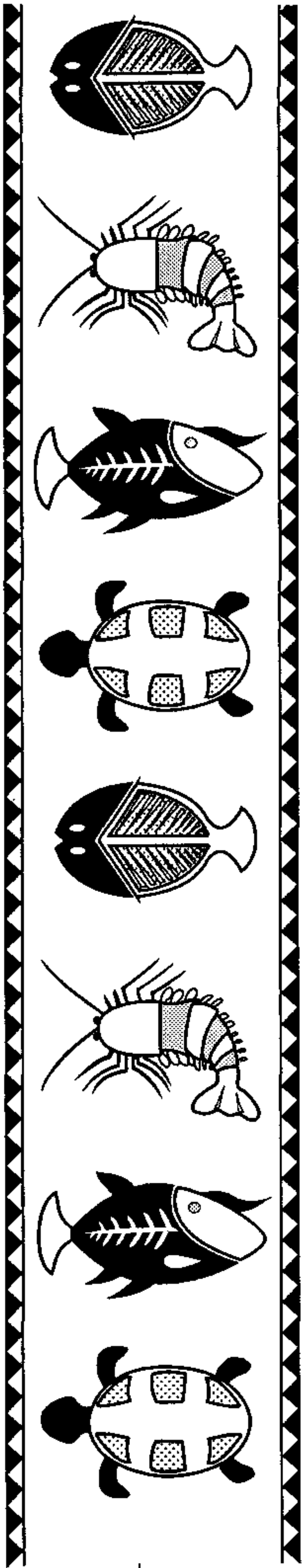

Inshore Fisheries Research Project
Miscellaneous Contributions

A REPORT TO THE GOVERNMENT OF TONGA ON AN EVALUATION OF THE PROGRESS OF THE INSHORE REEF ASSESSMENT AND MONITORING PROJECT

South Pacific Commission
Noumea, New Caledonia

A report to the
Government of Tonga
on
an evaluation of progress of the
INSHORE REEF ASSESSMENT AND MONITORING PROJECT

prepared by

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Presented to the Government of Tonga
by the
South Pacific Commission
and the
International Center for Living Aquatic Resources Management

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Executive Summary

The Inshore Reef Assessment and Monitoring Project in Tonga has been implemented over a three year period. A sample survey during 1986/87 provided the first estimates of total fish catches, and of the relative importance of different species and fishing gears in the Tongatapu nearshore fisheries.

A similar survey was executed in Ha'apai in 1988/89 but the data have not yet been analyzed.

Routine fishing conducted on the Tongatapu shelf during 1987/88, using a standardized array of fishing gears, produced excellent results but the data have only been subjected to preliminary analyses.

All of the work has been accomplished by the Project Leader (on contract to an aid organization) and a single temporarily-employed Field Assistant, plus occasional unskilled casual workers. No member of the staff of the Tongatapu Fisheries Division has been directly involved in the Project and there has consequently been no transfer of the skills utilized or acquired during the course of the Project.

The decision to repeat the Tongatapu sample survey in Ha'apai resulted in the routine fishing in Tongatapu being terminated with consequent loss of continuity and adverse effects on the potential usefulness of the data.

Recommendations are made concerning the future of the Project. It will be necessary for the Fisheries Division to make a decision on the incorporation of the work on the Project into the routine work of the Division.

It is recommended that the assistance of the South Pacific Commission Inshore Fisheries Research Project be sought in the analysis of the accumulated data and the preparation of a comprehensive set of reports.

Acknowledgements

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1. INTRODUCTION

This project had its origins in 1987 when the Fisheries Division of the Kingdom of Tonga decided to embark on a project designed to test the feasibility of implementing the so-called "ICLARM approach" to the assessment and monitoring of small-scale, multi-species, multi-gear fisheries (Munro 1983, 1986, Munro and Fakahau 1987), such as are typified by the fisheries of the island shelf of Tongatapu, the main island in Tonga.

Previous information on the artisanal and subsistence fisheries of Tonga are exceedingly sparse (Gillett et al 1988) and the only substantial documents are those of Halapua (1982).

There have been previous attempts to set up fisheries statistical systems in Tonga or recommendations for their creation. During the mid-1970s an FAO project collected data and some of the results are given in brief by Thomas (1978). However, no final report appears to have been generated and a substantial part of the data is said to have been destroyed in the 1982 cyclone. The FAO project might have had its methodological base in the report by West (1976) but this is not evident from any of the records. Subsequently, Grant (1977) prepared some recommendations for collection of fisheries statistics, but it appears that these recommendations were not acted upon.

Polacheck (1986) prepared a report on behalf of FAO and reviewed the previous attempts to gather fisheries statistics. In connection with the "small-scale reef fisheries" He pointed out that "the two sectors of the fishery for which almost no information is currently being collected are the reef fisheries by small-boat fishermen and the shore-based collectors, gatherers and fishermen". He also stated that "... it is important to collect (data) within a framework of possible management and stock assessment options which are likely to be used and for which it is realistically possible to collect ... sufficient data". He also expressed an opinion that the "single-species approach ... is unlikely ever to be a workable approach to the management of the highly-complex, multi-species situation found in the reef situation". It will be shown later that this is a debatable assumption.

Polacheck's (1986) report highlighted the lack of success that had attended previous efforts to document the small-scale reef and lagoon fisheries and recommended that information be collected on catches and catch rates in different locations and also recommended that, whatever the system adopted, it should initially be developed to sample the more important and accessible components of the fishery. This is an important qualification.

It was against this background that the leader of the current project, Mr. Karl Felfoldy-Ferguson, was instructed to try to implement the "ICLARM approach" (Munro 1983, 1986; Munro and Fakahau 1987) to the monitoring and assessment of the small-scale, multi-species, multi-gear artisanal fisheries of Tongatapu. The essential features of this approach are the execution of a basic frame survey designed to provide an inventory of fishermen, fishing gears and vessels and pertinent socio-economic data plus an assessment of the species composition of catches taken by various fishing methods or gear sizes, estimates of the catch rates in those gears and of the approximate total landings of the main species captured by the fishery. This is then followed by a continuing programme of routine fishing with a standardized array of fishing gears, which are designed to give adequate samples of the most important species in the catches. These are in turn expected to provide the basis for estimates of growth and mortality parameters and thus permit basic assessments of whether or not the species involved are "overfished" or "underfished" in terms of their growth and mortality rates and rates of exploitation.

The emphasis on the species composition of the catches is an important aspect of the methodology. Virtually all previous fishery sample survey methodologies recommend that catches be categorized by family, value, method of capture, etc. However, such categorizations are of singularly little use to the fishery manager who must know the specific identity of the fish stocks that are being managed.

Conventional approaches to this problem have involved the execution of very detailed sample surveys of the fisheries (Caddy and Bazigos 1985) to evaluate the catch, catch composition and numbers of fishermen and gears, but with no provision for actually assessing the state of the fishery. There is no example of the implementation of such an exercise followed by successful management of any tropical fishery. Indeed, examples of the successful implementation of frame surveys along the lines suggested by Caddy and Bazigos (1985) are difficult to find.

The essential point is that even if a successful sample survey is conducted (e.g. Sahney 1983, for Jamaica), one is still little advanced in deciding what management measures are needed or, indeed, whether any measures are required at all. The principal argument in the "ICLARM approach" is that the actual magnitude of landings is of little singularly little importance and, for socio-economic purposes the economic status of the fishing community can be gauged with comparatively little effort. The critical questions relate to the rate of exploitation of the principal species in the fishery. Are they overexploited or could more effort be brought to bear? Are there unexploited or under-exploited stocks which could be targeted? It is argued by Munro (1986) that these question can be answered on the basis of samples of the exploited species being acquired by a continuing programme of routine fishing with a standardized array of fishing gears. The development of length-converted catch curves by Pauly (1982) has provided an extraordinarily robust means of estimating the mortality rates of fish stocks based on the average annual size composition of the stock (Pauly and Morgan 1987) and various computer-based analytical suites of programs provide a means of efficiently analyzing such data.

This project was reviewed soon after its inception (Munro 1987), at which time a routine array of fishing gear was selected and an offer was made to actively provide the project with scientific support as a module of ICLARM's "Management-orientated fish stock assessment project". However, this offer was not taken up and the project proceeded along the predetermined lines. The offer still stands.

The consultant has an interest in the success of the project which should be made clear at the outset, insofar as the methods have been proposed by the consultant and by the Principal Fisheries Officer of The Kingdom of Tonga (Munro 1983,1986; Munro and Fakahau 1987) on the basis of extensive experience of the seemingly intractable problem of the cost-effective evaluation, assessment, monitoring and management of small-scale fisheries. The project which is under review represents the first attempt to systematically implement the proposed methodology.

