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EXPLORATORY FISHING FOR LARGE PELAGIC SPECIES IN SRI LANKA

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EXPLORATORY FISHING FOR LARGE PELAGIC SPECIES IN SRI LANKA

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This paper discusses the execution and findings of a project that sought to "obtain information on the availability of surface and deep-swimming tuna in Sri Lanka" and on the technical feasibility of the exploitation of those species by "small-to-medium size craft in the 25 to 100 nm range of the EEZ."

The project was carried out during 1987 - 1988 under a Technical Cooperation Programme agreement between FAO and the Government of Sri Lanka. It was executed by the National Aquatic Resources Agency (NARA) of Sri Lanka with technical assistance from the Bay of Bengal Programme for Fisheries Development (BOBP).

Under the project, exploratory fishing was conducted with Negombo and Galle as bases using a boat provided by the Ministry of Fisheries. Gillnets, troll lines and longlines were the fishing gears used.

The BOBP is a multi-agency regional fisheries programme which covers seven countries around the Bay of Bengal - Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka, Thailand. Its main goal is to develop, demonstrate and promote technologies, methodologies and systems to help improve technologies, methodologies and systems to help improve the living standards of small-scale fisherfolk communities. The BOBP is sponsored by the governments of Denmark, Sweden and the United Kingdom, by member-governments in the Bay of Bengal region, and also by UNFPA (United Nations Population Fund), AGFUND (Arab Gulf Fund for United Nations Development Organizations) and UNDP (United Nations Development Programme). The main executing agency is the FAO (Food and Agriculture Organization of the United Nations).

This paper is a technical report and has not been cleared by the FAO or the Government of Sri Lanka.

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EXPLORATORY FISHING FOR LARGE PELAGIC SPECIES IN SRI LANKA

Main Report

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1. INTRODUCTION

Tunas make a major contribution to the fish production in Sri Lanka, the current average annual production of 35,000 tonnes making up 17% of all fish landed in the country. Fishing effort is intensive within a range of about 25 miles from the coast and the present level of exploitation does not encourage further expansion of the fishery in this range. On the other hand, direct and indirect evidence points to the availability of tunas in the offshore range, beyond the presently exploited areas. Although the Government is eager to develop the fishery, available knowledge is insufficient to determine the viability of expanding the fishery further offshore. In addition, there is also an equally important need to identify the suitable type and size of craft and suitable fishing methods to exploit tunas further offshore.

From 1984 to 1986, tuna resources and the fishery in Sri Lanka were studied with funding support from the FAOAJNDP project "Marine Fishery Resources Management in the Bay of Bengal", executed by the Bay of Bengal Programme (BOBP). A parallel project was executed in Maldives at the same time, through the same regional project, in view of the shared migratory nature of the resources. At a Working Group Meeting held in 1984 (Colombo 4- 8 June) between scientists of the two countries, both Sri Lanka and Maldives strongly recommended that exploratory fishing for tuna in the unexploited areas of their EEZs be undertaken in order to obtain information on the availability of surface and deep swimming tunas and on the technical feasibility of their exploitation by small to medium size crafts in the 25 100 mile range of the EEZ.

The exploratory tuna fishing project in Sri Lanka, established with US $ 96,000 funding support from FAO {TCP/SRL/6653(l)} , was executed by the National Aquatic Resources Agency (NARA) of Sri Lanka during 1987 - 1988, with technical assistance from the BOBP.

2. SURVEY METHODOLOGY/PROGRAMME

2.1 Survey Area

Exploratory fishing operations were conducted from Jan 1987 to December 1988, covering the western and southern offshore seas of Sri Lanka. For a detailed and systematic investigation and analysis, the area was sub-divided into four sub-areas-North West (NW), West (W), South West (SW) and South (S), as shown in Figure 1. Operations were confined mainly within the 48 - 160 km range with Negombo and Galle being the bases of operation.

2.2 Cruise Schedule

The survey strategy envisaged four fishing trips per month and four fishing'days per trip, in order to cover all sub-areas during each month. The boat made 74 trips during the two years, spent 312 days at sea and fished during 248 days. The fishing effort in number of fishing days is given in Table 1 by month, gear and sub-area and in Table 2 by gear, sub-area and range.

