CPS/Inshore Fish. Res./BP.34
6 mars 1988

ORIGINAL : ANGLAIS

COMMISSION DU PACIFIQUE SUD

COLLOQUE SUR LES RESSOURCES HALIEUTIQUES COTIERES DU PACIFIQUE
(Nouméa, Nouvelle-Calédonie, 14 - 25 mars 1988)

RAPPORT PRELIMINAIRE SUR UN PROGRAMME D'EVALUATION DES STOCKS DE POISSONS DEMERSAUX DES GUYOTS DE TONGA

Document présenté par

S.A. et V.A. Langi
Division des pêches, Royaume de Tonga

SOMMAIRE

On a procédé à l'analyse des données recueillies pendant les 9 premiers mois d'un programme, d'une durée de 5 ans, consacré à l'évaluation des stocks de poissons démersaux des guyots de Tonga. Cette analyse avait principalement pour but de vérifier la validité de l'échantillonnage et d'établir des paramètres qui permettront de procéder ultérieurement à des comparaisons. Les données obtenues sont de deux ordres : la prise par unité d'effort et les rapports taille/poids. Le sommaire des résultats dérivés de chaque groupe de données est repris ci-dessous.

a) Prise par unité d'effort

25% de l'effort de pêche aux espèces démersales sont attribuables à la méthode de l'échantillonnage.

Pour le premier semestre de 1987, la prise totale s'est élevée à 235 tonnes. On escompte une prise totale de 470 tonnes par an.

Le rendement maximum soutenable est de l'ordre de 325 tonnes par an.

La prise moyenne par unité d'effort atteint est d'1,5 poisson, soit 6,71 kg, par heure et par moulinet standard.

b) Rapports taille/poids

On a réussi à calculer les régressions tailles/poids pour 7 espèces importantes.

Pour chacune de ces espèces, on a dressé un tableau des paramètres de croissance et de mortalité.

L'analyse du rendement par recrue révèle que l'espèce la plus importante pour l'exportation, Pustipomoides filamentosus, n'est exploitée qu'à 46% de son rendement par recrue potentiel, alors que l'exploitation des autres espèces importantes est voisine du potentiel.

On a ainsi pu conclure, dans l'ensemble, à la validité de l'échantillonnage, même si l'évaluation du coefficient Bo, soit l'importance initiale du stock, nécessiterait un plus grand nombre de mesures de longueur associé à des expériences probantes sur l'épuisement des stocks.

1. INTRODUCTION

In October 1986, following an SPC/FAO/UNDP workshop on stock assessment, the Tonga Fisheries Division began a 5-year programme to assess the stocks of bottom fish of the seamounts in Tonga. The design of this programme was directly based on ideas learnt at the workshop in Noumea. (Walters & Hilborn 1986).

Data collected during the first 9 months of the programme were analysed at the NMFS Honolulu Laboratory under the supervision of Dr.J. Polovina, in order to highlight any problems in sampling design, and to establish parameters upon which to base future comparisons.

This report gives the results of this preliminary analysis, based mainly on the first 9 months of data. The data falls into two broad categories;

1) Catch and effort information
2) Length and weight measurements

These form the 2 main sections of this paper.

2. BACKGROUND

2.1 Fishing Grounds

The majority of seamounts in Tonga lie on a submerged ridge, running in a NE-SW line parallel to the Tonga ridge which carries the 170 islands of Tonga (Figure 1). As an estimation of size of fishing grounds, the length of the 200 metre isobath was recorded as 930 nautical miles. However, the hydrography of many areas is imcomplete and new seamounts are still being discovered.

2.2 The Fishery

The commercial development of the fishery, with its target species of snappers and groupers (f. Lutjanidae, Serannidae), began in 1980 after the visits of the SPC Deep Sea Fisheries Development Project in 1978 and 1979, and the establishment of the UNCDF boatbuilding scheme. In July 1987, 37 boats were engaged in bottom fishing. By December 1987, this number had increased to 45. All fishing boats use the FAO-designed Western Samoan wooden reel, with a multiple-hook terminal rig. (For a detailed description of this fishing technique, see Mead (1979)). The depth of fishing varies from 50 - 400 metres.