1.1. Terms of reference

The terms of reference stipulated for this review are as follows:

In conjunction with staff of the Tonga Fisheries Department:

review progress of the Inshore Reef Assessment and Monitoring Project;

assist in interpretation of fishery data, including that obtained by controlled fishing with a standardized array of gear;

assist in the design of future data gathering activities;

review the recently completed survey of Ha'apai fishing activities.

There was also provision for "other activities" to be "defined by the Tonga Fisheries Department", but no additional activities were stipulated during the course of this review.

1.2. Objectives of the Project

As described by Felfoldy-Ferguson (1987), the project objectives are to evaluate the feasibility of implementing the approach outlined in Munro and Fakahau (1987). In essence, this involves the execution of a frame survey of the fishery in question to provide a base line for the planning of future work, for the establishment of an inventory of fishing gears, vessels, fisherfolk and socio-economic factors and a survey to estimate the composition and magnitude of catches of the fishery. Thereafter, a programme of routine fishing with a standardized array of fishing gears is implemented. Figure 1, reproduced from Munro and Fakahau (1987) shows the expected flow of activities and accomplishments.

1.3. Summary of activities to date

The work of the project has been divided into four phases, starting with a sample survey of the Tongatapu inshore fishery, then a year of routine fishing on the Tongatapu shelf, followed by a repeat of the exercise in the island group of Ha'apai, in which the routine fishing operations have only recently started. The addition of the work in Ha'apai precluded the implementation of the second year of routine fishing in Tongatapu and constitutes a serious deviation from the original plan, because a continuous routine fishing programme is the key factor in the "ICLARM approach". However, as will be shown later, this deviation from the original plan can probably be turned to good advantage, in that the reefs of the Ha'apai group are very lightly exploited and provide a striking contrast to the fisheries of Tongatapu. This advantage will only be realized if the project continues for sufficient time to permit the analysis of the data.

This was the first occasion on which frame and sample surveys of the inshore fisheries have ever been accomplished in Tonga. All of this work has been done by the Project Leader, Mr. Karl Felfoldy-Ferguson assisted by a Field Assistant, Mr Sione Mailau, who has high school leavers' qualifications, plus a variable number of casually-employed unskilled workers.

2. REVIEW OF PROGRESS

2.1. Tongatapu frame and catch assessment survey

The basic results of the Tongatapu catch survey have been presented by Felfoldy-Ferguson (1988). The frame survey included the registration of fishermen by a door-to-door census, interviews with fishermen dealing with socio-economic questions, fishing methods, fishing assets, fishing grounds utilized, fishing effort and other pertinent information.

Information on the magnitude and species composition of catches was obtained by monitoring the activities of selected fishermen and from market surveys of landings.

The fishing grounds were mapped and measured on the basis of aerial photographs and nautical charts and the grounds subdivided on an ecological basis and on the basis of usage by the fishing community. The deep shelf to the north of Tongatapu is entirely unutilized and only the portions of this shelf proximal to Ton-

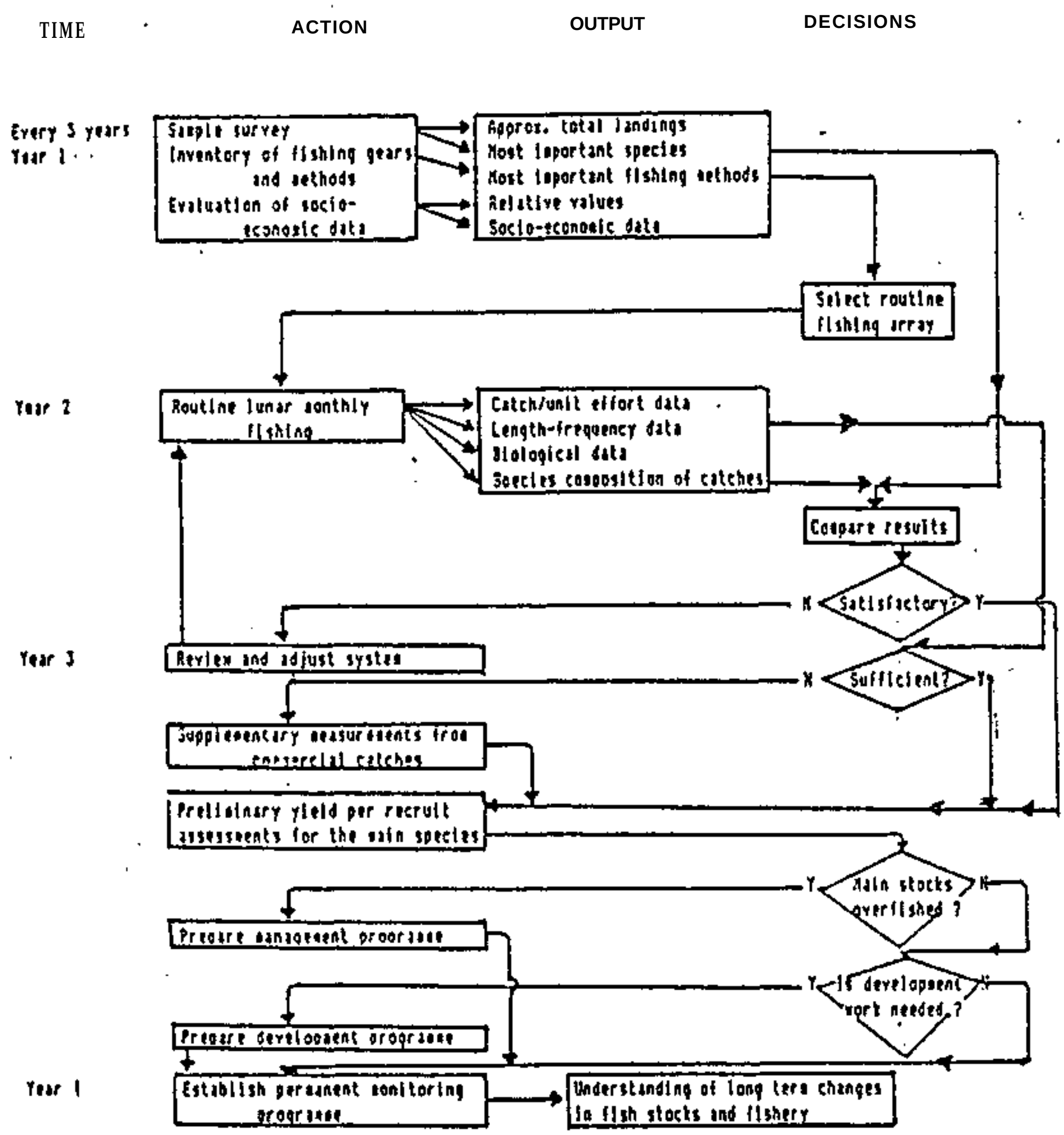


Figure 1. Time frame, actions, decisions and outputs of a systems approach to atock assessment, monitoring and management (from Munro and Fakahau, 1987).

gatapu are regarded as "accessible" to the smallcraft operated by the fishery.

Table 1 shows the estimated composition of the catch in the principal fisheries gears used in, the Tongatapu artisanal fishery in 1987, which is primarily based on gillnets (574,800 net/hours), spear fishing (634,230 man-hours), handlining (1,148,937 line-hours) and other methods (mainly fixed fish traps) (notionally 468,473 gear-hours). The current estimate of total landings of 824 mt (Table 2) is an upwards revision of the estimate presented by Felfoldy-Ferguson (1988) which, on examination, was found to contain a logical error in its derivation. The results refer to fish only, and no attempt was made to gather data on catches of invertebrates. This stemmed from a misunderstanding of the scope of the work.

Parts of the data from the FAO statistical survey that remain on file at the Fisheries Division might merit re-examination to see if any useful comparisons of catch rates or catch compositions can be made with the present data.

2.2. Tongatapu routine fishing

The Tongatapu nearshore fishing grounds have been sampled on a routine basis for a full calendar year (13 lunar months) from September 10, 1987 to September 26, 1988. Additionally, samples were taken in February 1988 and July 1988, covering all stations and all fishing gears.

The gears selected for the routine fishing were gill nets, handlines and Antillean fish traps (Munro 1987). The choice of the fish traps was on the basis of fairly extensive trials conducted in Papua New Guinea (Dalzell and Aini, undated) and a few brief trials in Tonga (Felfoldy-Ferguson 1988). The traps have also been extensively tested in New Caledonia (Kulbicki and Moutham 1987).

The routine fishing produced a sample of 13,806 fishes; 8,314 in traps, 4,607 in gillnets and 885 on handlines. Table 3 shows a comparison between the overall percentage composition of the the landings of the fishery with the catches (by number and percent by weight) in the routine fishing gears. The predominant species, *Lethrinus nebulosus,* comprises 23.7% of the catch of the fishery and constituted 12.3% of the routine fishing catch (N= 781). The mullet, *Mugil cephalus* is 17.0% of the artisanal catch and 9.9% of the routine fishing catch (N = 590). The third-ranked species, *Lethrinus elongatus,* is represented in the catches by only 136 specimens, reflecting its importance in the labour-intensive handline fishery.