2.3 Fishing Methods/Gear

A 10.4 m combination boat (gillnet-cum-longliner; Abu Dhabi boat NW 35), provided by the Ministry of Fisheries, was used for the survey. Powered by a 56 hp Yanmar diesel engine, the boat also had crew accommodation, a fish hold of 6.5 t capacity, a net/line hauler, radio communication, a satellite navigator and an electronic log. (Figure 2)

Fishing gear used for the survey included 30 panels (1,000 meshes each) of drift gillnet of 125,150 and 180 mm mesh (Figure 3) and 40 bundles of longline (Figure 4) and four troll lines. The panels in the gil-lnet were arranged to have two identical halves with each half made of seven panels of 125 mm stret-ched mesh, six panels of 150 mm stretched mesh, and five panels of 180 mm stretched mesh. Cut pieces of fish-skipjack, sword fish, dolphin fish etc-were used as bait on the shark longlines. Tuna longlines were operated only on a few occasions due to difficulties in obtaining good quality whole bait. Two single hook (no. 6) troll lines (200 m length) were operated while sailing. Shoot-ing of combined gillnet and longline gear began between 4.30 pm and 5 p.m. beginning with the longlines. Hauling was usually done after midnight.

2.4 Operational Bases and Supplies

Negombo and Galle (Fig. 1) were the bases used throughout the two-year survey. Both are major fishing centres with large concentrations of fishing boats. The envisaged use of other bases such as Colombo (CFC Mutwal) and Beruwela for the survey did not materialize, because supplies and services were not readily available at these places. Both at Negombo and Galle, supplies of fuel, ice, food as well as repair facilities were readily available alongside the pier. However, use of only two bases along the survey area resulted in longer running hours for the vessel as the whole survey area needed to be covered each month. This is also a factor that affected the overall economic performance of the boat.

Sale of fish at Negombo was effected through public auction. At Galle fishery harbour, the catches were sold to CFC (Ceylon Fisheries Corporation) due to problems experienced initially when dealing with the private sector there. The system of grading of fish and the low prices offered by CFC compared to private buyers, also influenced the revenue from sale at Galle.

2.5 *Crew*

A skipper and a crew of four manned the survey boat. They were all experienced in fishing on offshore “multi-day” boats and very familiar with exploratory fishing methods. No training was therefore necessary for the crew.

Crew on commercial boats work on a catch share basis, a 50% share of net revenue after deducting operational costs from the gross revenue. In view of the exploratory nature of fishing, the crew on the survey boat were paid a fixed monthly wage as well as a variable percentage share from the net revenue to ensure monthly incomes on par with those obtained by crew on commercial boats.

2.6 Catch Sampling Procedures

An observer (a research assistant or a technician) was present on board during every fishing trip to make observations, record data on fishing operations, collect samples etc.

Information collected included the following:

a) **Fishing operations** - Position and time of fishing, amount of gear used, catch by species and gear - position of fish in net, gilling and entanglement, longline catch vis-a-vis position of hook on mainline etc.

b) **Environmental data** - Sea condition, surface sea temperature, weather condition, sighting of fish schools, birds, marine mammals etc.

c) **Biological data** Length frequency data of major species, collection of gonad and gut samples, Parasites etc from main species.

Some of the biological data and samples were also collected at the points of landing.

3. RESULTS

3.1 Catches and catch rates

The catches realized by the survey boat, according to the gear and other basic operational para-meters, are given below:

	No. of. trips	No. of. sea days	No. of. fishing days	Fish Catch (Kg) gillnets	longlines	troll lines	Total
1987	37	152	119	16,262	3,664	83	20,009
1988	37	160	129	28,295	1.431	1,350	3 1,076
Total	74	312	248	44,557	5,095	1,433	5 1,085

A total of 51 t were caught during 74 fishing trips - 87% from the gillnets, 10% from the longlines and 3% from the troll lines.

In Sri Lanka, the day boats as well as the multi-day boats conduct only one fishing operation per day (using either one gear or combination of two). Hence, the fishing effort in this study has been considered in terms of number of fishing days for estimating catch rates.

Fishing effort by month, sub area and distance from shore (range), for drift gillnet and longline operations during 1987 and 1988 are presented in Tables 1 & 2.

Distribution of gillnet fishing effort in the four sub areas was uneven in 1987, but relatively more even in 1988. During both years, longlines were operated only on some gillnet fishing days, (about half of them), depending on when bait fish was available. This was mainly influenced by the availability of bait fish. Range wise, it is seen that the majority of operations were within the 48 to 160 km range.