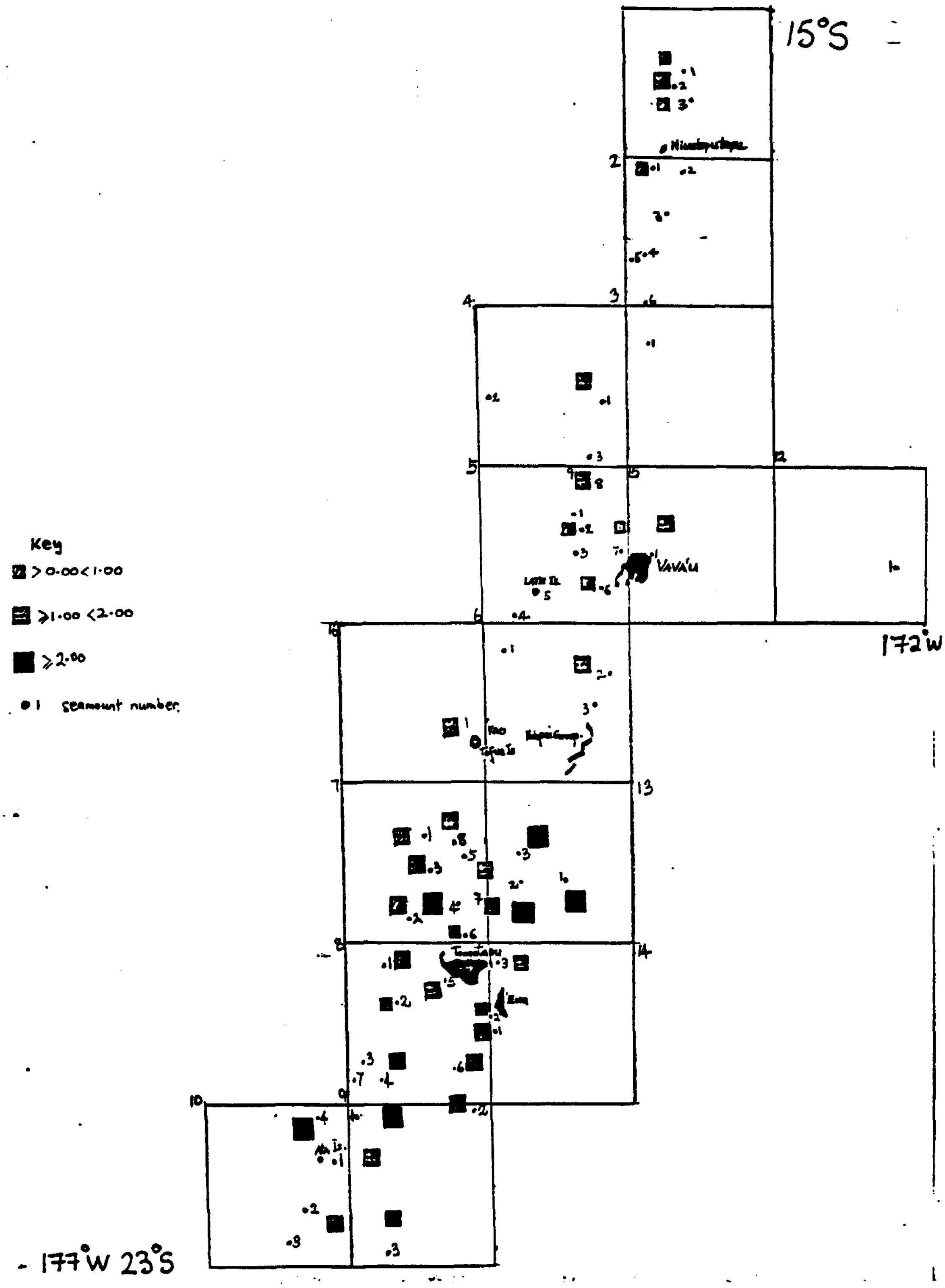

Figure 1 : Map of Tonga showing seamount locations and deep-bottom catch rates (number of fish per reel-hour for the commercial fishery (All species combined)

CATCH & EFFORT DATA - METHODS

3.1 Data Collection

Details of catch and effort are recorded in 3 centres: - Tongatapu, Vava'u and Niuatoputapu. In Tongatapu attempts are made to record every trip by every boat, but only 66% coverage has so far been achieved. In Vava'u trips are only recorded quarterly. In Niuatoputapu every trip is recorded from the single deep-bottom fishing boat based there. Elsewhere no recording has taken place due to lack of manpower.

Table 1 shows the number of boats in each major centre, and the percentage of fishing effort recorded.

TABLE 1 : PERCENTAGE OF FISHING EFFORT CAPTURED BY SAMPLING METHOD

CENTRE	% SAMPLED	NO. BOATS
Tongatapu	66.6	11
Niuatoputapu	100.0	1
Vava'u	5.6	16
Ha'apai	0.0	6
'Eua	0.0	3
Total	24.8	37

Table 1 shows that about 25% of all fishing effort is being sampled. Therefore, to extrapolate estimates of catch or effort to Tonga as a whole, recorded figures must be multiplied by 4.