Other species are represented in the routine fishing data in varying degrees. For some of the smaller species, such as *Leptoscarus vaigiensis,* adequate samples are readily attainable,

Table 1. Tongatapu catch assessment survey, shoving species contributing 1.8% or more by weight in any type of fishing gear.

	SPECIES:	Gillnet: No:	Kg:	%Kg:	Handline: No:	Kg:	%Kg:	Spear: No:	Kg:	%Kg:	Other: No:	Kg:	%Kg:
1	Lethrinus nebulosus	74	23.55	3.71	131	107.29	46.79	86	33.11	13.31	4	1.01	.56
2	Mugil cephalus cephalus	176	155.39	24.51	0	.00	.00	0	.00	.00	122	104.43	58.05
3	Lethrinus elongatus	15	6.40	1.01	43	38.57	16.82	7	2.93	1.18	0	.00	.00
4	Sargocentron spiniferum	69	22.10	3.48	38	14.74	6.43	41	13.86	5.57	1	.26	.14
5	Lethrinus ramak	5	1.30	.21	59	15.28	6.66	18	3.91	1.57	2	.31	.17
6	Leptoscarus vaigiensis	289	40.43	6.38	0	.00	.00	26	6.60	2.66	8	1.46	.81
7	Trichiurus lepturus	27	36.96	5.83	0	.00	.00	0	.00	.00	0	.00	.00
8	Parupeneus pleurotaenia	102	24.30	3.83	0	.00	.00	0	.00	.00	39	9.67	5.38
9	Lethrinus harak	13	3.66	.58	15	8.51	3.71	0	.00	.00	5	.92	.51
10	Selar crumenophthalmus	83	18.04	2.84	0	.00	.00	0	.00	.00	28	6.50	3.61
11	Siganus argenteus	127	20.95	3.30	0	.00	.00	44	13.11	5.27	11	1.40	.78
12	Mulloidichthys vanicolensis	69	17.23	2.72	0	.00	.00	18	4.39	1.77	23	4.53	2.52
13	Rastrelliger kanagurta	29	21.78	3.43	0	.00	.00	0	.00	.00	0	.00	.00
14	Lutjanus fulviflamma	84	9.40	1.48	11	2.84	1.24	20	4.36	1.75	18	2.05	1.14
15	Leiognathus equula	72	15.16	2.39	0	.00	.00	0	.00	.00	22	3.98	2.21
16	Sphyraena forsteri	25	7.50	1.18	12	2.60	1.14	0	.00	.00	4	.81	.45
17	Gymnocranius japonicus	2	1.30	.21	6	4.35	1.90	3	1.70	.68	0	.00	.00
18	Mulloidichthys flavolineatus	64	13.16	2.08	0	.00	.00	0	.00	.00	8	1.46	.81
	Other Species:	1017	195.49	30.83	111	35.13	15.32	423	164.74	66.24	189	41.11	22.85
	Totals:	2342	634.09	100.00	426	229.31	100.00	686	248.71	100.00	484	179.90	100.00
	Gear Hours sampled			1090			520			697			528.00
	Catch/Gear-hour	2.15	.58		.82	.44		.98	.36		.92	.34	

Table 2: Estimated total landings of major species in the Tongatapu fishery by different fishing gears.

		Gillnet:	Handline:	Spear:	Other:	Total:	
	Estimated total annual gear hours:	574800	1148937	634230	468473		%
	Estimated total annual landings:	mt/year:	mt/year:	mt/year:	mt/year:	mt/year:	mt/year:
1	Lethrinus nebulosus	12.39	76.34	105.94	.56	195.23	23.7
2	Mugil cephalus cephalus	81.85	.00	.00	58.18	140.03	17.0
3	Lethrinus elongatus	3.37	27.44	38.08	.00	68.90	8.4
4	Sargocentron spiniferum	11.62	10.49	14.56	.14	36.81	4.5
5	Lethrinus ramak	.70	10.87	15.08	.17	26.82	3.3
6	Leptoscarus vaigiensis	21.31	.00	.00	.81	22.12	2.7
7	Trichiurus lepturus	19.47	.00	.00	.00	19.47	2.4
8	Parupeneus pleurotaenia	12.79	.00	.00	5.39	18.18	2.2
9	Lethrinus harak	1.94	6.05	8.40	.51	16.90	2.1
10	Selar crumenophthalmus	9.48	.00	.00	3.62	13.10	1.6
11	Siganus argenteus	11.02	.00	.00	.78	11.80	1.4
12	Mulloidichthys vanicolensis	9.08	.00	.00	2.53	11.61	1.4
13	Rastrelliger kanagurta	11.45	.00	.00	.00	11.45	1.4
14	Lutjanus fulviflamma	4.94	2.02	2.81	1.14	10.92	1.3
15	Leiognathus equula	7.98	.00	.00	2.21	10.20	1.2
16	Sphyraena forsteri	3.94	1.86	2.58	.45	8.83	1.1
17	Gymnocranius japonicus	.70	3.10	4.30	.00	8.10	1.0
18	Mulloidichthys flavolineatus	6.95	.00	.00	.81	7.76	1.0
20	Other Species:	102.98	24.98	34.67	22.92	185.52	22.3
	Totals:	333.96	163.15	226.42	100.22	823.75	100.0

Table 3: Comparison of compositions of routine fishing catches with the overall landings of the Tongatapu fishery.

		Observed abundance in routine catches								Annual landings of the fishery	
		Gillnets		Handlines		Traps		All gears		Total	%
	SPECIES:	No.	%Kg	No.	%Kg	No.	%Kg	No.	%Kg	mt/year	by wt.
1	Lethrinus nebulosus	125	3.21	68	16.25	588	16.92	781	12.13	195.23	23.7
2	Mugil cephalus cephalus	590	29.82	0	0	0	.00	590	9.94	140.03	17.0
3	Lethrinus elongatus	0	.00	86	5.79	50	.30	136	2.03	68.90	8.4
4	Sargocentron spiniferum	49	.61	51	4.24	204	1.50	304	2.12	36.81	4.5
5	Lethrinus ramak	0	.00	28	1.31	24	.11	52	.47	26.82	3.3
6	Leptoscarus vaigiensis	432	5.58	0	0	0	.00	432	1.86	22.12	2.7
7	Trichiurus lepturus	86	3.38	0	0	0	.00	86	1.13	19.47	2.4
8	Parupeneus pleurotaenia	175	1.87	0	0	4	.02	179	.63	18.18	2.2
9	Lethrinus harak	153	2.04	33	1.21	5	.03	191	1.09	16.90	2.1
10	Selar crumenophthalmus	24	.39	0	0	0	.00	24	.13	13.10	1.6
11	Siganus argenteus	74	.92	0	0	360	4.00	434	1.67	11.80	1.4
12	Mulloidichthys vanicolensis	46	.46	0	0	52	.42	98	.29	11.61	1.4
13	Rastrelliger kanagurta	276	12.78	0	0	0	.00	276	4.26	11.45	1.4
14	Lutjanus fulviflamma	264	1.98	61	2.06	511	2.86	836	2.3	10.92	1.3
15	Leiognathus equula	27	.19	0	0	0	.00	27	.06	10.20	1.2
16	Sphyraena forsteri	87	1.89	14	1.28	0	.00	101	1.06	8.83	1.1
17	Gymnocranius japonicus	0	.00	137	23.47	1239	15.68	1376	13.05	8.10	1.0
18	Mulloidichthys flavolineatus	126	.88	0	0	827	4.57	953	1.82	7.76	1.0
19	Parupeneus pleurospilos	0	.00	0	0	2773	29.24	2773	9.75	0	0
20	Upeneus arge	0	.00	0	0	357	8.63	357	2.88	0	0
	Other species	2073	34.00	407	44.39	1320	15.64	3800	31.33	185.52	22.3
	Totals:	4607	100.00	885	100	8314	100.00	13806	100	823.75	100.0

whereas larger species such as *Lethrinus ramak,* while important to the fishery in terms of weight, are large and consequently-poorly represented in the routine catches in numerical terms.

Invertebrates, including slipper lobster (Scyllaridae) were also captured by the routine fishing but were not recorded.

The use of the Antillean fish traps, has presented a few surprises. The basic premise was that traps would provide samples of those species which are captured by spearfishing and handlining, without having to expend a very great amount of man-hours on routine fishing with these gears,. This premise has been largely supported, to the extent that it is obvious that the introduction of the Antillean fish trap as an artisanal fishing gear in Tonga should be seriously considered. Unanticipated results of the utilization of Antillean traps were the discovery of entirely unexploited stocks of *Parupeneus pleurospilos* and *Upeneus arge* and an unidentified species of scyllarid lobsters, and marginally exploited stocks of *Mulloidichthys flavolineatus* and *Gymnocranius Japonicus.*

2.3. Ha'apai frame and catch assessment survey

The frame survey and catch assessment survey of the artisanal fishery of Ha'apai was conducted from October 1988 to November 1989. All of the data were at Ha'apai and the consultant was consequently unable to study the basic data. Some of the data have been entered onto a database and a preliminary analysis of the numbers of fishermen, vessels and fishing methods was the only information available for study.