The average catch rates (kg/fishing day) for the two gears during the two years were as follows:

For all sub-areas	1987	1988
Gillnet operation	136.65	219.3
Longline operation	49.51	28

For different sub-areas

Gear	Fishing days	North West	West	South West	South
Gillnet operation					
1987	119	142.2	172.5	153.8	132.9
1988	129	90.5	205.2	251.9	323.6
Longline operation					
1987	74	3.3	29.2	41.5	113.1
1988	51	36.8	7.6	24.3	39.5

Gillnet catch rates were generally higher in 1988 than in 1987, in all areas except the North-West. Longline catch rates showed exactly the opposite trend. Average annual catch rates estimated for gillnet and longline operations in the different ranges investigated and in all the sub-areas does not allow detailed comparisons. Gillnet catch rates obtained for 48-80 km and 80-160 km ranges in 1988 were higher than those obtained in 1987, except in the North-West (Table 3).

Further, gillnet catch rates in 1988 for both these ranges tends to show an increase southwards, from North West to South. In the longline fishery where there were adequate operations within the 48-160 km range, the highest catch rates were obtained in both years from the sub area south.

Monthly variations in catch rates in gillnet and longline fisheries for the whole study area are shown in Fig.5. No seasonal patterns are visible in the longline fishery, probably due to inadequate operations in most monsoon months (April/May to October). Fig.5 also shows the variations of catch rates in gillnet and longline fisheries in relation to the lunar cycle and surface temperature. High catch rates were generally observed during the new moon period. Catch rates were also found to increase during full moon, when the sea was rough and strong winds prevailed. No clear correlation between surface temperature and catch rates was evident.

3.2 Catches of Tuna and Shark species

The percentage species composition in the gillnet and longline catches, for all sub-areas combined, is given in Table 4. While tunas (62 - 76%) dominated the gillnet fishery, sharks were the major component (75 - 80%) of the catch in the longline fishery and second largest group in the gillnet fishery (12 - 16%)

Skipjack tuna (4266%) was the most dominant tuna species followed by yellowfin tuna (9-16%) in the gillnet fishery. In the longline, primarily because most operations were with shark longline using cut-bait, the percentage of tuna species were relatively small and yellowfin (l-4%) and bigeye (0-0.8%) were recorded (Table 4).

Variations in the annual catch rates of major species groups in the two fisheries in different sub-areas are presented in Table 5. In both years, skipjack catches in gillnet fishery show a decrease in relative abundance from south to north while a reverse trend is seen in the case of yellowfin. Shark catches in the longline fishery were the highest in the south compared to other sub-areas.

Seasonal variations in the catch rates obtained for skipjack and yellowfin in the gillnet fishery on a quarterly basis are given in Table 6. Both species show a greater abundance in the offshore range (beyond 80 km) than the coastal range during the 1st and 4th quarters of 1987. This trend could not be observed in 1988 as all ranges were not covered during all quarters. However, higher catch rates are observed during the 2nd and 3rd quarters (south-west monsoon period) than in the rest of the year.

Sharks constitute an important component in rhe offshore catches, accounting for 78% and 14% respectively of the catch in longline and gillnet fisheries (Table 4). The silky shark ***C. falciformes*** made up 70% and 88% of the shark catches in gillnet and longline fisheries respectively (Table 7).

The oceanic white tip shark was more prominent in the south-west and the south, while the hammerhead shark, S. ***levini*** and milk shark ***R.*** acutus catches were high in the west and north-west, compared to the southern areas.

3.3 Gear efficiency

The efficiency of gillnets of different mesh sizes was estimated in terms of catch numbers and catch weight. The results obtained are summarized in Table 8. In terms of numbers, the 125 mm mesh net and 150 mm mesh net were equally efficient and more so than the 180 mm mesh size net. However, on the basis of catch weight, the 150 mm mesh net wasfound to be the most effective in both years.

Available data on the vertical position on the net where the fish was gilled or entangled are summarized and presented in Table 9. It is seen that a large percentage of fish (skipjack and yellowfin) were caught in the central portion of the net, followed by the upper portion.

The efficiency of longlines depends on the type and size of hook, size and **quality of bait and** fishing depth of the hook. Data collected on the numbers and kinds of fish caught by hooks on the long-line which fish at different depths due to the catenary formed by the mainline, are presented in Table 10. These show that shallower hooks (hook numbers 1+5 and 2+4) caught more sharks and sword fish than the deep set hook no. 3.

3.4 Gillnet *selectivity*

Except for target species such as skipjack and yellowfin, most other varieties caught in gillnets were observed to have been caught by entangling rather than gilling. They were entangled by the mouth and teeth (small tuna), tail (cetaceans and dolphin fish), bill (bill fish) or a combination of the above. A small percentage of skipjack and yellowfin were also entangled by their snout and fins.