Catch per unit of effort (CPUE) is recorded as numbers of fish per species caught per reel-hour. Although counts are made of each species of fish in the catch, only the following 7 major species shown in Table 2 below are used in the data analysis:

TABLE 2 : MAJOR SPECIES TAKEN IN THE FISHERY

SP1	Pristipomoides filamentosus	(palu hina)
SP2	P. flavipinnis	(palu sio'ata)
SP3	Etelis coruscans	(palu tavake)
SP4	E. carbunculus	(palu malau)
SP5	Epinephelus morrhua	(ngatala)
SP6	E. septem-fasciatus	(mohuafi,tonu or mala)
SP7	Lethrinus chrysostomus	(manga)

3.2 Results

3.2.1 Geographical variations in CPUE

Spatial maps were drawn showing the CPUE (numbers of fish per reel-hour) for each location. Figure 1 shows the CPUE for all species combined. The highest catch rates are from areas fished from Tongatapu with a maximum of 2.3 close to 'Ata island. It is important to note that more locations around Tongatapu have been recorded than elsewhere in the Kingdom due to concentration of sampling effort.

The CPUE data were summarised by the grid squares shown in figure 1. Results are shown in figure 2. Grid square 13 shows the highest catch rate of more than 2 fish per-reel hour. Grid squares 9 and 16 are nearly as high, while grid square 2 is the lowest. These figures will be monitored on an annual basis.

3.2.2 Total catch

Figure 3 shows the recorded catch (numbers of fish) for the whole of Tonga for each quarter from November 1986 to July 1987. These values must be multiplied by 4 to estimate the total catch.

At the time that figure 3 was prepared in August 1987, the data set did not span a full year, an estimate of annual catch was made by doubling the total catch estimate for the 6 months from January to June 1987. On this basis, the predicted annual catch would be 107,496 fish, which, using the calculated average fish weight of 4.365 kg, gives a predicted total landing of 470 t.

At the end of 1987, a total of 40,982 fish had actually been sampled. Using the same extrapolation technique (multiplying by 4), the estimated total mumber of fish caught in 1987 would be 163,928, or 716 t. This figure is 52% higher than the predicted 470 t and a 123% increase on the estimated 1986 catch of 321 t. These increases are no doubt at least partly associated with the increasing number of vessels entering the fishery.

3.2.3 Production Curves

A plot of catch against effort, using data extrapolated to the whole of Tonga was begun (figure 4). From the small amount of data presently available, catches appear to increase as effort increases, indicating that the fishery is still on the ascending limb of the catch curve. More data points added later will give a more meaningful picture.

3.3 Discussion

3.3.1 Sampling methods

Analysis of CPUE data so far has shown that the sampling method is adequate to obtain the information required to estimate total catch and effort in Tonga. The data collected will allow yearly monitoring of catch rates of individual species and enable patterns of over or underexploitation to be detected. As the study progresses, more information will emerge on levels of exploitation, the abundance and distribution of the resource, sustainable yields, species composition, etc.

3.3.2 Catch rates

The total catch rate for Tonga may be calculated as total number of fish caught divided by total effort in reel-hours. This gives a value of 1.5 fish/reel-hour, or 6.7 kg/reel-hour at an average fish weight of 4.365 kg. This is compared with catch rates given for 10 Pacific Island countries in Table 3.

