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THE COLLECTION AND USES OF INSHORE REEF FISHERIES INFORMATION TO ASSESS AND MONITOR THE SELF FISHERIES OF THE KINGSOM OF TONGA USING THE ICLARM APPROACH. SUMMARY OF THE FIRST YEAR'S ACTIVITIES AND RESULTS

by

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ABSTRACT:

This report is the summary of the actions and decisions made during the first year of operation of a pilot project to create the foundation for a nationwide implementation of the ICLARM approach to assess, manage and monitor the shelf fisheries of Tonga. The data gained clearly indicate that the Tongatapu reef fishery is now fully developed producing an estimated 50.16 kg/ha annual harvest at 4.16 vessel/100 hectares fishing intensity. This yield is a result of fishing activity conducted predominantly in shallow waters. Experimental trap and line catch rates from the deep lagoon are comparable of those reported from lightly fished areas elsewhere.

The importance of stepwise expansion of coverage and field training of the staff is emphasized as the best mean to utilize the limited human and material resources of the pacific island countries.

A. BACKGROUND:

Several earlier attempts were made by both, the staff of the Fisheries Division and outside organizations to assess the potential of stocks (Thomas 1978) and the magnitude of catches (F.A.O. 1980) from the reef fisheries (used here as defined by Munro 1973) of the Kingdom . Reviews of these results by Polacheck (1986) and Felfoldy-Ferguson (1987) concluded that the incompleteness of the data and the fact that the objectives and methodology of these attempts were not management oriented rendered these results insufficient for documenting the necessity and urgency for stock management and conservation. Nevertheless, indications for the dispersed nature of landings, the small size of landed fish and declining catch per effort rates were given in the reviewed documents.

Given the structure and the apparent trends of the coral reef fisheries, as well as the limited nature of human and material resources of Pacific island countries, the ICLARM approach (Munro 1983;1986, and Munro & Fakahau 1986) could be considered appropriate for the region. It has, however , not been fully tested in the South Pacific to date.

The Fisheries Division of Tonga has launched the Tongatapu Inshore Fisheries Project in February 1987, to establish the feasibility of a cost effective assessment and monitoring system with eventual nationwide coverage, and - after the initial period of operation - sustainable with local staff and material resources. The six month progress report (Felfoldy-Ferguson 1987) has been reviewed by Munro (1987). Other relevant background information is given in Fakahau & Shepard (1986).

B.OBJECTIVES

The Objectives of the Tongatapu Inshore Program are:

- To evaluate the feasibility of the ICLARM system relative to the specific conditions exist in the Kingdom of Tonga

- To create the foundation for a nationwide coverage through experience and training.

C.METHODOLOGY

1. FRAME SURVEY:

The first years actions proposed by the ICLARM approach

	Sample survey	--------->	Approx.total landings
Year 1	Inventory of fishing		Most important species
	gears and methods	--------->	Most important fishing methods
	Evaluation of socio	--------->	Relative values
	economic data	--------->	Socio-economic data

were addressed with the following surveys:

a. FISHERMEN REGISTRATION INTERVIEW:

A trained crew conducted a door to door survey and interviewed fishermen using a questionnaire developed for the information needs of the ICLARM approach.

The questionnaire contained six groups of questions as:

- Personal and socioeconomic: As family size, other sources of income, percentage of catch retained for family, extended kinship and social group consumption, family members helping in the fishing process and the length of the fisherman's experience in fishing.

- Fishing methods, practiced, with indication of during what season or lunar cycle it is practiced, if changed, what determines change.

- Fishing assets, fishing gear, vessels, outboard engine owned, rented or shared.

- Fishing grounds, frequented in the course of a particular fishing method practiced, if changed, what determine which location is used.

- Information related to fishing effort, as the number of days per week fished, the length of the fishing trip, actual hours fished per fishing trip, number of weeks unavailable by social or weather constraints per season.