2.4. Ha'apai routine fishing

The Ha'apai routine fishing survey commenced in October 1989 and is scheduled to cover a full year. Two stations are being monitored. Catch per unit of effort is greatly in excess of that obtained at Tongatapu. Data compilation is planned to be identical to that for Tongatapu.

2.5. Data compilation and analysis

The Tongatapu frame survey and catch assessment data have been compiled and analyzed and preliminary results presented at a regional fisheries workshop (Felfoldy-Ferguson 1988b). As no computer was available to the project until June 1988 the Tongatapu frame survey data and catch assessment data were compiled by hand on analysis sheets. The Fisheries Division took delivery of a sophisticated computer system in October 1987, but the Project Leader felt that pressures on its use were such that access could not be guaranteed on a regular basis and additional computers were ordered for the use of the Project.

Subsequent to the delivery of the Project's computer facilities, the compilation of catch data from the routine fishing at Tongatapu appears to have been maintained at a steady rate and all catch records have been accumulated in an spreadsheet database using Lotus 1-2-3. This database permits rapid sorting of the routine fishing data into catches by species and by gear type or size. The relatively complex nature of the database has meant that data entry has been the task of the Project Leader. Several attempts were made to employ assistants to undertake these duties but both appointees were unequal to the task.

The data for the Ha'apai frame survey have been compiled into a simple database using a commercially available database program. Data on numbers of households, numbers of fishermen, fishing gear usage and vessel usage have been compiled for all 27 villages in the Ha'apai group. For most of the villages close to 100% of households were contacted and interviewed. Overall, 95% of 1,539 households were contacted and 726 fishermen identified and enumerated.

Compilation of the Ha'apai catch assessment data is only in a preliminary phase and no results are yet available.

2.6. Accomplishments

Overall, the physical work accomplished by the project has been extraordinary. In no case has any expertise in the Fisheries Division been available to assist the Project and even the primary task of training a Field Assistant to accurately identify the 278 species of fishes so far recorded in catches has fallen to the Project Leader. The frame surveys alone have accomplished what no previous project has been able to do; namely, the accurate enumeration of the numbers of fishermen, fishing gears and vessels in Tongatapu and Ha'apai.

The Project has compiled the first comprehensive list of species in the nearshore catches and made estimates of the magnitude of the Tongatapu nearshore catch, based on observed catch rates in different fishing gears and the estimated total fishing effort in those gears. More sophisticated estimates of total landings are theoretically feasible using, for example, methods proposed by Caddy and Bazigos (1985). However, it must be borne in mind that only two people were available to accomplish this work. As was pointed out previously, the accurate identification of the species composition of the artisanal catches is considered to be an essential part of the methodology and thus precludes the employment of unskilled enumerators for catch assessment surveys, although such persons could be employed for doing the frame surveys.

It must also be emphasized that the objective of the catch assessment survey was to make an estimate of the <u>approximate</u> magnitude of the total catch. Such a course is anathema to the purists in fisheries science and those versed in the management of temperate water fisheries. Those who will object to this objective must explain what benefits would accrue if vastly greater amounts of money and manpower were expended on elaborate stratified sampling schemes. To take an extreme example, one can ask what would be consequence of an error of, say, 30% in the current estimate of the Tongatapu catch of 820 metric tons, which is split between several hundred species of fishes? The most important species, *Lethrinus nebulosus,* is estimated to comprise about 24% of the weight of Tongatapu catch or about 195 mt. A 30% error either way would therefore place the estimate at between 140 and 260 mt per year. In the context of the present state of the artisanal fishery such a difference is of singularly little importance and for the less important species the actual magnitudes of the differences diminish very rapidly.

The most important outcome of the catch assessment survey is that the most important species in the fishery have been identified with a high degree of certainty. The species comprising more than 1% of the total catch can be regarded as the key species in the fishery and any management measures need to be based on the assessment of the state of the stocks of these species.

The Tongatapu routine fishing was conducted by the Project Leader and his assistant plus a casual boat hand. A total of over 13,806 fishes of of over 200 species were captured, identified, measured and weighed in a single year by these three persons (Table 3). Two species provided samples of over 1000 fishes, four species are represented by samples of 501-1000 fishes and nine species by between 101-500 specimens. The more abundant samples provide a basis for the estimation of growth and mortality rates but the absence of the expected second year of data places a constraint on what can be done with the data for the less abundant species.

3. INTERPRETATION AND ANALYSIS OF DATA

Table 2 illustrates what is now becoming established as a basic premise in tropical fisheries; that, even when several hundred species are represented in the catch, only about twenty species will comprise more than 1% of the catch and that a very small number of species will constitute more than 5% of the artisanal catch. These top species can be considered to be the "indicator" species in the fishery and their state of exploitation can provide the basis for regulation of the fishery. For example, five species of the family Lethrinidae are represented in the 18 species which represent more than 1% of the artisanal catch. They can all be expected to have similar basic fishery parameters, particularly the growth performance index, ϕ or ϕ'

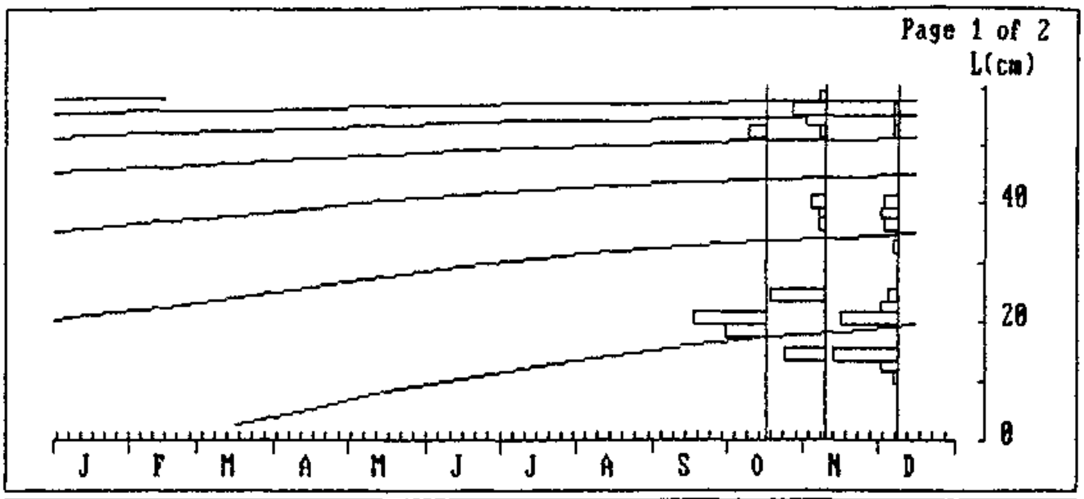
(Munro and Pauly 1983, Pauly and Munro 1984, Moreau et al 1986) and catchabilities by the predominant gears. It is therefore possible, in the short term at least, to concentrate on assessing the status of the predominant species, and use the acquired data to extrapolate to some of the lesser species, with due emphasis being placed on acquiring additional data on the other important species at the earliest possible time.

The original concept called for routine fishing to be conducted on a continuing basis at a steady but low level of effort for an indefinite period. Unfortunately, a decision was made to deviate from this plan, abandon the routine fishing at Tongatapu and replicate the Tongatapu sample survey at Ha'apai. This has meant that there is uncertainty regarding the degree to which the single year of routine fishing was typical, that seasonal patterns of abundance could not be verified and that there was no opportunity to adjust the routine fishing pattern in the light of accumulated experience (Fig.1). However, benefits can also be expected from comparisons between the Ha'apai and Tongatapu data because Ha'apai waters are much less intensively fished. For example, groupers (Serranidae) are virtually absent from the Tongatapu inshore catch but abundant in Ha'apai. The deduction is that groupers might be expected to decline in the Ha'apai catches in response to increased fishing effort.

It is feasible to calculate confidence limits for the estimated total landings of the Tongatapu fishery and, in due course, the Ha'apai fishery, based on the observed catch rates in different gears, and it is recommended that this be done.