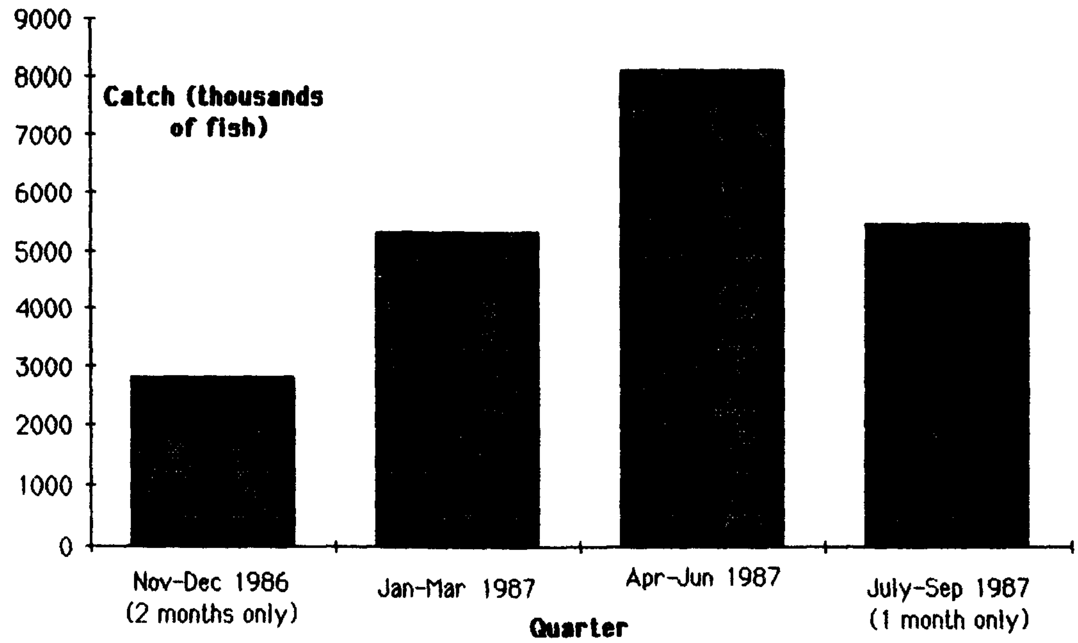

Figure 2 : Total deep-bottom fish catch in Tonga

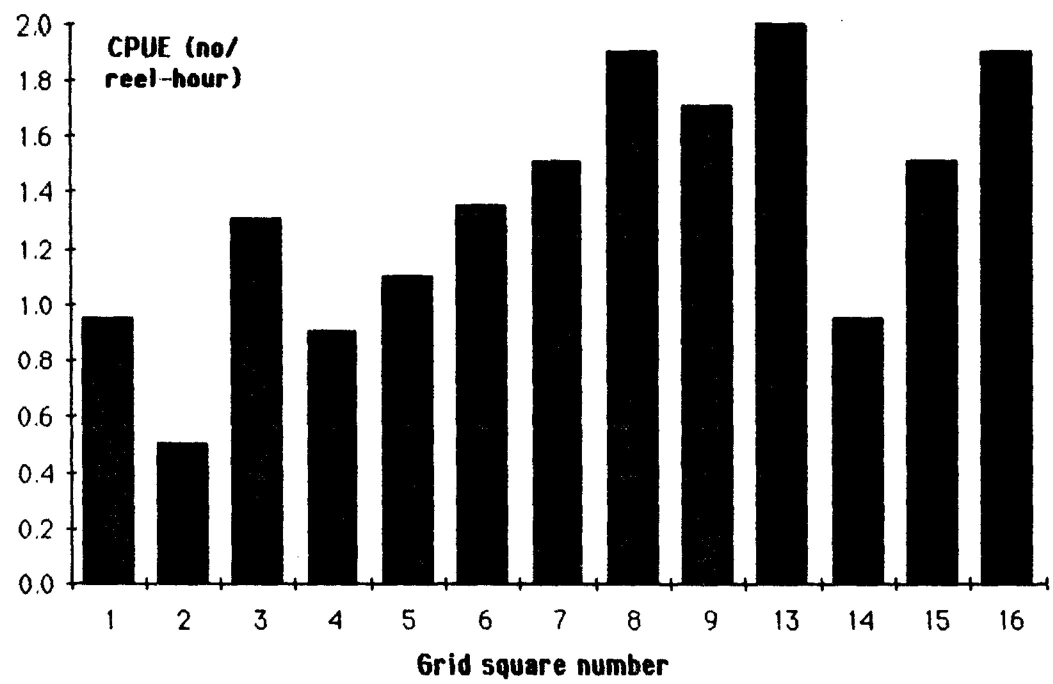

Figure 3 : Geographical variation in catch-per-unit-effort

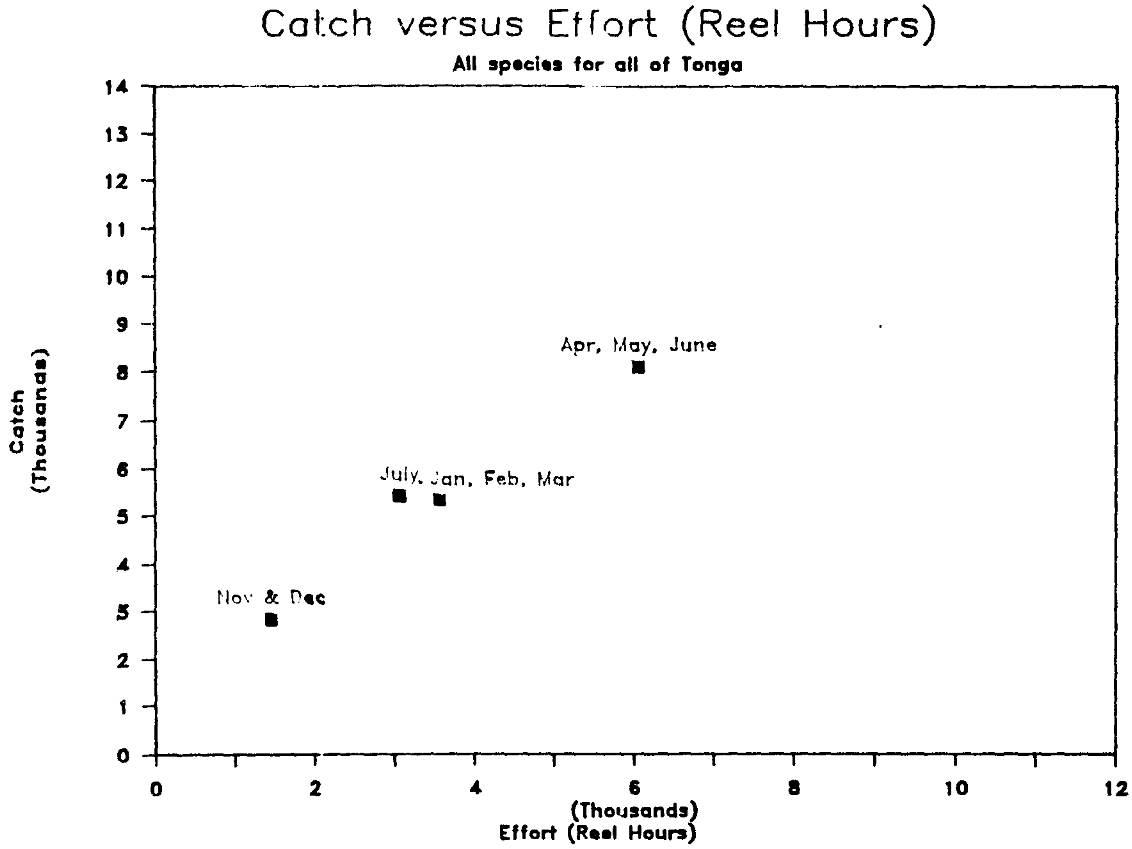

Figure 4 : Plot of catch vs effort (reel-hours)

TABLE 3 : HAND-REEL CATCH RATES (IN KG/REEL/HOUR) BY SPC BOTTOM FISHING PROJECTS AT DIFFERENT PACIFIC ISLAND LOCATIONS. (from Crossland, 1980)

American Samoa	4.4	Palau	3.3
Kosrae	9.6	Papua New Guinea	4.9
New Caledonia	7.6	Tonga (1978)	3.6
New Hebrides (Tanna)	3.1	Tonga (1979)	5.7
Niue (1978)	2.8	Truk	4.1
Niue (1979)	7.0	Yap	6.9

AVERAGE : 5.3

The average figure for the Tongan fishery, 6.7 kg/reel-hour, is higher than the average of 5.3 given in the table, and also higher than the 1978 and 1979 figures for Tonga (Mead 1979). However, these earlier figures came from exploratory or fishery training exercises in Tonga, not from a commercial fishery. The difference in catch rates could be attributable to a wide variety of differences in fishing pattern and methods of operation.

3.3.3 Sustainable yield

It is too early in this study to accurately assess sustainable yield from the bottom fishery in Tonga, but it is possible to make a very rough estimate from the data gathered so far. A recent approach to estimating sustainable yield was that used in Hawaii (Ralston & Polovina 1982) and the Mariana Islands (Polovina et al, 1985). Here the length of the 100 fathom (200m) isobath was used to predict the annual sustainable yield of bottom fish. An estimate of 220-270 kg per nautical mile of 100-fathom contour was obtained.