- Miscellaneous questions related to the degree of awareness of the state of the natural resource, fishermens'' need of assistance etc.

b. SURVEY AND INVENTORY OF FISHING GROUNDS:

Maps (1:50000) based on aerial photography and navigational charts

(1:50000) were surveyed to determine the extent of the Tongatapu shelf, the reef flats and the 12.5m and 24.0m isobaths. Echosoundings on transects were used to detect the patchiness of coralheads, rocky features, bottom irregularities and the nature of bottom materials. Seagrass coverage was visually estimated at low tides, and transects were constructed through mangrove to estimate its extent of growth.

c. CATCH ASSESSMENT SURVEY

Market surveys were used to assess the species composition of various catches and to estimate the values of such catches. Fishermen practicing the predominant fishing methods, were selected and their catches analyzed on a biweekly schedule. The information gained included species composition, length, weight and sex of individual specimens,the method and gear used, the gear hour effort associated with the catches, and the exact location fished.

d. SELECTION AND STANDARDIZATION OF THE GEAR ARRAY:

Based on the results from the frame survey, hook and line gear, gillnets, and fishtraps were constructed.

The methodology of this phase of the project included gillnet fishing with 2"; 3" and 4" gillnets, hook and line fishing with 1/0; 2/0; and 3/0 fish baited and artificial fly hooks and have introduced antillean 'Z' traps (Munro 1980) of 52 cm height as well as "double" A-Z traps of 104 cm height, both employing 3cm mesh size. Most gillnet operations were confined to shallow waters to 10m depth and the nets were set in tandem, unbaited, overnight and then hauled in the morning. Handlines were used at various depths, most frequently in the vicinity of the traps.

The traps were set on the reef slope from 10m to 35m and in the lagoon at the depth of 30-35m. Traps were either unbaited or lightly baited with pacific saury and checked on the 3 days, 4 days or of 7 day soaking schedule Spear fishing (diving) was excluded because the lack of skills in the crew. The collection of weir trap fishing data was continued with selected fishermen, since the daily operation of the gear has negligible variation.

2. DATA ANALYSIS AND PROCESSING:

The data collected from the frame survey and the catch assessment survey were tabulated manually and analyzed from the tabulated form. All data pertaining to the standardization of the selected gear as catch details and fishing conditions were entered in Dbase 111+ and Lotus 123 and analyzed on the H.P Vectra microcomputer. Length weight relationship is calculated by the equation:

$$W = aL^{b}$$

Where W is the weight in grammes, L is the length in centimeters and a and b are constants. Catch per unit effort for trap catches is expressed in terms of availability, an index equal to the mean daily ingress into traps is computed using the formula:

$$\bar{A} = \frac{PCs}{r(1-e^{-Rs})}$$

Where C is the actual catch produced by s night of soaking, P is the probability of escape, R is a coefficient for the rate of retention r. Both p and r values were adopted from Munro (1974) (p= 0.116; r= 0.884) and represent only an approximation for the Tongatapu inshore trap stocks.

D. RESULTS:

1. FRAME SURVEY

a. FISHERMEN REGISTRATION

The inventory of fishing methods and fishing assets had 92.8% coverage and registered 1640 fishermen of the Tongatapu island, owing, sharing or renting 255 outboard powered skiffs and 236 canoes. The inventory of existing fishing gears and their estimated yearly usage is given in (Table 1.0)

TABLE 1.0 INVENTORY OF GEAR AND GEAR USAGE.

DESCRIPTION OF GEAR	QUANTITY:	ESTIMATED YEARLY GEAR HOUR
LINE GEAR (SETS)	1156	300,214
SPEAR AND SPEAR GUN	999	634,230
CASTNET, GILLNET, BEACH SEINE	434	574,800
ACTIVE WEIR TRAPS	24	100,800
OTHER GEAR	545	252,396

Fifty eight percent of the fishing population practice multiple fishing methods. Common combinations of methods include net fishing seasonally alternated with spear fishing and complemented with hook and line fishing according to lunar cycle. A variety of other combinations exist depending on the skills and assets of individual fishermen. The generalized (average) fishermen is found to be 36 years of age with about 11.8 years of experience and 5.4 dependents who consume at least 26.8% of the total yearly catch. Fishing is a family affair to 43.0% of the fishermen registered.

b. SURVEY AND INVENTORY OF FISHING GROUNDS:

The survey of fishing grounds estimated of the total self area extending to 947 square km. The various environments within the self include 117.85 square km of shallow water environments of primary importance. Details are given in Table 2.