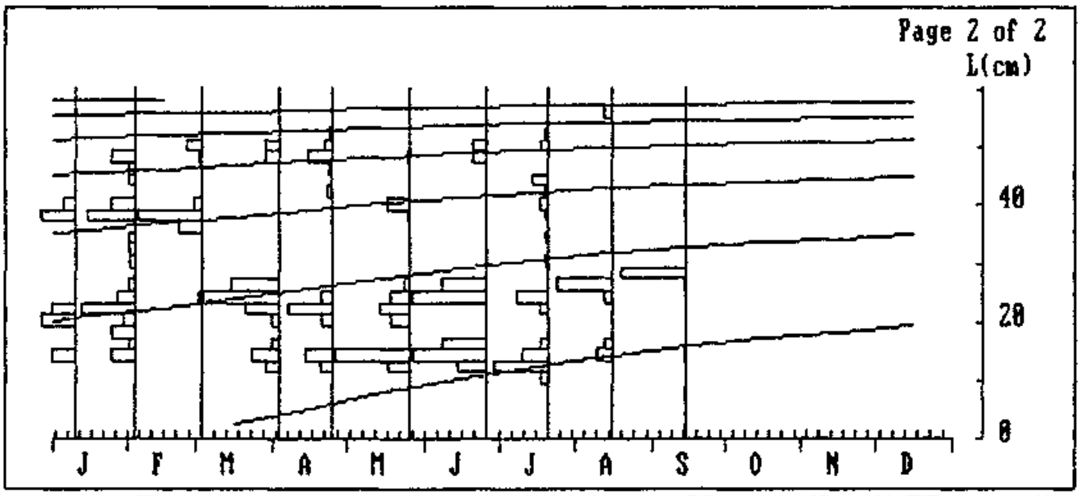
Preliminary data analyses have been carried out on a few species to illustrate the types of analysis which are possible. Figures 2 and 3 show the results of analysis (using the ELEFAN suite) of the current data set for *Lethrinus nebulosus* captured in traps. Despite considerable variability in the sampling, some length classes being absent from most samples (possibly related to size specific habitats), three size classes are discernable in most of the length-frequency samples, and estimates of Lµ = 62.6 cm and K = 0.45 are close to published estimates for this species. The length-converted catch curve (Fig. 3), yields a preliminary estimate of the totalt mortality coefficient Z = 1.025 and suggests that the rate of exploitation is low (E = 0.17).

Figures 4, 5 and 6 show an example of the results of analysis of trop-catch data for M*ulloidichthys flavolineatus,* which provided exceptionally clear modal progressions. This relatively large species of goat fish is almost completely unexploited in Tongatapu, as it is not vulnerable to any of the traditional fishing methods. The catch curve yields an estimate of of the natural mortality rate M = 1.013. Figure 6 shows the



Species name ▸ Lethrinus nebulosus (Tongatapu)

Loo	▸	62.60 cm
K	▸	0.450
C	▸	0.300
WP	▸	0.000
SS	▸	5
SL	▸	22.000 cm
Rn	▸	0.207



Species name ▸ Lethrinus nebulosus (Tongatapu)

Loo	▸	62.60 cm
K	▸	0.450
C	▸	0.300
WP	▸	0.000
SS	▸	5
SL	▸	22.000 cm
Rn	▸	0.207

Figure 2. Estimation of growth parameters for *Lethrinus nebulosua* using the ELEFAN I program. Data derived from fishing with Antillean Z-traps at Tongatapu from October 1987 to September 1988.

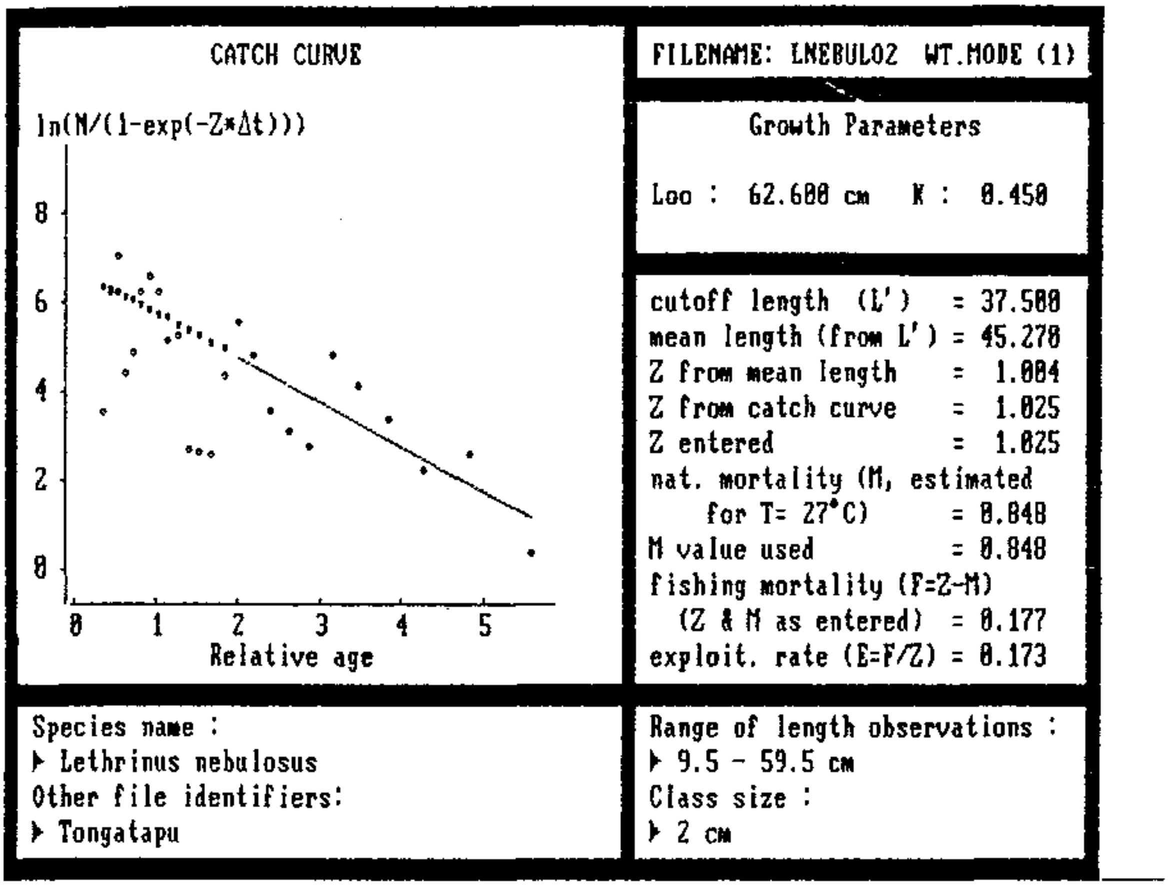
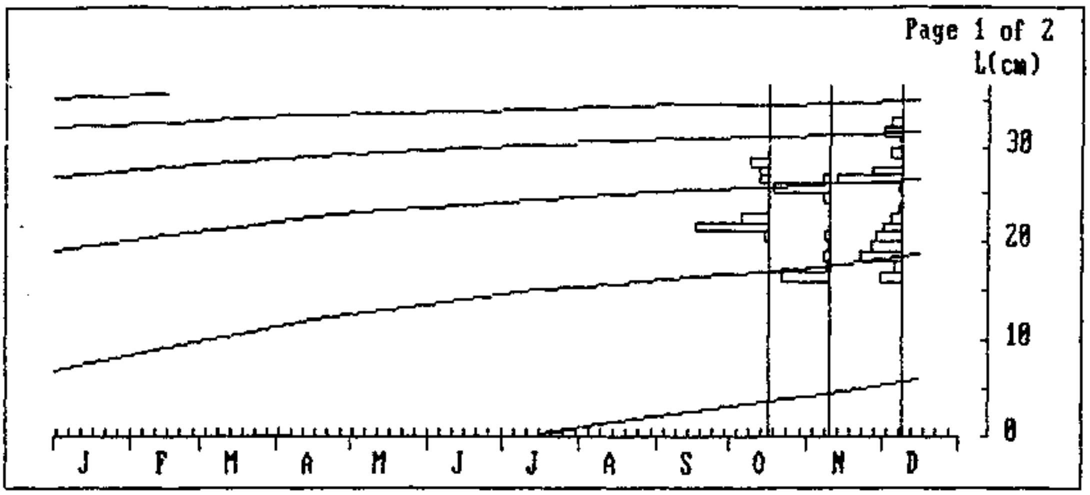
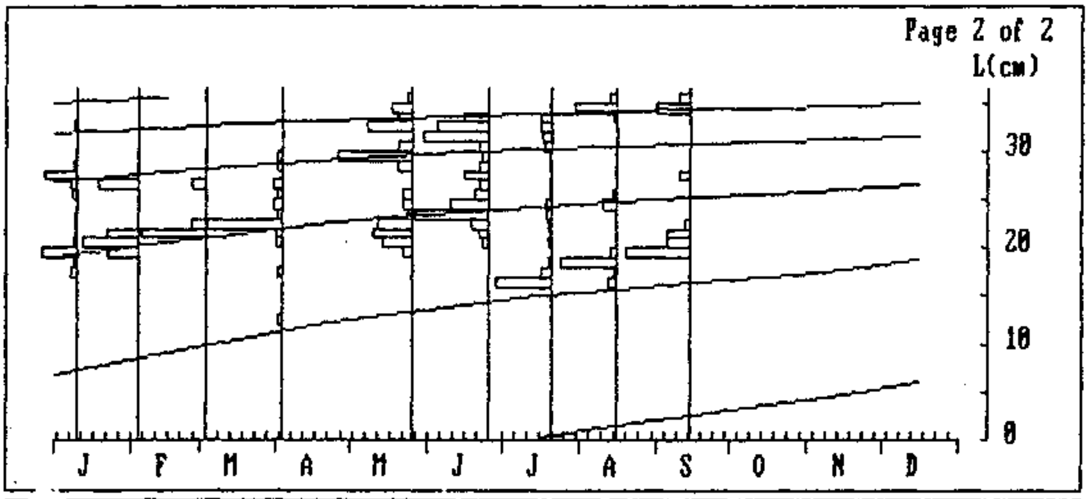


Figure 3. Estimation of mortality rate of *Lethrinus nebulosus* using the ELEFAN II program. Data derived from fishing with Antillean Z-trapa at Tongatapu from October 1987 to September 1980.