Using this estimate, Tonga's 930nm of 200m contour would yield 153 to 260 t per year. We may wish to add on an arbitrary 25% to cover as yet undiscovered seamounts, giving a figure of 191 to 325 t p.a. Fiji's Fisheries Division (1987), following Brouard (1984) who worked on Vanuatu's bottom fish, doubled Polovina's estimate before adding for unknown seamounts. This method allows for the fact that, in an unexploited or very lightly exploited stock, the standing biomass can be expected to generate considerably higher catch rates in the initial development of the fishery than will be sustained in the longer term. Applying the method to Tonga's case gives yield estimates of between 382 and 650 t per annum, but these could only be expected to hold for the first year or two of the fishery's operation.

As noted previously, total deep-bottom fish landings in Tonga were estimated at 321 t and 716 t in 1986 and 1987 respectively. Tonga's present catches could therefore be fast approaching or exceeding the sustainable yield. Caution is thus recommended in allowing increases in fleet size until more data is collected. If properly managed at stable levels of exploitation, the bottom fishery could continue successfully for many years. According to Munro (1986), when the maximum annual harvest is being taken, CPUE will decline to one half or one third of its initial values. If we apply this generalisation to Tonga, using the maximum CPUE value of 2.3 fish/reel-hour (estimated for grid square 13 in figure 1), then the following picture emerges:-

> Initial CPUE = 2.3 fish per reel-hour, or 10.5 kg per reel-hour. At MSY, CPUE falls to, say, 3.5 kg per reel-hour. If MSY = 325 t (based on Polovina's figures plus an arbitrary 25% then 325 t /3.5 kg gives the equivalent of 93,000 reel-hours of effort. The average number of of reel-hours per trip is 73, so 93,000 reel-hours / 73 = 1274 trips. The average number of trips per year per boat is 37, therefore 1274 / 37 = 34 boats. That is, it is estimated that 34 boats will be required to harvest the maximum sustainable yield. At present, there are 45 boats in the bottom fishing fleet.

