus	111	47.2	4.9	X	X	X	X	X	X
Pristipomoides multidens	44	8.22	2.1	X	X				X
Etelis oculatus ***	15	5.76	4.4	X	X	X			X
Epinephelus magnicuttis	13	5.58	4.9		X			X	X
Lutjanus malabaricus	11	1.30	1.4						X
Gnathodentex mossambicus	10	1.73	2.0						X
Epinephelus morrhua	9	1.61	2.0	X	X*	X	X	X*	X
Tropidinus zonatus	9	1.01	1.3	X		X	X	X	X
Pristipomodies flavipinnis	8	0.45	0.6	X	X*	X		X*	X
Epinephelus compressus	5	12.1	27.6	X					
Lutjanus argentimaculatus	5	2.25	5.1			X		X	X
Etelis radiosus **	5	2.18	5.0						
Epinephelus sp.	5	0.31	0.7		X*			X*	
Tangia sp	4	1.34	3.8						
Pristipomoides filamentosis	4	1.13	3.2	X	X*			X*	X
Tropidinius argyrogrammicus	4	0.16	0.5	X					X
Epinephelus chlorostigma	3	0.45	1.7		X*	X		X*	X
Lutjanus bohar	2	1.06	6.1	X		X	X	X	X
Lethrinus miniatus	2	0.87	5.0	X		X		X	X
Seriola dumereli	2	0.48	2.8						
Variola louti	2	0.07	0.4	X		X	X		X
Pristipomoides auricilla	2	0.07	0.4		X*	X		X*	
Leptocephalidae	1	0.93	10.6						
Epinephelus tauvinna	1	0.91	10.4		X*	X		X*	
Seriola purpurescens	1	0.49	5.6					X	X
Caranx lugubris	1	0.44	5.0				X	X	
Gymnosurda nuda	1	0.40	4.6						
Caranx sp.	1	0.39	4.4			X		X	X
Lutjanus erythropterus	1	0.37	4.2						
Lethinus kallopterus	1	0.27	3.1						
Paracaesio sp.	1	0.26	3.0						
Branchiostegus wardi	1	0.13	1.5						
Cephalopholis sp.	1	0.02	0.02						

** *Etelis radiosus* is a recently described species (Anderson, 1981).

*** *Etelis oculatus* is identified from Fourmanoir & Laboute (1978).

* The source only reports the genus, not the species.

A. New Caledonia. Fusimalohi & Grandperrin, 1979.

B. New Hebrides. Fusimalohi, 1979.

C. Palau. Taumia & Crossland, 1980.

D. Niue. Mead, 1980a.

E. Trust Territories of S. Pacific. Mead & Crossland, 1980.

F. Fiji. Mead, 1980b.

TABLE 3. Mean catch rates (kg/hr x no. of lines) of bone fish, obtained by the South Pacific Commission deep sea fisheries development project in different places around the South Pacific area.

Place	Average catch	Source
New Caledonia	7.1	Fusimalohi & Grandperrin, 1979
Niue (1979)	7.0	Mead, 1980
Palau	3.0	Taumia & Crossland, 1980
Tanna	2.8	Fusimalohi, 1979
West New Britain	4.3	Fusimalohi & Crossland, 1979
Yap Island	4.6	Mead & Crossland, 1980
Fiji	9.2	Mead, 1980.

The mean catch rate in this study, is about the average for the region and is at a level which could probably support an artisinal fishery. Although it was not possible to demonstrate in this study, it is considered that the bait used has a significant influence on catch rates. It is likely that oily fish with red flesh, such as skipjack tuna, produce higher catch rates. It should be pointed out that most of the fishing was undertaken by unexperienced trainees and catch rates can be expected to increase with experience of the crew.

Catch rates, depth and time of the day.

Since this study was carried out in conjunction with a training programme, not all depths and times of day could been fished in all areas. Hence for the analyses in this section, and the test of differences in mean weights, data from the three areas have been pooled.

The obtained value of the ratio variance/mean value is significantly higher than one (X^2 - test, $p < 0.001$, d.f. = 166) and the catch rates are clumped in their distribution with one group of low catch rates and a second with high. However, the test for differences in catch rates for different times of the day, and differences in catch rates at different depths shows that no differences could be found (ANOVA, $p = 0.05$, d.f. = 22 and 8 respectively) and hence fishing at different depths or at different times of the day is not the cause of this clumping of catch rates.

It is possible that the uneven distribution of catch rates was caused by a combination of bait effectiveness and whether or not fishing was undertaken in a good place. Time of day was not important but certain places within an area yielded high catch rates whilst others did not irrespective of depth.