TABLE 2.0 INVENTORY OF FISHING GROUNDS

ENVIRONMENT:	Square km.	REMARKS
SHALLOW ENVIRONMENTS		
MANGROVES	3.37	
REEF FLATS	41.77	Partially exposed at 0.0 tide
REEF SLOPES	64.27	
SHALLOW LAGOON	8.44	Less than 6.0m depth
TOTAL SHALLOW	117.85	Of which 61.0% is covered by seagrass
DEEP ENVIRONMENTS		
DEEP LAGOONS	57.22	
OUTER SHELF	771.93	Boundary defined at the 160m isobath
TOTAL DEEP	829.15	
TOTALS:	947.00	

c. CATCH ASSESSMENT SURVEY

The catch assessment survey measured 213 landings made by 37 fishing units practicing hook and line, net, weir trap and spear fishing. The landings corresponded to 9,902 kg of fish land crustaceans per 2320 Hr of fishing effort, and obtained from the analysis of 225 catches. The efficiency of the particular gear is then calculated (Table 3.0).

TABLE 3.0 GEAR EFFICIENCY

DESCRIPTION OF GEAR	G/GEAR HOUR	AVERAGE VALUE/kg T$
Line gear	213	1.65
Castnet	135	1.45
Gillnet, 2" mesh	382	1.46
Gillnet, 3" mesh	631	1.79
Gillnet, 4" mesh	421	1.86
Average gillnet (weighted)	446	1.68
Weir trap	418	1.75
Spear, Spear gun	315	2.05
Others (estimated)	115	1.09

The magnitude of landings for the predominant fishing methods are estimated along with estimated values corresponding with the catches. (Table 4.0)

TABLE 4.0 ESTIMATED YEARLY LANDINGS AND CATCH VALUES

METHOD OF FISHING	METRIC TONS	T$
Line	63.83	105,319
Net fishing	256.36	430,685
Wire trap	42.15	73,735
Spear, spear gun	199.78	409,553
Other gear	29.03	30,477
TOTALS	591.13	1049,769

The catch assessment survey has also added 17 species to the preliminary species list. It is worth to note that 14 of the 17 species previously unencountered came from catches of spear fishermen.

d. SELECTION AND STANDARDIZATION OF THE GEAR ARRAY:

The total of 1059 gear hours were used to date to collect data on the performance of the selected array of gear in respect to species and size selectivity, and catch per unit effort in various environments. Corresponding catch was 541 kg giving magnitudes of catch per unit effort of .912kg/hour for hook and line, .353 kg/hour for gillnets and .637 kg availability per trap night. Details of the trap results are given in Felfoldy-Ferguson (1988). The data available on hook and line and net gears are not sufficient yet to allow the calculation of gear selectivity. Species lists and catch compositions for the particular fishing methods used are given in appendix B,C and D.

E. DISCUSSION

The 1640 fishermen and the 491 vessels are distributed throughout the Tongatapu island. All but one vessel, however, based on the northern shore of the island and thus, nearly 100% of these seagoing units operating on the extensive north-north eastern reef system and shelf. Powered boats comprise 52% of the fleet. Their range of operation extends to all the protected areas of the shelf. Most of them lacking ice boxes and fishing trips seldom exceed 24 hours. The range of unpowered units is much less and the dugout canoes normally operate on the coastal fringe only.

Gillnet fishing is the most prominent fishing method. Both the estimated landings and the value of the catch produced is the highest in the sector. Of the four main methods practiced in Tongatapu the most productive is the extended drive-in net (silita), however, the set gillnet (fakamohe) producing the highest values of catch per unit effort. The differences result from market preferences for larger size of fish and the mesh sizes employed by these methods (silita employs 2"-2 half" mesh and fakamohe employs 3 half"-4" mesh). Spear fishing is normally less efficient but often produces the most valuable catches. Night speargun fishing is the most effective. Weir traps are highly efficient, providing the fishermen with good seasonal catches of highly priced mullet and goatfish. Licensing requirement limit the entry into this sector of fishery.