3.3.4 Depletion estimates

Attempts were made to carry out "Depletion" or "Intensive Fishing" experiments on 3 seamounts by the government vessel the M.V. Takuo during November and December 1986. The aim of this type of experiment is to fish a seamount intensively, over a short time period, until catch rates drop, thus showing depletion in fish stocks. By carefully recording hours of effort and catches, graphs can be constructed to estimate the initial size (Bo) of the fish stock on that seamount, using the Leslie model (Ricker 1975).

Unfortunately, these attempts were mainly unsuccessful. The seamounts were larger than expected and a longer time was required to deplete them using one boat. Subsequently the research section lost the use of the boat and no further experiments could be conducted.

Without the use of a boat, further work can be done on depletion estimates only with full cooperation of the commercial fishing boats. This will be attempted, since an estimate of Bo needs to be obtained.

4. LENGTH - WEIGHT DATA

4.1 Methods

Length - weight data are collected in the same three centers, Tongatapu, Vava'u and Niuatoputapu. Measurements are taken quarterly, in the months February, May, September and December. In the sampling month, one whole catch from every boat is measured i.e. 4 catches per boat per year.

Catches from the 2 government fishing vessels, MFV Takuo and Albacore, are also recorded whenever they go fishing. These fishing trips are infrequent and inconsistent due to high running costs and other commitments on the part of the vessels.

All lengths are fork lengths, taken to the nearest centimetre. All weights are recorded before the fish are gutted and taken to the nearest 0.1 kg on 20 kg and 100 kg hanging spring balances.

4.2 Results

4.2.1 Length - weight regression

Length/weight regression analyses were successfully completed for the seven major species listed in table 2. This will enable us to avoid further weighing of these fish after the first year.

4.2.2 Length frequency distribution

Quarterly length-frequency distribution histograms for each species were plotted. They show that we do not have enough data in a time series to be able to run the ELEFAN series of computer programmes which allow estimation of population parameters from modal progressions. We were advised by Dr. Polovina to collect 1000 length measurements per year per species. This will still not be enough to run ELEFAN, but enough to allow reasonably reliable estimates of Z/K. More pragmatically, this is all it is feasible to collect without upsetting the fishermen.

4.2.3 Population parameters

From the length-frequency data, it was possible to estimate the following population parameters for each species:

Lc	(= the smallest length fully represented in the catch)
Linf	(= asymptotic length (von Bertalanffy growth equation))
Lm	(= length at onset of sexual maturity)
Lmax	(= maximum length recorded)
Lbar	(= mean length of all fish with lengths greater than Lc)
K	(= growth factor (von Bertalanffy growth equation))
M	(= coefficient of natural mortality)
F	(= coefficient of fishing mortality)
Z	(= coefficient of total mortality (sum of F and M))
M/K	(= ratio of natural mortality to growth)
Z/K	(= ratio of total mortality (F + M) to growth)
F/M	(= ratio of fishing mortality to natural mortality)
Y/R	(= yield per recruit (expressed as a fraction of Winf, the asymptotic weight) (Beverton & Holt 1966))

To compute Linf and Z/K a modification of the Beverton & Holt equation was used (Wetherall at al. in press). Z/K is assumed to equal M/K if the stocks are lightly exploited. This could not be assumed in our case since commercial fishing has occurred since 1980. For M/K values, data obtained from the Marianas (Polovina and Ralston 1986) were used where possible. Elsewhere, a value of M/K = 2.0 was used (Ralston 1986).

To compute F/M the following equation was used:

$$(Z/K)/(M/K) = (F+M)/M = (F/M) + 1$$

Lm was estimated to be 50% of Linf (Grimes 1986).

For a preliminary estimate of K, Linf was used (following Manooch (1986)) as follows:

$$\mathrm{Log}\ 10\ (K) = 1.098 - 0.658\ \mathrm{Log}\ 10(\mathrm{Linf}\ (mm))$$

Only 4 species, (SP1-3 & SP5) had enough observations to allow Linf and Z/K to be directly calculated. From the calculations and estimates, the following table was compiled:

TABLE 4 : POPULATION PARAMETERS FOR THE SPECIES LISTED IN TABLE 2

Species	Lr	Lc	Lmax	Z/K	M/K	Linf	Lm	F/M	K
SP1	56	65	75	4.1	2.5	77.2	38.6	0.6	0.16
SP2	39	43	57	11.5	4.6	57.5	28.8	1.5	0.19
SP3	44	59	96	3.33	2.2	99.3	49.6	0.5	0.13
SP4	59	70	114	-	-	-	-	-	-
SP5	48	60	80	1.33	-	74.2	37.1	-	0.16
SP6	108	120	172	-	-	-	-	-	-
SP7	44	54	76	-	-	-	-	-	-

4.2.4 Yield per recruit

For each species the maximum yield per recruit is calculated from the Beverton & Holt equation and compared with the yield for the current size of entry to the fishery.