While 62% of the skipjack caught were gilled, only 37% of the yellowfin were seen gilled. The highest percentage of gilled skipjack was observed with 15 cm mesh net, although over 50% gilling was recorded with other meshes too. In the case of yellowfin, the 17.5 cm net had the highest proportion of gilled fish (Table 11). The length frequency distribution of skipjack and yellow fin gilled and entangled in different sizes of mesh, are given in Figures 6a and 6b respectively.

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Based on the length frequencies of gilled fish, the selection curves obtained showed the optimum length of fish caught in the 12.5, 150 and 180 mm mesh sizes of nets to be 46, 56 and 65 cm for skipjack tuna and 47, 53 and 61 cm for yellowfin tuna, respectively.

3.5 Sightings of fish schools and cetaceans

A total of 30 fish schools (8 in 1987 and 22 in 1988) were sighted during the survey and these were mostly tuna schools. They were either of single species schools or of mixed species and have been classified as follows :

		No of observations
i	Schools of single species	12
ii	Schools of mixed species	3
iii	Schools of single species associated with dolphin	3
iv	School of mixed species associated with dolphin	1
v	School of single species associated with whales	3
vi	School of single species associated with drifting logs	1
vii	School of mixed species associated with drifting logs	1
viii	Fish school associated with whales and dolphin	1
ix	Fish school associated with birds	1
x	School of mixed species associated with shark	1

Schools of single species sighted were of skipjack, yellowfin or frigate tuna. Schools of mixed species comprised skipjack and yellowfin.

A total of 27 whales were sighted during both years, but these could not be identified by species due to lack of knowledge and experience. The majority of the observations were from the south. Blue whales were seen in pairs as well as in groups. A total of 18 groups of dolphins were reported, the number of animals in a group varying from 8 to 1000.

4. ASSESSMENT OF FEASIBILITY

4.1 Earnings and prices

Operational data on NW 35 for the two years are presented in Table 12. Total earnings from the sale of catch amounted to Rs. 392,850.50 in 1987 and Rs. 453,359.65 in 1988. The value per kg of fish caught has decreased from Rs. 19.63 in 1987 to Rs. 14.59 in 1988. Values of the catches per sea day and fishing day are slightly higher during 1988 compared to 1987.

Good quality catches made by day boats fetch higher prices than catches by multi-day boats. In Galle, the Fisheries Corporation grades the fish and pays relatively low prices for non-first grade fish. Galle businessmen offered relatively better prices than the Fisheries Corporation but cash payments were generally delayed and deals not properly settled.

4.2 *Costs*

Cost per kg of fish produced is lower in 1988 than in 1987, resulting in lower operational costs for a kg of fish produced in 1988 compared to 1987, despite increased operational costs per sea/fishing day in 1988. While the number of trips made by the survey boat is identical in both years, the boat achieved more sea fishing days in 1988, recording increased catches (over 50% increase).

A breakdown of expenditure during the operation of NW 35 is given below :

Fuel	26%
Ice	12%
Food	7.6%
Water	0.4%
Bait	1.6%
Repairs	10.3%
Crew Salary/Incentives	32.8%
Miscellaneous	9.3%

It is anticipated that fuel costs and payments to the crew would not be as high in a commercial fishing vessel. Further, acquisition of a badly maintained boat at the beginning of the survey necessitated heavy expenditure on repairs to bring it to proper shape for the survey.

4.3 Economics

Operational data presented in Table 12 shows total earnings from sale of catch to be Rs. 846,210.15 and operational expenditure to be Rs. 933,052.63 for both years.

The following constraints may have influenced the economic performance of the vessel during the survey.

a) Use of only two bases (Negombo and Galle) along the survey area resulted in additional running hours and running expenses as the whole survey area had to be covered on a regular (monthly) basis.

b) Use of fishing gear of fixed design without changes to take advantage of changing fishing conditions.

c) Fishing operations, being survey oriented, were carried out in pre-determined locations even when catches were poor.

d) High maintenance costs of the vessel caused by its poor condition when commissioned, amounted to 10.3% of the total annual operational expenditure.

e) Grading of fish and low prices paid by CFC compared to private buyers in Negombo, affected total income.

f) Although the vessel was partly operated or non- operational during the civil disturbances in 1988, the crew members were paid their salaries.