The line gear, being both, very operator dependent and fairly inexpensive to purchase, produced low average efficiency, as many obtain the gear without having the necessary skills and produce rather meager catch of low value fish. Net fishing methods are normally practiced in shallow waters (to 10m), and free diving has its physiological depth limitations. Since most fishermen skilled in hook and line fishing uses this method as complementary, most of the line fishing also takes place in shallow waters and leaves deep lagoons and outer shelves virtually unexploited.

The standardization of the selected gear array is now underway. Nor the gillnet neither the line catches are sufficient to calculate gear size selectivity.

In gillnet and line gear catches only Mirypristis pralinus and Scarus sordidus produced small overlapping catches in two and three inch mesh nets, essential to calculate gear selectivity, using the method given by Pauly (1984).

The A-Z traps on the other hand now have sufficient data to estimate the probability of capture or the availability index (Munro 1974). Average availability values are given in for all species of trap stocks (Table 5.0). Figures 1.0 to 4.0 show the length distribution of the four most common species in trap catches demonstrating that the trap selectivity is essentially a one-sided affair.

An interesting comparison emerges when A-Z trap and line catches from the deep lagoon areas are analyzed. Trap stock availability is over 1.0 kg/trapnight, and also line catches are 167.0 kg/100 line hours, comparable of the 161.4 kg. from lightly fished areas of the Jamaican shelf reported by Munro (1980)

As it has been pointed out by Munro & Fakahau (1986) that the frame survey does not give real insight into the dynamics of the fishery but allows the formation of "some judgement" about relative production rates. It is in essence to calculate the harvest per unit area and compare it with reported harvests from similar areas elsewhere.

The first estimate of total landings of 591.13 metric tons of finfish and .242 tons of crustaceans also provides valuable information about the level of development in the fishery. Stevenson and Marshall (1974) suggested that average harvests in fully developed reef fisheries might normally range between 20.0 and 50.0 kg/ha/year. Marshall (1980) reviewed potential fish yields from coral reefs and found a range of 8.0 - 50.0 kg/ha/year. Hill (1978) reported 80.0 kg/ha/year harvest from an intensively exploited reef in Samoa. Munro and Thompson (1973) have shown that yields could be as high as 43.2

kg/ha/year associated with high fishing intensities (3.09 canoes/100 hectares) and that these yields are achieved by fishing with small meshed gear. As the fishing intensity increases further, gear sizes will be lowered if the high yield is to be at least temporarily sustained. Most likely, however the predictions of the modified exponential surplus yield model (Munro and Thompson 1973) will hold, projecting the decline of yields at higher fishing intensities. The distribution of the estimated yearly gear hour for the predominant fishing methods over fishing grounds reveals that substantial portion, if not all, of the Tongatapu landings originate from the shallow water environments, amounting to 11,785 hectares. The projected annual harvest then, corresponds to 50.16 kg/ha and associated fishing intensities created by the 255 powered an 236 unpowered skills and canoes might be as high as 4.16 vessels/100 hectares. These results seem to be in line with the observations of Munro (1987) concerning visual appraisals of shallow reef fish stocks catch analysis of landings by individual fishermen market visits and experimental trap catches that there are strong indications that "..the near - shore stocks of the Tongatapu shelf are extremely heavily exploited and are in urgent need of management".

In the practical sense the Tongatapu Inshore Fisheries project represent only the foundation for future work. As the Tongatapu project matures, it extends to the Ha'apai group where inshore fishing grounds are less heavily fished at present. This stepwise approach to a country wide coverage ensures that equipment or manpower - which is in short supply - is not overextended at the detriment of the quality of the output.

Training is an essential element of the ICLARM approach and must be considered in the view that the exercise is a long term fisheries management task and as the expatriate staff leaves it has to be continued with local field technicians. While some degree of formal education is essential, on the job field training of talented young nationals seems to be the best course for countries like Tonga.

F. CONCLUSION

In conclusion, the first year of operation, the Tongatapu Inshore Fisheries Project has laid a satisfactory base for the continuation of the project, as it has been proposed by the actions and time frames of the ICLARM approach. The experience gained during the first year, if complemented with further staff training, will ensure that the human resource needs to continue and expand the program, are met.