Many fishermen believe that night-fishing produces the best result. Our investigations do not support this, and e.g. high catch rates were recorded at noon, when it is generally considered impossible to catch fish.

Depth associations among the 15 most common species.

The result of the two cluster analyses are illustrated in Figures 2A and 2B. Two different independent clustering methods are used to assess the stability of the groupings. Since both methods produce similar results, it suggests that they reflect the true association between the species.

From a practical point of view a knowledge of species associations is of interest since it may enable some control over the species caught to be maintained. Figure 2 indicates for instance that *Etelis oculatus*, *Epinephelus compressus*, *E. magniscuttis*, *E. morrhua* and *Gnathodentex mossambicus* will be caught together. Similarly, other associations can be assessed from Figure 2 and higher similarity values can be interpreted as higher probabilities of being encountered together.

Species composition mean weights and depth.

The depth distribution for the 15 most common species encountered are depicted in Figure 3.

The mean weight (Table 4) is significantly higher at certain depths (ANOVA, $p < 0.001$, d.f. = 9) with a general trend for fish weight to increase with depth. The mean weight at 200-210m is significantly higher than at depths 140-150m and the mean weight at 220-270m is higher than the mean weights at 80-110 and 140-190m. The depth range is divided into 20m intervals, because even though the echosounder will give a precise reading, it is not possible to know exactly where the hooks are.

Since there is no significant variation in catch rate with depth fishing at greater depths yields bigger but fewer fish. Unless certain species, or large fish are sought, it could bemore beneficial to fish in shallower water.