5. IMPROVEMENTS TO FISHING CRAFT FOR OFFSHORE FISHERY

5.1 Modifications to Abu Dhabi 10.4m boat

It has become common practice now for this class of boats to be engaged in fishing trips of 5-8 days duration. These boats can be used for offshore fishing trips of 8-10 day duration, if the following modifications are made (Fig. 7).

a) Increased crew accommodation - The boat now has proper accommodation for only two crew members. In order to optimise sea days and increase economic returns, proper crew accommodation must be provided for ail members. Crew accommodation could be provided for four members in the forepeak of the vessel by shifting the fishing gear store to the unused space in the aft of the vessel behind the engine. This may also reduce the forward trim observed in wind or choppy seas when the boat is loaded. Separate lockers can also be provided for the crew who may spend over 60% of their working life at sea.

b) Separation of the galley from .the wheel house It is a navigational hazard when the wheel house is lit, as during cooking in the night. In the proposed design, the galley is separated from the wheel house. The skipper has a bunk in the wheel house, in addition to a toilet with a shower, cupboards for charts, instruments etc.

c) Efficient utilization of engine room capacity - Fuel capacity can be increased up to 1,500 litres (including the service tank) by constructing hull shaped fuel tanks. Almost all boats are seen carrying 500-1000 litres of fuel in containers on deck. This may affect their stability.

d) Fishermen also carry extra fresh water (400-500 litres) on deck, in addition to the vessel capacity of 400 litres. It is proposed to increase the fresh water capacity to 1000 litres, in tanks accommodated under the main deck.

e) Improvements to engine room ventilation - Modifications to the ventilation system have been effected by fishermen on similar vessels which originally had an air inlet but no outlet. A blower ought to be installed in the engine room as the temperature is generally too high.

f) The existing bilge system is inadequate for deep sea fishing. The original bilge system in most of this type of vessels does not work and local well-type bilge pumps are fitted to most of

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them. There is also no sea water supply on deck for washing, fire fighting etc. It is therefore suggested that a reliable belt-driven bilge pump from the main engine be installed.

g) Slipping of net was often observed with the double grooved net hauler. A single grooved one may be more effective in hauling gillnets. Very few vessels of this type use 40 bundles of longline, probably due to inadequate space to keep them and difficulties in gear handling. A longline winch suitable for 50-60 bundles is recommended.

h) Better insulation in the fish hold to keep the ice without melting for 8-10 days.

It is felt that this type of vessel will not be economically viable unless it is used for 8-10 days of deep sea fishing. The cost of constructing a new 10.4 m Abu Dhabi fishing vessel in 1990 was Rs.2.13 million. The proposed vessel with the above modifications could be built at Rs. 2.2 million. Details are given below:

Return on investment for the proposed 10.4 m Abu Dhabi vessel is calculated below.

1.	Investment		
			Rs.SRL
	a)	Hull	1,000,000
	b)	Engine	530,000
	c)	Net hauler	90,000
	d)	SSB Radio	100,000
	e)	Electrical system	80,000
	f)	Equipment	120,000
	Sub total		1,920,000
	Fishing gear 60 nets, 50-60 baskets longline		300,000
	Total investment		2,220,000
2.	Annual Fixed Cost		
	a)	Depreciation of Hull-16 years	62,500
	b)	Depreciation of engine-8 years	66,250
	c)	Depreciation of equipment-12 years {1(c), (d), (e) + (f)}	32,500
	d)	Depreciation of fishing gear-4 years	75,000
	e)	Insurance 1.8% on boat and 5% on engine	44,500
	Total fixed cost		280,750
3.	***Annual Fixed Cost*** (on the basis of 240 sea days and 190 fishing days per year)		
	a)	Fuel	250,000
	b)	Ice	125,000
	c)	Water	25,000
	d)	Bait	25,000
	e)	Food	60,000
	f)	Repairs	75,000
	g)	Crew share 40%	362,200
	Total expenses		922,200
4.	Total annual cost (2/3)		1,202,950
5.	Annual revenue 72 t*x 19.00 per kg		1,368,000
6.	Net profit		165,050
7.	Rate of return		13.7%

* On the basis of catch estimate in Field Document 2

These calculations show that a vessel of this class could be economically viable if the necessary improvements are carried out.

5.2 New design for offshore fishery in the EEZ

A Consultant Naval Architect assigned to examine the performance of the 10.4 m Abu Dhabi type boat recommended the consideration of a new design for overcoming various limitations in the economic performance and to extend the offshore coverage up to the boundary of the EEZ. All the details are presented in Field Document 2 of this report.