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Table 5.0

SUMMARY OF A - Z TRAP CATCHES

SPECIES	CATCH BY NUMBER	%NUMBER	CATCH BY WEIGHT	%WEIGHT	AVAILABILITY BY #	AVAILABILITY BY WEGHT	AVG-WGHT
	1	0.04	240	0.05	1.32	317	240.0
Family: Dasystidae							
Dasyatis kuhuli	12	0.50	15786	3.28	15.84	20840	1315.5
Family: Congridae							
Muraenesox cinereus	3	0.12	4567	0.95	3.96	6029	1522.3
Muraenesox albomarginatus	3	0.12	3542	0.73	3.96	4676	1180.7
Family: Muraenidae							
Gymnothorax schismatorhynchus	2	0.08	1790	0.37	2.64	2363	895.0
Gymnothorax fimbratus	1	0.04	1245	0.26	1.32	1644	1245.0
Gymnothorax albomarginatus	3	0.12	2250	0.47	3.96	2970	750.0
Gymnothorax monochrous	2	0.08	1572	0.33	2.64	2075	786.0
Gymnothorax pseudothyrosoides	12	0.50	8299	1.72	15.84	10956	691.6
Family: Sphyreanidae							
Sphraena forsteri	3	0.12	1224	0.25	3.96	1616	408.0
Family: Holocentridae							
Myripristis pralinus	10	0.42	684	0.14	13.20	903	68.4
Myripristis hehagonus	1	0.04	144	0.03	1.32	190	144.0
Flammeo sammara	4	0.17	297	0.06	5.28	392	74.3
Adioryx cornutus	18	0.75	3907	0.81	23.76	5158	217.1
Adioryx spinifer	15	0.62	840	0.17	19.80	1109	56.0
Family: Mulloidae							
Upenus vittatus	2	0.08	267	0.06	2.64	352	133.5
Mulloidichthys vanicolensis	12	0.50	1464	0.30	15.84	1933	122.0
Parupeneus pleurospilos	1126	46.82	212255	44.04	1486.51	280212	188.5
Parupeneus bifasciatus	15	0.62	2150	0.45	19.80	2838	143.3
Parupeneus trifasciatus	14	0.58	1999	0.41	18.48	2639	142.8
Parupeneus barberinus	3	0.12	426	0.09	3.96	562	142.0
Family: Apogonidae							
Apogon aureus	64	2.66	2288	0.47	84.49	3021	35.8
Apogon trimaculatus	7	0.29	629	0.13	9.24	830	89.9
Family: Priacanthidae							
Priacanthus blotchii	1	0.04	79	0.02	1.32	104	79.0
Family: Serranidae							
Plectropomus leopardus	2	0.08	12357	2.56	2.64	16313	6178.5
Epinephelus flavocareuleus	2	0.08	406	0.08	2.64	536	203.0
Epinephelus maculatus	3	0.12	7418	1.54	3.96	9793	2472.7
Epinephelus fuscus	6	0.25	980	0.20	7.92	1294	163.3
Epinephelus hoeftii	1	0.04	587	0.12	1.32	775	587.0

Table 5.0 (cont.)