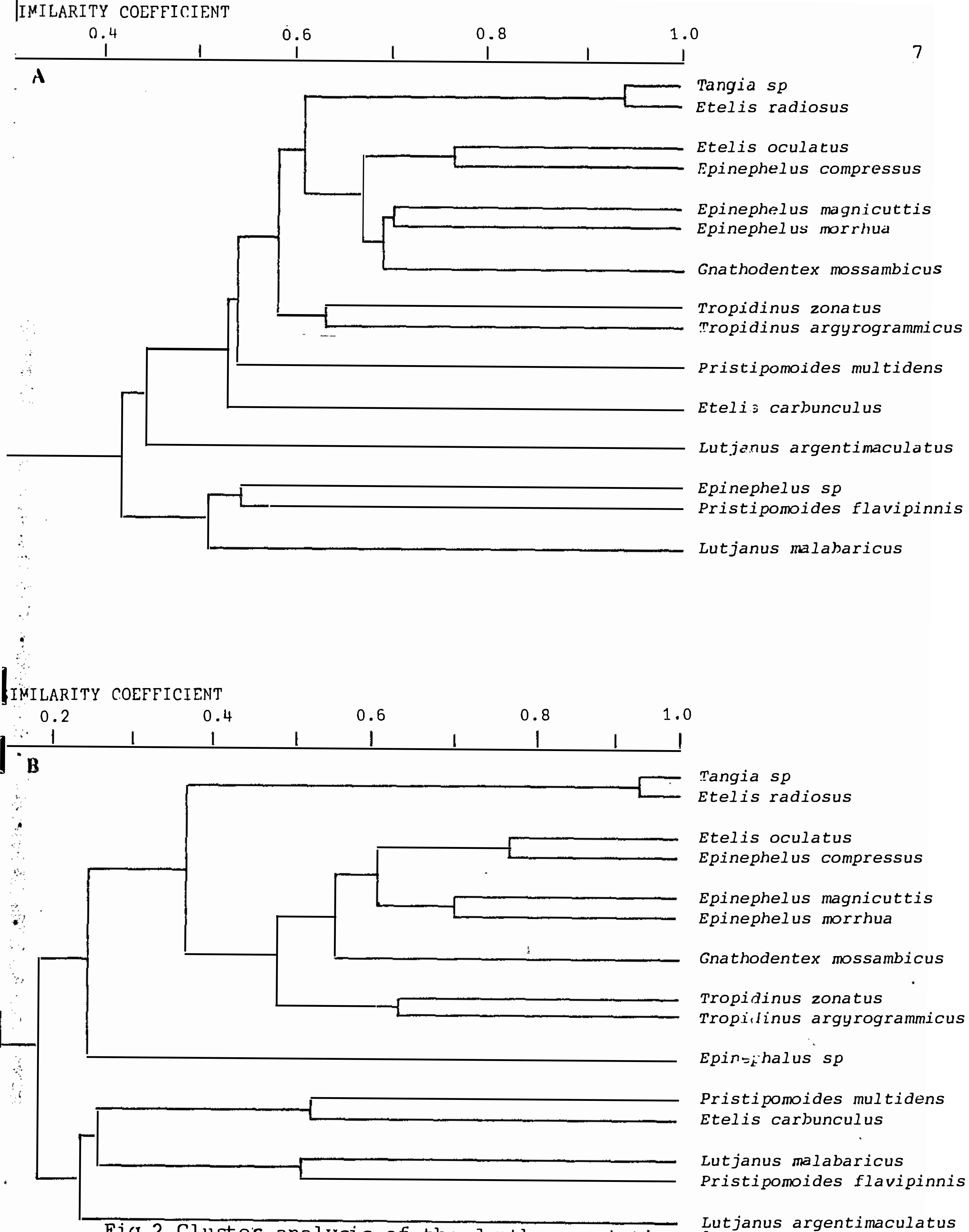
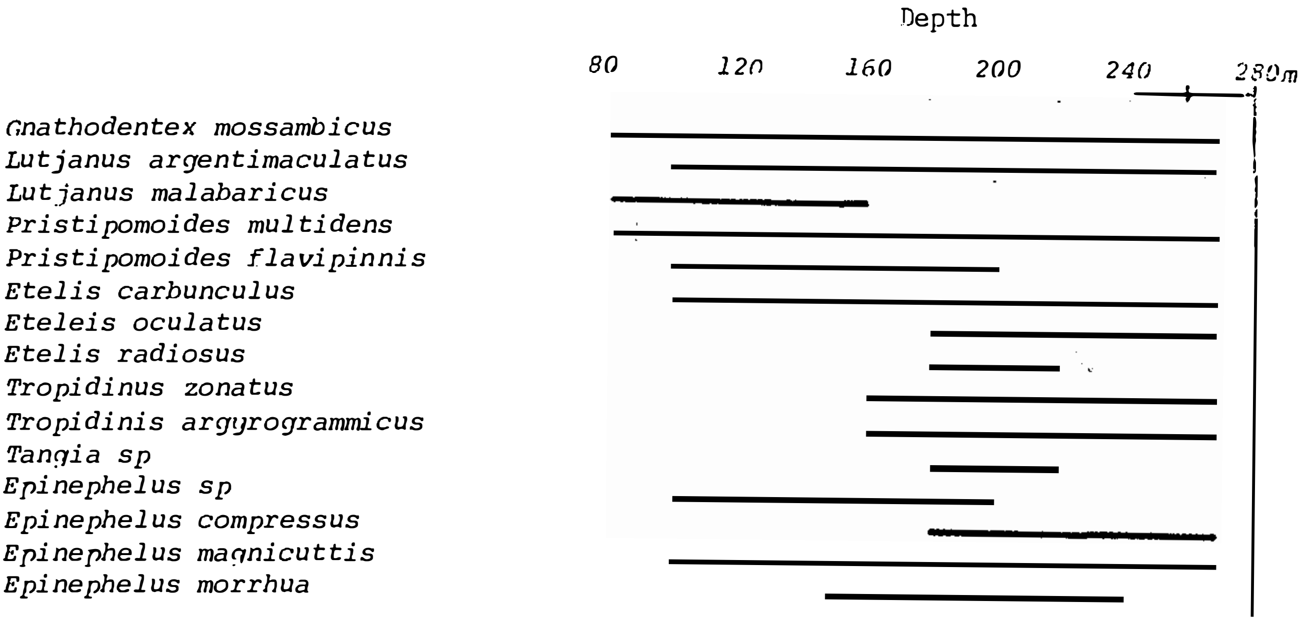


Fig.2. Cluster analysis of the depth associations between the 15 most common species. Based on a combination of the similarity coefficients proposed by Jaccard (1908) and Bray-Curtis (1957).
A. Single linkage clustering.
B. Unweighted pair-group method using the arithmetic means (UPGMA).

TABLE 4. Mean weight for different intervals.

Depth (m)	Mean weight (kg)	95% confidence interval	sample size
80 - 90	1.6	1.1	8
100 - 110	2.2	1.0	15
120 - 130	3.3	1.5	15
140 - 150	1.3	0.9	12
160 - 170	2.3	0.5	21
180 - 190	3.1	1.1	40
200 - 210	4.3	1.3	47
220 - 230	4.9	0.7	20
240 - 250	5.8	2.9	51
260 - 270	4.8	1.2	56

Fig.3. The depth distribution of the 15 most common species.



CONCLUSION.