6. RECOMMENDATIONS

It is recommended that fishing gear experiments be conducted as a follow-up activity to the project to investigate the possibility of improving the efficiency of drift gillnet-cum-longline fishing operations and the quality of the catch. These would be designed to establish:

- the optimal soaking time and the possibilities of conducting more than one operation per day;
- the variability of catch rate with changes in the fishing depth of gillnet, lunar periodicity, time of day, etc; and
- optimum length of the floatline in the shark longline

On the basis of exploratory fishing operations, it is recommended that improvements identified for the Abu Dhabi type offshore boat be considered for development of the offshore fishery, as well as for the new-design craft recommended by this project.

A workshop on fishing craft should be conducted for offshore fisheries in Sri Lanka. It would discuss the characteristics and performance of the existing and proposed types of craft, for the benefit of offshore fishermen, boatbuilders, financiers, technical officers and fisheries administrators.

It is recommended that more attention be paid to the the supply of tuna bait for the offshore tuna longline fishery.

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Tabk 1: Fishing effort (fishing days) by month, gear and sub area

1987	No of trips	Gillnet NW	Gillnet W	Gillnet SW	Gillnet S	Longline NW	Longline W	Longline SW	Longline S
J.	2	–	3	–	–	–	2	–	–
F	2	–	4	1	–	–	4	1	–
M	3	-	8	6	-	-	8	5	
A	4	-	2	9	-	1	2	8	1
M	2	–	2	3	4	–	1	2	3
J	5	-	-	1	-	-	2	-	-
J	4	1	4	3	6	-	2	2	4
A	4	2	4	7	–	–	3	4	–
S	3	-	-	7	3	-	-	5	2
O	3	1	–	4	5	I	–	3	4
N	3	3	4	5	–	1	3	3	–
D	2	6	3	–	–	2	–	–	–
Total	37	11	39	46	18	3	28	33	13
1988									
J	1	4	1	-	-	3	-	-	-
F	3	6	2	6	1	1	-	2	1
M	3	–	3	7	4	–	1	2	3
A	3	3	2	6	4	1	1	2	2
M	2	–	–	3	3	–	–	2	–
J	3	3	3	4	–	1	2	1	–
J	4	1	2	4	3	1	1	-	1
A	4	4	3	5	3	2	-	31	2
S	5	1	3	7	3	–	1	1	2
O	5	3	4	7	3	1	1	3	2
N	3	2	1	2	3	–	–	1	2
D	1	1	–	–	–	–	–	–	–
Total	37	28	24	51	26	10	7	18	14

Table 2: Fishing effort (fishing days) by gear, sub area and range

1987	Gillnet				Longline			
Distance from Shore	O-48	48-80 (km)	80-160	>160	O-48	48-80 (km)	80-160	>160
NW	2	4	5	–	1	1	1	–
W	3	10	24	2	2	6	18	2
SW	1	5	35	5	–	3	25	5
s	–	11	7	–		7	6	–
1988								
NW	5	14	9	–	2	6	2’	–
w	–	2	22	–	–	–	7	–
SW	–	6	43	2	–		16	2
s	–	5	21	–	–	3	11	

NW-Northwest. W-West. SW-Southwest. S-South.

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Table 3 : Catch per unit effort (kg/fishing day) in gillnet and longline fisheries for different ranges (in km)

	Gillnet				Longline			
	0-48	48-80	80-160	160	0-48	48-80	80-160	>160
1987								
NW	92.5	1Y3.3	121.2	-	0.0	0.0	10.0	-
W	117.3	88.3	144.2	970.0	11.0	1.2	30.6	39.5
SW	1042.0	137.4	142.2	73.8	-	8.3	34.6	96.0
S	-	146.3	112.0	-	-	149.0	71.2	
1988								
NW	179.3	56.3	94.4	-	0.0	3Y.3	16.3	
W	–	199.5	205.8	–	–	–	7.6	-
SW	-	322.7	248.9	103.0	–		51.1	17.5
S	–	387.6	308.3	-	-	11.7	38.9	-