Family: Pteroinae							
Pterois volitans	4	0.17	285	0.06	5.28	376	71.3
Parapterois heterurus	14	0.58	1490	0.31	18.48	1967	106.4
Family: Synaceiidae							
Synaceia verrucosa	2	0.08	3810	0.79	2.64	5030	1905.0
Family: Bothidae							
Bothus pantherinus	33	1.37	5137	1.07	43.57	6782	155.7
Family: Echeneidae							
Echeneis naucrates	15	0.62	8447	1.75	19.80	11151	563.1
Family: Nemipteridae							
Scolopsis personatus	9	0.37	853	0.18	11.88	1126	94.8
Scolopsis dubiosus	1	0.04	69	0.01	1.32	91	69.0
Family: Lethrinidae							
Gymnocranius japonicus	247	10.27	55652	11.55	326.08	73470	225.3
Gymnocranius lethrinoides	8	0.33	2266	0.47	10.56	2991	283.3
Lethrinus miniatus	20	0.83	2549	0.53	26.40	3365	127.5
Lethrinus nebulosus	11	0.46	15978	3.32	14.52	21094	1452.5
Lethrinus nematacanthus	10	0.42	1117	0.23	13.20	1475	111.7
Lethrinus rubrioperculatus	3	0.12	399	0.08	3.96	527	133.0
Lethrinus lentjan	6	0.25	1404	0.29	7.92	1854	234.0
Family: Lutjandae							
Lutjanus bohar	2	0.08	399	0.08	2.64	527	199.5
Lutjanus fluviflamma	293	12.18	32830	6.81	386.81	43341	112.0
Lutjanus rufolineatus	21	0.87	2515	0.52	27.72	3320	119.8
Lutjanus kasmira	86	3.58	11354	2.36	113.53	14989	132.0
Lutjanus fulvus	10	0.42	2810	0.58	13.20	3710	281.0
Lutjanus gibbus	1	0.04	170	0.04	1.32	224	170.0
Lutjanus caeruelovittatus	1	0.04	115	0.02	1.32	152	115.0
Family: Theraponidae							
Therapon jaruba	108	4.49	24989	5.19	142.58	32990	231.4
Family: Pomacentridae							
Pomacentrus sp.	7	0.29	335	0.07	9.24	442	47.9
Family: Labridae							
Bodianus perdito	1	0.04	226	0.05	1.32	298	226.0
Cheilinus trilobatus	6	0.25	400	0.08	7.92	528	66.7
Cheilinus chlorurus	2	0.08	209	0.04	2.64	276	104.5
Cheilinus diagrammus	1	0.04	174	0.04	1.32	230	174.0

Table 5.0 (cont)

Family:	Scardae							
	Scarus sordidus	2	0.08	681	0.14	2.64	899	340.5
	Scarus ghobban	1	0.04	136	0.03	1.32	180	136.0
	Scarus tricolor	2	0.08	81	0.02	2.64	107	40.5
Family:	Pomachantidae							
	Centropyge bicolor	5	0.21	195	0.04	6.60	257	39.0
Family:	Chaetodontidae							
	Chaetodon auriga	5	0.21	369	0.08	6.60	487	73.8
	Chaetodon mertensii	14	0.58	394	0.08	18.48	520	28.1
	Heniochus accuminatus	76	3.16	3533	0.73	100.33	4664	46.5
Family:	Acanthuridae							
	Acanthurus nigrifuscus	2	0.08	88	0.02	2.64	116	44.0
	Acanthurus thompsoni	1	0.04	30	0.01	1.32	40	30.0
Family:	Siganidae							
	Siganus argenteus	7	0.29	575	0.12	9.24	759	82.1
Family:	Balistidae							
	Pseudobalistes fuscus	2	0.08	2019	0.42	2.64	2665	1009.5
	Sufflamen chrysopterus	1	0.04	213	0.04	1.32	281	213.0
Family:	Aluteridae							
	Cantherihines dumerili	5	0.21	841	0.17	6.60	1110	168.2
	Cantherihines fronticinctus	3	0.12	668	0.14	3.96	882	222.7
Family:	Tetraodontidae							
	Fugu sp.	6	0.25	3006	0.62	7.92	3968	501.0
	Pleuranacanthus sceleratus	1	0.04	1033	0.21	1.32	1364	1033.0
Family:	Diodontidae							
	Diodon hystrix	2	0.08	2393	0.50	2.64	3159	1196.5
TOTALS		2405	110	481929	100	3175	636226	