There is no significant difference in mean catch rate between the three areas Port Moresby, Milne Bay and Manus (Kruskal-Wallis one-way analysis of variance, ANOVA, $p=0.05$). The mean catch rate for all three areas is 3.7 +/- 0.85 (+/- 95% confidence interval).

The available data do not indicate any differences in catch rates between different time of the day, or between different depths (ANOVA, $p = 0.05$). However, the distribution of catch rates is contagious (X^2 - test, $p < 0.01$) and it is concluded that this is probably due to the influence of good sites within an area, and to the influence of the type of bait used.

There is a significant difference in mean weight at different depths (ANOVA, $p=0.01$), so that the mean weight is higher at 200-210m than at 140-150m, and that the mean weight is higher at 220-270m that at 80-110 and 140-190m.

Certain of the 15 most common species are more likely to be encountered together. The most likely combinations are: *Tangia sp.* and *Etelis radiosus*; *Etelis oculatus* and *Epinephelus compressus*; *Epinephalus magniscuttis* and *E. morrhua* (similarity of 0.7, using a combination of the Jaccard and Bray-Curtis coefficients, have been chosen as an arbitrary limit for grouping).

RECOMMENDATIONS FOR FUTURE RESEARCH PROGRAMMES.

Objectives:

(1) To test if there are differences in catch rates due to time of day and depths, or combinations of these two factors.

(2) To test the effect of bait on the catch rate.

(3) To test if certain areas give consistently higher catch rates, and to determine the characteristics of such areas.

(4) To obtain biological information on the dominant species, so that the deep water resources can be managed effectively.

Methods:

(1) Decide the depth range to be fished. Arrange a number of transects evenly over the area to be surveyed (Figure 4). For the first trip, select randomly one of these transects and steam along it until the first depth in the range is reached. For the second trip, select a new transect randomly and go to the second depth in the range, and so on. This means that there is a systematic sampling of depths and a random sampling of transects.

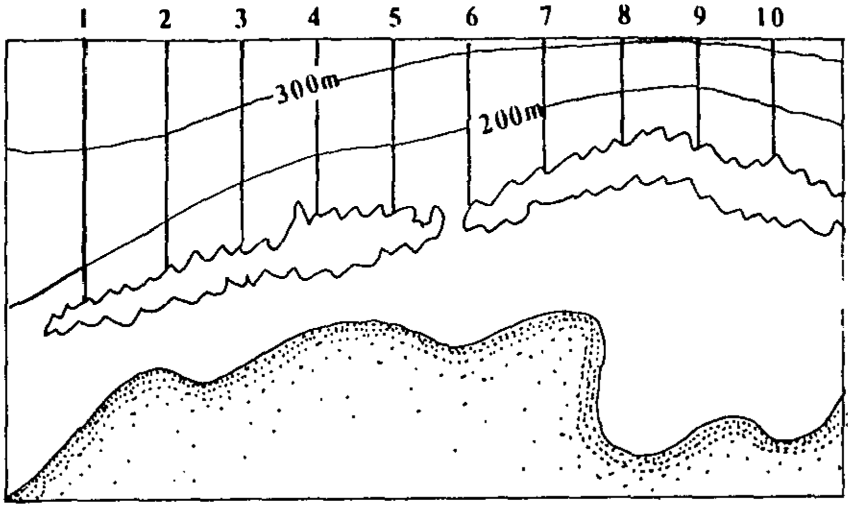


Fig.4. A method of arranging transects over the area to be surveyed.

Each station is fished for 24 hours, and all depths are fished the same number of days. After each depth is fished for four days, an initial analysis is performed, and if desired additional days can be added.

(2) Always fish at the same depth and at the same time of the day. Record the catch rates produced by different kinds of bait and fish for at least 30 hours with each bait.

(3) Fish at the same time of day over different type of bottoms, e.g. sea mountains, steep slopes, rock bottoms, mud bottoms, and so on, using the same type of bait. Classify different bottom types, record catch rates and species composition.

(4) By using several reels, sufficient data should be obtained for objectives (3) to be met.

Analysis:

(1) With this sampling programme, the objectives can be tested with a parametric (Sokal & Rohlf, 1969) or non-parametric (Daniel, 1978) two-way analysis of variance.

(2) One-way analysis of variance (same references as above) can be used to detect differences. If differences are found, *a posteriori* procedures described in these two references can be used to tell which bait is the most efficient.

(3) Same analyses as above to detect difference. Cluster analyses, or principal coordinate analysis (Sneath & Sokal, 1973) can be used to analyse similarities in species composition between different types of bottoms.

(4) Use monthly length frequency data, or preferably growth rings from otoloiths or scale, to determined growth equations.

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