Table 4 : Percentage species composition of the catch in gillnet and longline fisheries during 1987 and 1988

a) *Gillnet*	1987	1988
Skipjack	42.8	66.1
Yellowfin	15.9	8.8
Frigate tuna	0.9	0.6
Kawakawa	0.6	0.1
Bullet tuna	1.4	0.1
Longtail tuna	0.4	
Bigeye tuna	-	0.4
	62.0	76.1
Sail fish	1.0	0.7
Sword fish	3.6	0.7
Marlin	9.9	3.0
	14.5	04.4
Shark	12.2	16.7
Skate	8.5	1.2
Dolphin fish	1.1	0.4
Marine Mammal	0.6	0.3
Seer	0.2	0.1
Wahoo	0.2	0.4
Other	0.7	0.4
	23.5	19.5

b) *Longline*	1987	1988
Shark	80.8	75.0
Skate	–	-
Yellowfin	4.0	0.9
Bigeye	0.8	-
Sailfish	-	3.8
Sword fish	12.4	5.1
Marlin	-	2.7
Dolphin	0.8	-
Wahoo	1.0	2.6
Other	0.2	

Table 5 : Average annual catch rates (in kg/fishing day) : Variations of major species groups in different sub areas in different fisheries

	1987				1988			
	NW	*W*	*SW*	*S*	*NW*	*W*	*SW*	*S*
a. Gillnet fishery								
Skipjack	7.7	49.8	95.2	66.9	40.1	149.4	182.8	190.0
Yellowfin	29.7	44.9	9.2	18.2	27.4	12.8	15.6	24.8
Other tuna	26.6	5.7	1.0	0.8	0.6	7.1	2.2	1.8
Total tuna	64.0	100.4	105.4	85.9	68.1	169.3	200.6	216.6
Billfish	34.8	33.5	16.0	8.8	1.0	5.2	15.9	12.5
Shark	11.3	20.0	17.8	24.9	20.6	19.3	27.6	90.2
Skate	25.0	11.8	13.2	9.7	-	6.5	2.7	1.9
Other	7.0	6.8	1.4	3.7	0.9	5.0	5.0	2.2
b. *Longline*								
Shark	-	21.0	31.2	103.8	20.8	7.0	19.6	27.5
Billfish	3.3	3.6	7.9	6.2	-	0.6	2.8	2.7
Dolphin	-	0.3	6.0	-	-			-
Yellowfin	-	2.0	1.5	3.1	6.0	-		9.3
Bigeye tuna	11	-	-	-	-	-	-	-
Others	1.3	0.2	-	-	-		1.9	

Table 6 : Catch rate (kg/fishing day) variations of major species in Gillnet fishery in different ranges (in km)

		0-48	48-80	80- 160	>160
1 st Quarter Feh-April 1987	Skipjack	34.5	51.5	137.3	78.0
	Yellow fin	-	6.3	11.7	157.3
	Shark	17.5	6.8	08.3	07.4
2nd Quarter May-July 1987	Skipjack	73.0	53.6	92.4	-
	Yellowfin	4.0	12.3	31.7	
	Shark	35.0	25.3	71.7	-
3rd Quarter Aug-Ott .	Skipjack	997.0	40.9	41.5	-
	Yellowfin	-	4.0	10.9	-
	Shark	-	15.0	12.4	
4th Quarter Nov-Jan 1987/88	Skipjack	2.5	8.0	19.6	-
	Yellowfin	13.0	24.5	34.3	-
	Shark	54.5	13.3	12.5	-
1st Quarter Feb-April 1988	Skipjack	139.0	37.9	69.8	0.0
	Yellowfin	10.0	42.0	6.0	0.0
	Shark	10.0	3.3	35.2	0.0
2nd Quarter May-July 1988	Skipjack	-	110.8	276.4	-
	Yellowfin		13.0	26.8	
	Shark		144.9	37.8	-
3rd Quarter Aug-Ott	Skipjack	125.0	211.9	212.6	150.0
	Yellowfin	80.0	36.3	18.5	0.0
	Shark	0.5	8.0	30.9	0.0
4th Quarter Nov-Dec. 1988	Skipjack	-	69.0	33.4	-
	Yellowfin	-	-	08.3	-
	Shark	-	20.0	90.2	-

Table 7 : Percentage species composition of sharks caught in different areas, using drift gillnets and drift longlines

	Gillnet				Longline			
Species	NW	W	S W	S	NW	W	SW	S
	%	%	%	%	%	%	%	%
C . falciformis	72.4	70.2	71.7	67.1	83.1	89.3	96.7	86.3
C . longimanus	-	4.5	18.9	21.7				6.9
R. acutus	13.7	9.1	5.0	7.7	-		-	-
I. oxyrinchus	4.6	-	-	-	-			
S . lewini	5.4	3.1	1.4	-	16.7	10.7	-	-
S . zysacna		2.4	-	-	-	-	-	-
A. superciliosus	3.9	4.4	-	-	-	-	-	-
Other carcharhinus		6.3	2.9	3.4	-	-	3.3	6.8
Total	100	100	100	100	100	100	100	100