Species name ▸ Mulloidichthys flavolineatus (Tongatapu trap catch)

Loo	▸	40.40 cm
K	▸	0.456
C	▸	0.300
WP	▸	0.660
SS	▸	7
SL	▸	22.000 cm
Rn	▸	0.318



Species name ▸ Mulloidichthys flavolineatus (Tongatapu trap catch)

Loo	▸	40.40 cm
K	▸	0.456
C	▸	0.300
WP	▸	0.660
SS	▸	7
SL	▸	22.000 cm
Rn	▸	0.318

Figure 4. Estimation of growth parameters for *Mulloidichthys flavolineatus* using the ELEFAN I program. Data derived from fishing with Antlllean Z-traps at Tongatapu from October 1987 to September 1988.

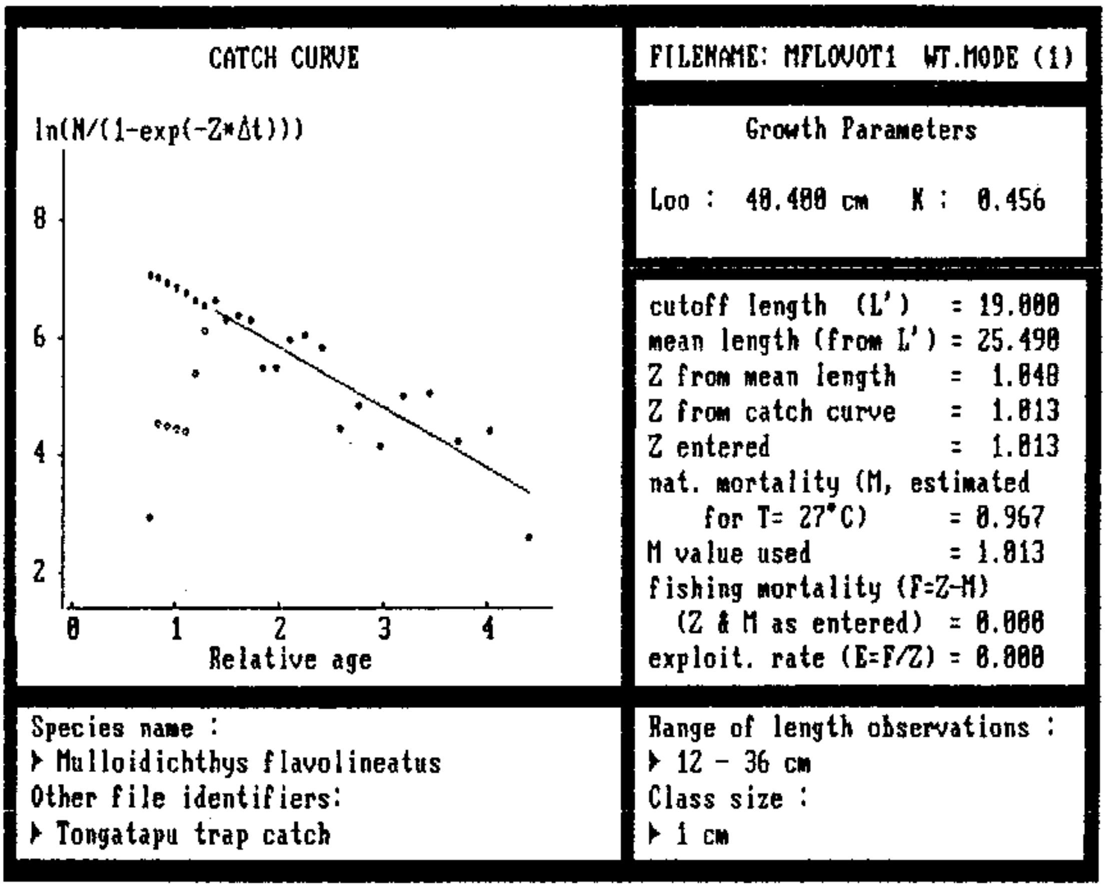


Figure 5. Estimation of mortality rate of *Mulloidichthys flavolineatu3* using the ELEFAN II program. Data derived from fishing with Antillean Z-traps at Tongatapu from October 1987 to September 1988.

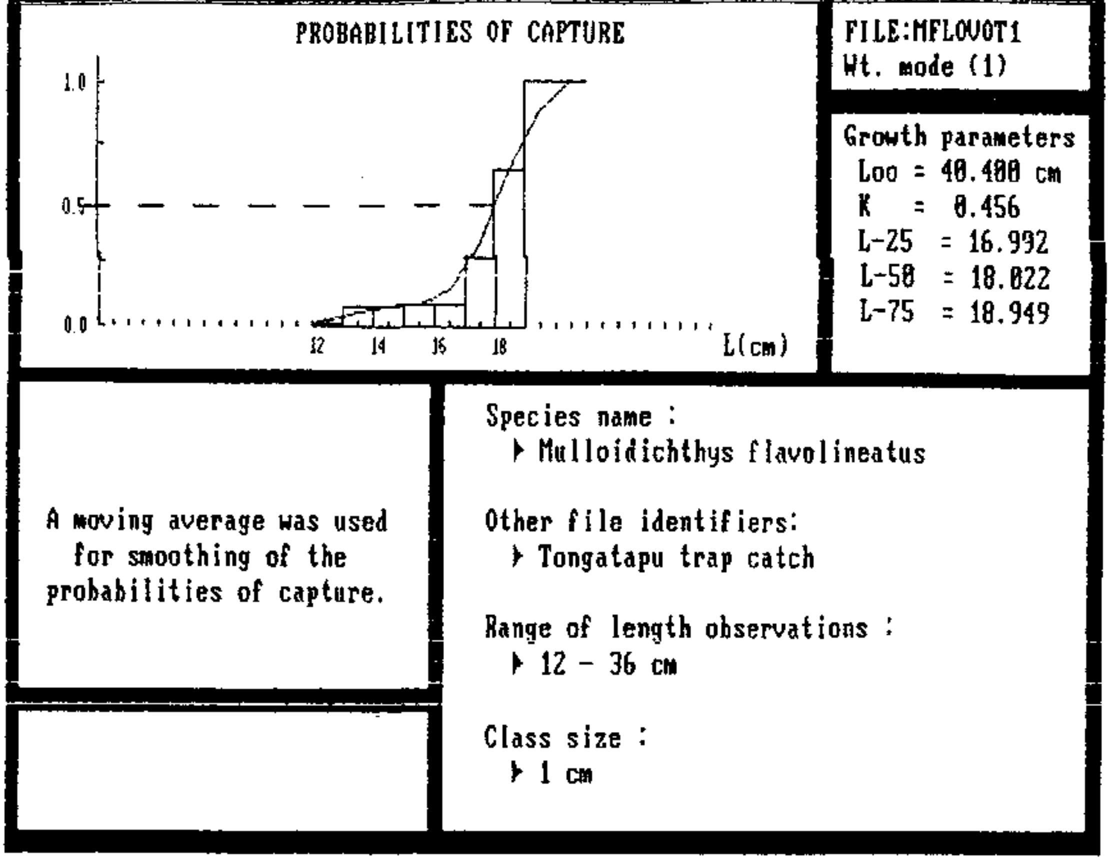


Figure 6. Selection curve for *Malloidichthys flavolineatus* in Antillean Z-traps, calculated by the ELEFAN II program.