Fig. No. 1

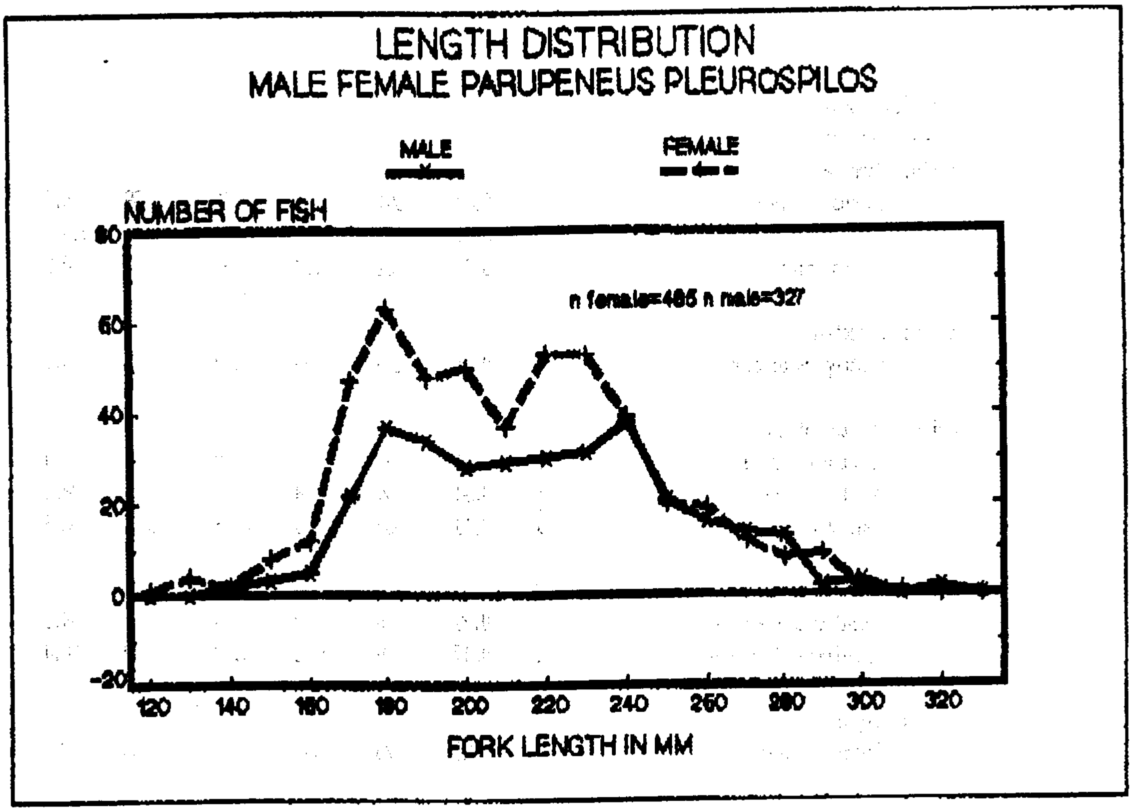

Fig. No. 2