Where F/M could be calculated, Y/R was computed for that level of F/M. Elsewhere, a level of F/M = 0.5 was used.

Where no values of Linf were available, Lmax was used to compute the C value for the Y/R table, Lm and Lopt.

Values of M/K required for the tables were derived from the Marianas data (see previous table). Where none was available, a value of M/K = 2.0 was used (Ralston 1986).

TABLE 5 COMPARISON OF THE CURRENT SIZE OF FISH AT ENTRY TO THE FISHERY (Lr) AND THE OPTIMUM SIZE (Lopt) TO GAIN MAXIMUM YIELD PER RECRUIT (Y/R).

Species	Lr	Lm	F/M	Y/R at Lr/Linf Max Y/R	Lopt (F/M)
P. filamentosus	56	38.6	0.6	0.46	29.3
P. flavipinnis	39	28.75	1.5	0.15	18.4
E. coruscans	44	49.6	0.5	0.99	39.7
E. carbunculus	59	57*	0.5	0.95	45.6
E. morrhua	48	37.1	0.5	0.76	29.7
E. septemfasciatus	108	86*	0.5	0.8	68.8
L. chrysostomus	44	38*	0.5	0.87	30.4

* estimated from Lmax, not Linf

4.3 <u>Discussion</u>

For every species except E. coruscans Lc>Lm i.e. the fish enter the fishery at a size larger than that at which they gain sexual maturity. This is a good situation, since the risk of driving down the spawning stock is reduced.

Polovina (1986c) concludes that :

if Lc>Lm then Fopt. < = 2M
if Lc<=Lm then Fopt. < = M

That is, the optimum level of fishing mortality can be almost twice that of natural mortality as long as the fish reach maturity before they are fully represented in the catch. We do not yet know the mortality rates for our species, but as long as Lc> Lm, there appears to be an inherent safety factor which provides some protection to spawning fish.

In considering yield per recruit, again a healthy picture appears. In every case the fishery can afford to take smaller fish than it is actually taking. However, the optimum length (Lopt) does not take size of maturity (Lm) into account. Obviously, if fish are taken after they reach maturity, a higher level of fishing effort can be employed without wiping out the spawning stock.

If we look at the ratio of current Y/R to max Y/R it appears that E. coruscans and E. carbunculus are very close to their optimum yield. All other species are satisfactory except P. filamentosus which is currently producing only half its potential.

In the case of P. flavipinnis, a first analysis of Z/K produced a negative value. Using a different method, a value of 11.5 was obtained, which is very high. This could be due to one, or a combination, of several factors:

a) the fish are being rapidly depleted through overfishing
b) the fishermen are avoiding them, possibly due to the inconvenience of hauling small fish from deep water (P. Mead, pers.comm.)
c) pooling of sexes during sampling
d) depth stratification.

The K (growth factor) values computed were consistently lower than those produced from the Marianas data (see Table 6) and must be viewed with caution.

TABLE 6 POPULATION PARAMETERS FOR THE SEVEN MAJOR SEPCIES CAUGHT BY HANDLINING IN THE MARIANAS

Species	Von Bertalanffy growth parameters Linf. (cm)	K(1/yr)	Instan-taneous natural mortality (M)	Age of entry to the catch tc(yr)	Age of maturity tm(yr)
C. lugubris	75.1	0.430	0.53	1.3	1.8
P. filamentosus	67.3	0.228	0.57	4.3	2.0
P. auricilla	42.6	0.335	0.81	3.6	2.4
P. zonatus	47.0	0.245	0.63	4.65	3.25
E. coruscans	97.6	0.166	0.38	6.2	4.1
E. carbunculus	69.1	0.175	1.55	3.45	2.75

If otoliths taken during the sampling programme can be read, then values of K for each species can be directly obtained from them. Once reliable K values are available then the M values can be calculated.

5. SUMMARY

Analysis of the first 9 months data has shown the basic sample design to be adequate except that:

a) more quarterly length samples are required (1000 p.a. for each major species to estimate Z/K; and

b) successful depletion estimates must be conducted to estimate Bo.

If the Hawaii and Marianas estimates are used, the total Tongan deep-bottom catch of 716 t for 1987 could be over the 'safe' estimated MSY of 325 t. A resulting drop in catch rates may thus be encountered in the future. The current catch rate of 6.71kg/reel-hour is high compared to catch rates obtained during trials elsewhere in the Pacific. However, the analysis of length data for the major individual species stocks reveals that, with the exception of P. flavipinnis and E. carbunculus, they are being slightly under-fished rather than over-fished.