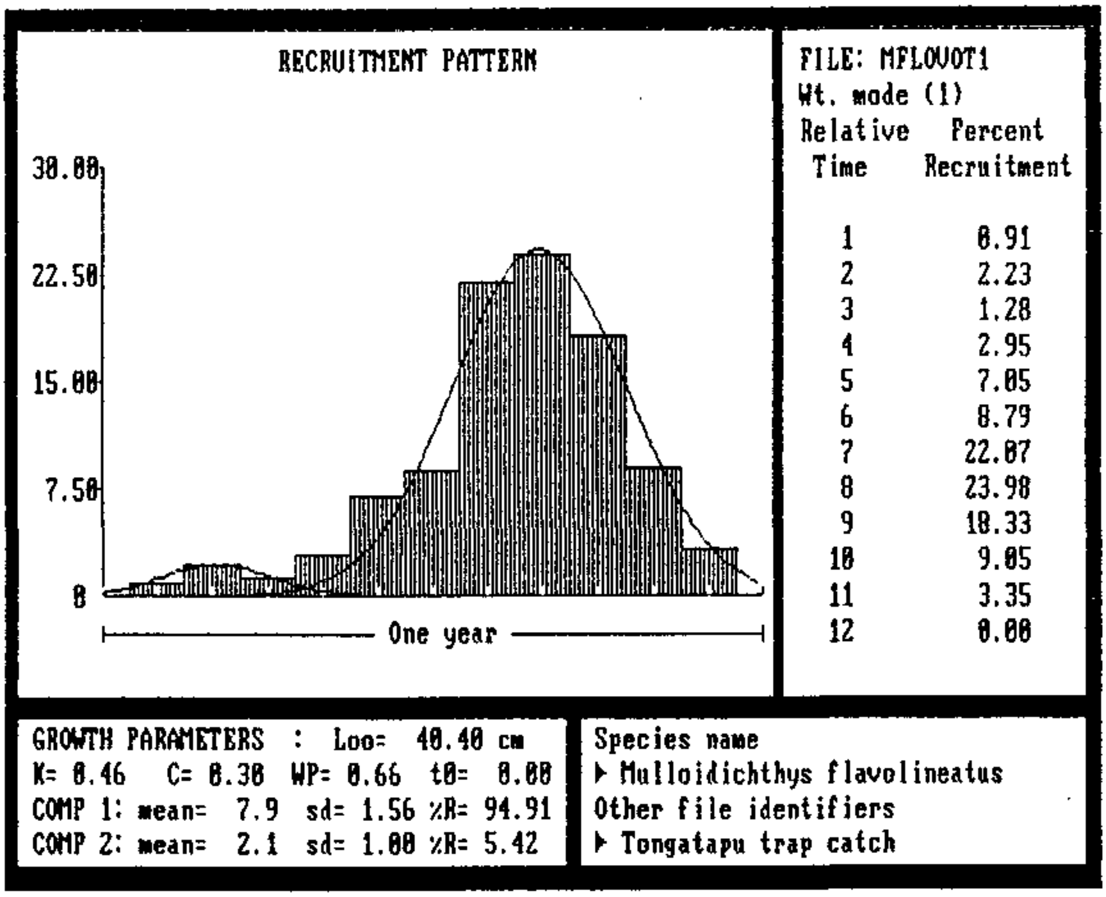


Figure 7. Recruitment pattern of *Mulloidichthys flavolineatus* at Tongatapu, calculated from the ELEFAN II program.

selection curve and Fig. 7 the recruitment pattern for this species, which has a clear single pulse of recruits.

The handline fishing provided modest catches of some species but further data need to be accumulated before hook selection curves can be developed and the data incorporated into the general pool.

The gill net fishing yielded good samples of many species and it will be possible to estimate selection of curves by various methods (e.g. Annex 1 and Figure 8 show the use of Holt's method for estimating gill-net selection curves for the parrot fish (*Leptoscarus vaigiensis).* However, most methods require a greater overlap in the selection ranges than is provided by the present data set and it is recommended that the present array of 1", 2", 3" and 4" mesh nets be supplemented by 1.5", 2.5" and 3.5" mesh nets.

The foregoing examples clearly show that useful results can be obtained for many species, even from a single year of sampling. However, the sampling programme needs to be continued if the less abundant species or less tractable data sets are to be fully utilized.

4. FUTURE DATA GATHERING ACTIVITIES

The work conducted over the past three years has quite clearly demonstrated that a single well-organized and hard working scientist with a single literate assistant can organize and execute a frame survey and catch assessment survey in an area such as Tongatapu or Ha'apai within the space of a single year. Likewise, the same combination plus casual labour can execute a routine fishing programme and acquire relatively large samples of fish by routine fishing and compile the data into a data base, also with a single year. However, all of these activities (sample surveys in Tongatapu and Ha'apai and a year of routine fishing in Tongatapu) have left exceedingly little time in which to analyze and consolidate the data.

The Tongatapu frame and catch assessment data remain on record sheets and have not been entered into any computer database. The analysis of the data is relatively superficial and more detail could be extracted if time was available to develop a suitable database, enter the data and analyze the information.

The data on routine fishing at Tongatapu have been compiled into a comprehensive database, but the analysis of these data has not yet been done. Furthermore, as the Project Leader is not a stock assessment specialist, the interpretation of the data and the analytical routines can be expected to generate some problems.

If the routine fishing at Ha'apai is conducted with the same intensity as that at Tongatapu it can be expected to generate very large amounts of data on size-frequency distributions and catch rates and catch compositions in the selected routine fishing gear. These data will also need to be compiled as they came to hand.

It is therefore concluded that for the immediate future no further data gathering activities should be contemplated pending analysis of the current data and a decision at the highest level concerning the future commitment of the Fisheries Division to this type of work. If the opinion is that this work has been worthwhile and should be continued, then a frame and catch assessment survey should be conducted at Va'vau in 1991. Concurrently, routine fishing should be continued at Ha'apai and recommenced at Tongatapu.

It is unfortunate that no member of the permanent staff of the Fisheries Division has been actively involved in this project and there has therefore been little opportunity to pass on the accumulated knowledge on survey techniques and data analysis. If, as seems possible, the Project is prematurely terminated by the donors the Fisheries Department will be left with a largely indigestible mass of information and no comprehensive written report.

If funding were to continue or if the work of monitoring the fishery is to be adopted as an integral part of the routine work of the Fisheries Division (as is implicit in the "ICLARM approach") then the routine sampling of the Tongatapu fishery should be recommenced at the earliest possible time and the Ha'apai sampling should be continued. The whole concept of the "ICLARM approach" is based on routine monitoring of the fish stocks on an indefinite basis, leading to the steady accumulation of data on all of the species in the fishery, the assessment of the status of the most important species initially and, as the database accumulates, the eventual extension of analyses to minor species in the fishery.

5. CONCLUSIONS

The following conclusions are drawn from the foregoing:

a) The Tongatapu frame and catch assessment surveys were competently executed and achieved an excellent degree of coverage and have provided information which was not previously available. Lack of access to computers in the early stages, the pressure of other work and understaffing of the Project have led to a situation in which the data have not been fully analyzed and the purpose of the data gathering therefore negated to some degree.

b) The Tongatapu routine fishing operations conducted during 1988 showed conclusively that substantial amounts of data can readily be gathered by a relatively low level of effort by technically-trained staff. Data compilation has been competently done but there has been insufficient time to make more than preliminary analyses of the data.

c) The decision to extend operations to Ha'apai and to discontinue routine fishing at Tongatapu was a departure from the original design of the Project and has substantially reduced the value of the year of fishing at Tongatapu. This is because it was not possible to accumulate additional data on species which were poorly represented in the catches, nor to adjust routine fishing operations in the light of accumulated experience. In short, the advantages of continuity of the exercise were lost.

d) The Ha'apai frame and catch assessment surveys conducted in the past year appear to have achieved very great coverage, probably because the fishing communities are more accessible and because of the experience gained in Tongatapu. Data analysis is incomplete because of pressure of other work.

e) The Ha'apai routine fishing programme which is operating on relatively lightly exploited stocks can be expected to produce substantial catches. Most of the species which are important at Tongatapu are also represented in the Ha'apai catch and it can therefore be expected that analysis of the Ha'apai data will contribute to the understanding of the status of the Tongatapu stocks and of the effects of intensive exploitation. The loss of continuity at Tongatapu is therefore to some degree offset by expected gains in the acquisition of growth and mortality rates at Ha'apai. The problems of data analysis are the same as for the Tongatapu data set.

f) The Project Leader is overburdened in terms of the range of duties which are expected of him. Additionally, he is not a stock assessment specialist. As a result, there is a danger of the Project Leader being unable to adequately analyze the accumulated data. The situation is made worse by the fact that the time-frame within which the Project Leader must work is unknown.

g) The lack of involvement of Fisheries Division staff in the Project means that if the external funding for the Project is prematurely terminated there will be no-one within the Division who is familiar with the data or able to write up the results.