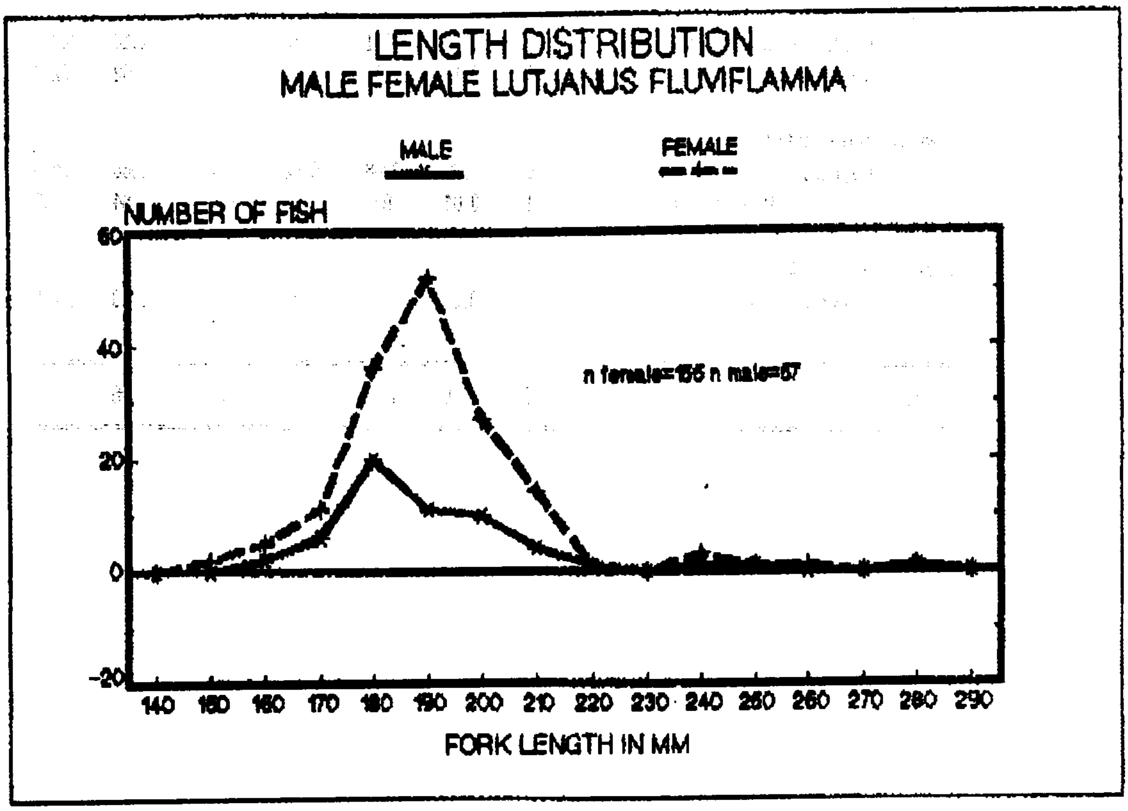

Fig. No. 3

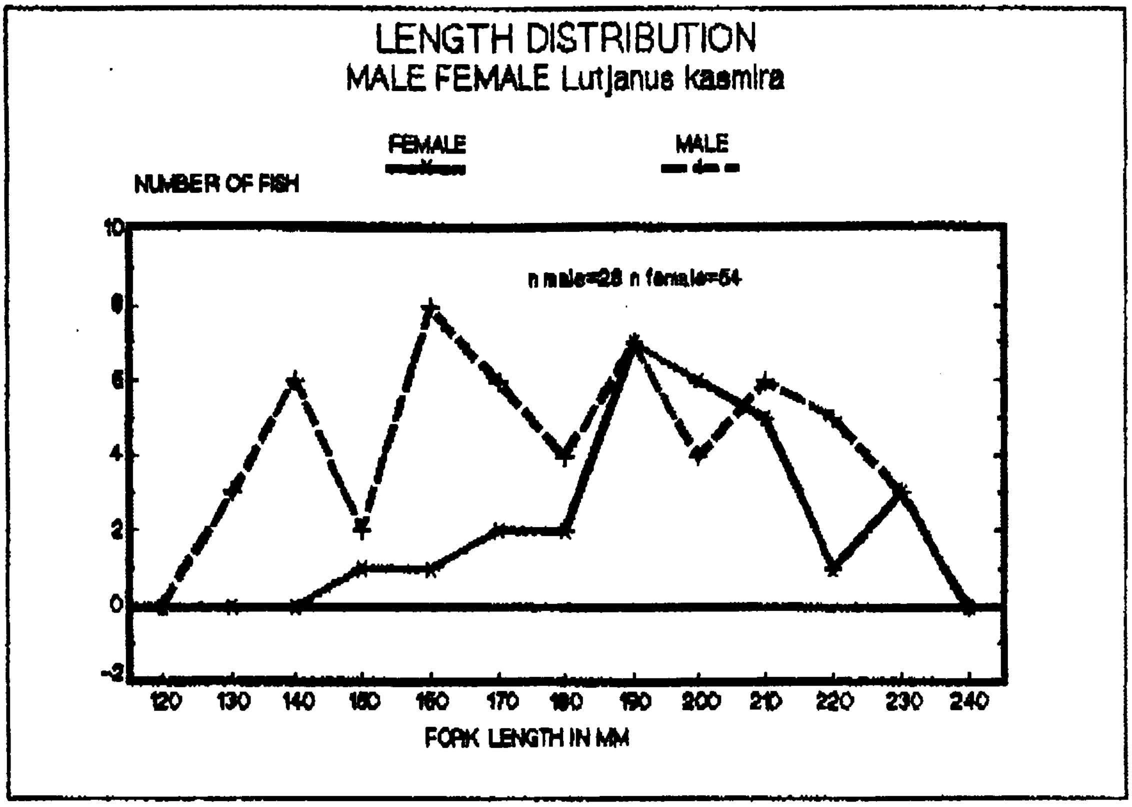

Fig. No. 4