Possibly the estimate of MSY for the Marianas is conservative for Tonga. As the programme continues, we hope to approach the true MSY for Tonga with greater accuracy. New fishing grounds recently discovered will be the site of depletion experiments, a crucial step towards estimating MSY based on data from Tonga rather than elsewhere. Further bathymetric work will assist in more accurate mapping of fishing grounds.

6. ACKNOWLEDGEMENTS

We wish especially to thank Dr J. Polovina who supervised our data analysis, giving us much of his valuable time and patient tuition. Thanks also to Ron Benco, his computer programmer. We thank Dr. R. Shomura, Director, S.W.F.C., Honolulu laboratory, who made the whole visit possible. We also thank Dr. J.Munro, T.Polacheck, C.Walters, R.Hilborn for their criticisims and suggestions.

In Tonga, we thank all research staff who assisted in data collection, P. Mead for his advice, and the fishermen for their patient cooperation.

We acknowledge with gratitude the funds provided by ADAB through FFA and the FAO/UNDP funds which made the data analysis possible.

7. REFERENCES

BEVERTON, R.J.H. and S.J. HOLT. 1986
Manual of methods for Fish Stock Assessment Part 2. Tables of Yield Functions FAO Fisheries Technical Paper No.38 (Rev. 1)

BROUARD, F. and R. GRANDPERRIN. 1984.
Les poissons profonds de la pente recificale externe a Vanuatu Mission Orstrom Vanuatu. Notes et Documents D'oceanographic 11, 131p.

CROSSLAND, J. 1980.
"Fishes of the Outer Reef Slopes" 1980. SPC Fisheries Newsletter No. 21, p.26-35 Noumea, New Caledonia.

FISHERIES DIVISION, FIJI. 1987.
"Management Plan for Fiji's Deepwater Snapper Fishery".

GRIMES, C.B. 1986.
Reproductive biology of the Lutjanidae: A review. In "Tropical Snappers and Groupers: Biology and Fisheries Management." Westview Press Inc., Boulder, Colorado.

MANOOCH, C.S., III. 1986.
Age and growth of Snappers and Groupers. In "Tropical Snappers and Groupers," see above.

MEAD, P.D. 1979.
Report on the South Pacific Commission Deep Sea Fisheries Development Project in the Kingdom of Tonga 3 June - 20 Sept. 1978. S.P.C. Noumea, New Caledonia.

MUNRO, J.L. 1986.
Methods for Appraisal and Assessment of Coastal Fishery Resources in the South Pacific Region. ICLARM, Australia.

RALSTON, S. and J.J. POLOVINA. 1982.
A multispecies analysis of the commercial deep-sea handline fishery in Hawaii. Fish. Bull., U.S. 80: 435-448.

RALSTON, S. 1986.
Mortality rates of snappers and groupers. In "Tropical snappers and groupers" see above.

RICKER, W.E. 1975.
Computation and Interpretation of biological statistics of fish populations. Bull. Fish Res. Board Can. 191, 382p.

POLOVINA, J.J. and S. RALSTON. 1986.
An approach to yield assessment for unexploited resources with application to the deep slope fishes of the Marianas. Fish. Bull. 84: No.4 1986.

POLOVINA, J.J. 1986a.
A variable catchability version of the Leslie model with application to an intensive fishing experiment on a multispecies stock. Fish. Bull., U.S. 84: 423-428.

1986b. Variation in catch rates and species composition in handline catches of deepwater snappers and groupers in the Mariana Archipelago. Proc. 5th. Int. Coral Reef Congr. 1985, Tahiti.

1986c. Assessment and Management of deepwater bottom fishes in Hawaii and the Marianas. In J.J. Polovina and S. Ralston (editors), "Tropical Snappers and Groupers: Biology and fisheries management." Westview Press, Inc., Boulder, Colorado.

POLOVINA, J.J., R.B.MOFFITT, S.RALSTON, P.M.SHIOTA, AND H.A.WILLIAMS
Fisheries Resource Assessment of the Mariana Archipelago,1982 to 1985. Marine Fisheries Review 47(4) pp.19 - 25.

WALTERS, C.J. and R. HILBORN. 1986.
A syllabus for Tropical Fisheries Stock Assessment. Preliminary Report. SPC Noumea, New Caledonia.

WETHERALL, J.A., J.J. POLOVINA and S. RALSTON. 1985.
In press. Estimating growth and mortality in steady state fish stocks from length-frequency data. In D. Pauly and G.R. Morgan (editors) Length-based methods in fishery research. The ICLARM/KISR Conference on the Theory and Application of Length-Based Methods for Stock Assessment. Sicily, Italy, February 1985 Vol. 1.