6. RECOMMENDATIONS

On the basis of the conclusions outlined above, the following recommendations are made:

a) If funding for the project is terminated by the donors, the Ha'apai routine fishing programme should be terminated forthwith and the staff should devote all remaining time to the compilation of the data and the documentation of the methods used in the two sample surveys and the year of routine fishing at Tongatapu. This will ensure that the even if it is not possible to complete the analysis of the frame and sample surveys and of the routine fishing at Tongatapu, the data base will be in a usable form and analysis of the data will still be feasible at some future time. However, as is shown by a perusal of the surviving FAO project files, it is extremely difficult to make good use of a data base once the original compilers have dispersed.

b) If funding is extended to the end of 1990, the Ha'apai routine fishing should be continued largely by the Field Technician and one or more assistants. The Project Leader should use all available time to complete comprehensive analyses of the Tongatapu and Ha'apai sample surveys and of the year of routine fishing data for Ha'apai. If the Ha'apai routine fishing data are to be effectively used it will be necessary to include a Tongan counterpart in the project during 1990, who would participate in the data analysis, supervise the routine fishing, learn the analytical techniques and assist in the preparation of the reports on the work accomplished.

c) If, as would be ideal, the Project continued beyond 1990, it would be possible to repeat the frame and catch assessment surveys at Va'vau and continue routine fishing operations at Ha'apai and Tongatapu. This would presuppose a commitment by the Fisheries Division to continuing the monitoring of the fisheries on an indefinite basis and a corresponding commitment of Fisheries Division staff to the execution of the routine fishing programme and the monitoring of the fisheries.

d) Irrespective of which of the three options eventuate, it is recommended that the Project seek the assistance of the South Pacific Commission's Inshore Fisheries Research Project in the analysis of the accumulated sample survey and size-frequency data and the preparation of a comprehensive set of reports. In this context it should be pointed out that the methodology used by the Project is of regional relevance and the principal species are widely distributed in the Region.

e) Data on invertebrates harvested by the nearshore fisheries should be collected in all future work.

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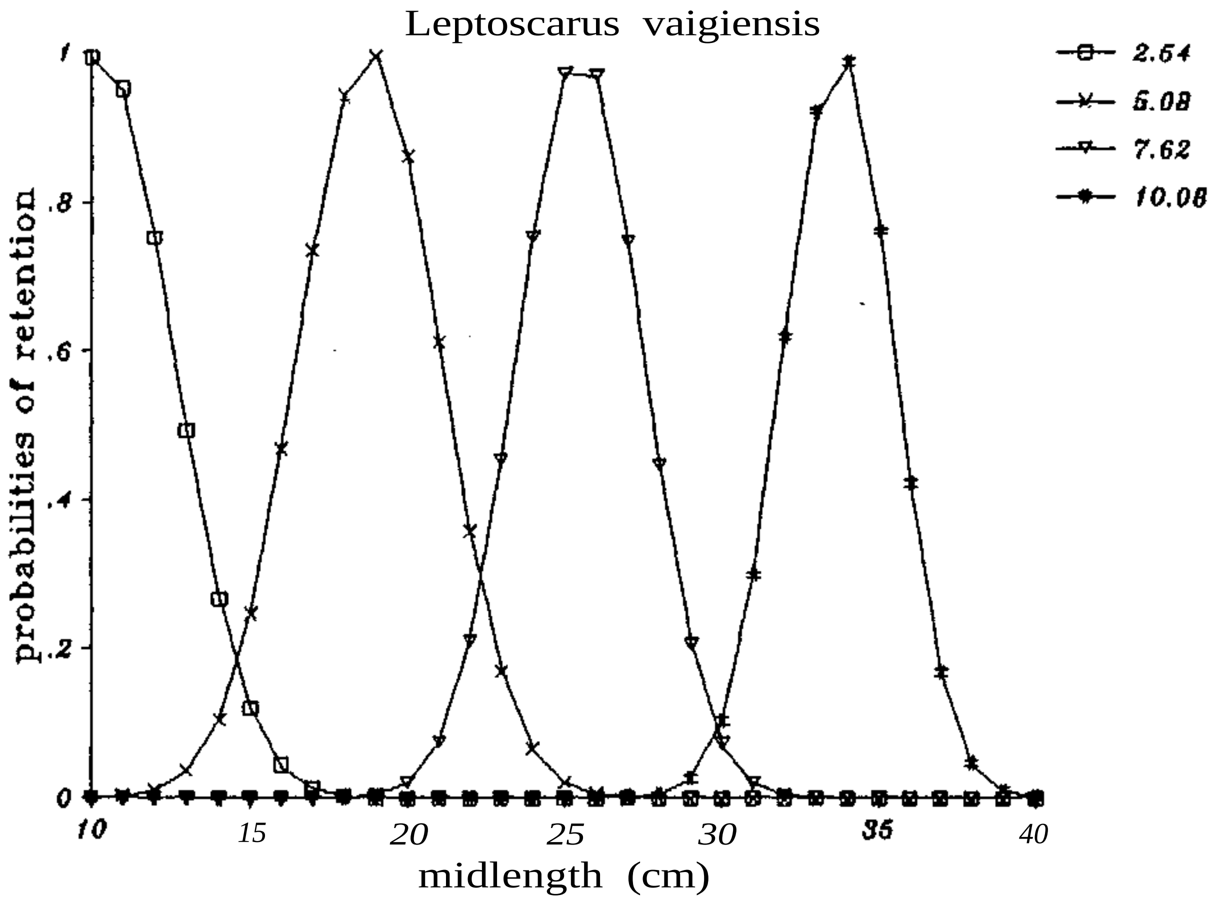

Figure 8. Gill-net selection curves for *Leptoacarua vaigiensis* derived by Holt's method. Computations are shown in Annex 1.

EZSELECT Template for calculation of gillnet selection curves

Species: Leptoscarus vaigiensis Location:Tongatapu
Notes:

	Mesh a	Mesh b	Mesh c	Mesh d	Mesh e	log ratios of catches				probabilities of retention Mesh a	Mesh b	Mesh c	Mesh d	Mesh e
Mesh size (cm)	2.54	5.08	7.62	10.08						2.540	5.080	7.620	10.080	.000
	Catch by numbers								mean Lopt	10.270	18.768	25.408	33.707	
	Ca	Cb	Cc	Cd	Ce	ln(Cb/Ca)	ln(Cc/Cb)	ln(Cd/Cc)	ln(Ce/Cd)	mean s.d. 2.295	2.249	1.973	1.742	
midlength (cm)														
10.0										.993	.001	.000	.000	ERROR
11.0	3									.951	.003	.000	.000	ERROR
12.0	15									.753	.011	.000	.000	ERROR
13.0	43									.493	.037	.000	.000	ERROR
14.0	25	2				-2.53				.267	.106	.000	.000	ERROR
15.0	10	3				-1.20				.120	.246	.000	.000	ERROR
16.0	4	11				1.01				.044	.469	.000	.000	ERROR
17.0	1	25				3.22				.014	.734	.000	.000	ERROR
18.0		33								.003	.943	.001	.000	ERROR
19.0		18								.001	.995	.004	.000	ERROR
20.0		11	1				-2.40			.000	.861	.021	.000	ERROR
21.0		5	5				.00			.000	.611	.075	.000	ERROR
22.0		3	9				1.10			.000	.356	.210	.000	ERROR
23.0			17							.000	.170	.452	.000	ERROR
24.0			50							.000	.067	.752	.000	ERROR
25.0			22							.000	.022	.970	.000	ERROR
26.0			16							.000	.006	.967	.000	ERROR
27.0			10							.000	.001	.746	.001	ERROR
28.0			6							.000	.000	.445	.005	ERROR
29.0			5	1				-1.61		.000	.000	.205	.026	ERROR
30.0			1	3				1.10		.000	.000	.073	.104	ERROR
31.0				7						.000	.000	.020	.299	ERROR
32.0				23						.000	.000	.004	.619	ERROR
33.0				18						.000	.000	.001	.921	ERROR
34.0				12						.000	.000	.000	.986	ERROR
35.0				10						.000	.000	.000	.759	ERROR
36.0				5						.000	.000	.000	.421	ERROR
37.0				2						.000	.000	.000	.168	ERROR
38.0										.000	.000	.000	.048	ERROR
39.0										.000	.000	.000	.010	ERROR
40.0										.000	.000	.000	.001	ERROR
41.0										.000	.000	.000	.000	ERROR
42.0										.000	.000	.000	.000	ERROR
43.0										.000	.000	.000	.000	ERROR
44.0										.000	.000	.000	.000	ERROR
45.0										.000	.000	.000	.000	ERROR
46.0										.000	.000	.000	.000	ERROR
47.0										ERROR	.000	.000	.000	ERROR
48.0										ERROR	.000	.000	.000	ERROR
49.0										ERROR	.000	.000	.000	ERROR
TOTAL	101	111	142	81	0									
				a =		-30.04	-37.18	-80.28						
				b =		1.95	1.75	2.71						
				Lsmaller		10.27	17.00	25.48						
				Llarger		20.54	25.49	33.71						
				s.d.		2.29	2.20	1.74						

Annex 1