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Table 8 : Catch number and catch weight of different species caught in panels of different mesh sizes

	(A) No of fish caught			% no. caught		
Mesh size	125 mm	150mm	180mm	125 mm	150 mm	180 mm
1987						
Skipjack	734	703	430	39.2	37.7	23.0
Yellowfin	158	227	159	29.0	41.7	29.2
Other tuna	325	258	202	41.4	32.9	25.7
Shark	79	67	66	37.3	31.6	31.1
Billfish	11	21	22	20.4	38.9	40.7
Other fish	60	56	22	43.5	40.6	15.9
Total	1367	1332	901	38.1)	37.0	25.0
1988						
Skipjack	1733	1873	1102	36.8	39.8	23.4
Yellowfin	180	168	136	37.2	34.7	28.1
Other **tuna**	333	256	237	40.3	31.0	28.7
Shark	138	165	93	34.8	41.7	23.5
Billfish	16	12	15	37.2	27.9	34.9
Other fish	67	38	21	53.2	30.2	16.7
Total	2467	2512	1604	37.5	38.2	24.4
	(B) *Total weight* (kg)			*% weight*		
1987						
Skipjack	2571	2636	1671	37.4	38.3	24.3
Yellowfin	829	994	988	29.4	35.4	35.1
Other tuna	136	133.2	84.2	38.5	37.7	23.8
Shark	509	761	785	24.8	37.0	38.2
Billfish	375	918	1218	14.9	36.6	48.5
Other fish	531	580	454	33.9	37.1	29.0
Total	495 1	6022.2	5200.2	30.6	37.2	32.2
1988						
Skipjack	6115.5	7421	5245.5	32.6	39.5	27.9
Yellowfin	979	877	857	36.1	32.5	31.6
Other tuna	127	120.5	101.5	36.4	34.5	29.1
Shark	1467	1707	1301	32.0	38.1	29.1
Billfish	494	268	601	36.2	19.7	44.1
Other fish	319	701	129	27.8	61.0	11.2
Total	9501.5	11094.5	8235	33.0	38.5	28.6

Table 9 : Vertical distribution (%) of the catches of skipjack and yellowfin tuna in the upper, middle and lower parts of gillnets.

Mesh size	Skipjack			Yellowfin		
	125 mm	150 mm	180 mm	125 mm	150 mm	180 mm
Position in the net						
Upper part	22.7	17.7	33.3	29.6	23.5	40.0
Middle part	58.3	73.1	56.0	44.4	67.6	50.0
Bottom part	19.0	9.1	10.7	26.0	8.8	10.0

Table 10 : Number and percentage composition of different species caught by longline hooks at different depths

Year 1987	Number caught				Percentage caught		
	(Shallow)	(Medium)	(Deep)				
Hook No.	1+5	2+4	3	Total	1+5	2+4	3
Shark	90	92	38	220	40.9	41.8	17.3
Yellowfin	–	2	2	4	-	50	50.0
Swordfish	20	16	8	44	45.5	36.4	18.2
Bigeye	2	-	-	2	100.0	–	–
Skate	2	2	1	5	40.0	40.0	20.0
Vanna (Dolphinfish)	–	6	1	7	-	85.7	14.3
Other	2	-	1	3	66.7	-	33.3
Total	116	118	51	285	34.5	35.1	30.4

Table 11 : Numbers of skipjack and yellowfin tuna gilled and entangled, by drift gillnets of various mesh sizes

Mesh sizes	Gilled			Entangled		
	125 mm	150 mm	175 mm	125 mm	150 mm	180 mm
Skipjack						
No.	661	820	376	560	294	262
%	54.1	73.6	56.6	45.9	26.4	43.4
Yellowfin						
No.	53	38	58	98	100	57
%	35.1	27.5	50.4	64.9	72.5	49.6

Table 12: Operational data for NW35, 1987 and 1988

	1987	1988
Trips (no.)	.37	37
Sea days (no .)	152	160
Fishing days (no.)	119	129
Catch gillnets (kg.)	16262.24	28294.5
Catch longlines (kg.)	3663.99	1431
Catch trolling lines (kg.)	83	1350
Total catch (kg.)	20009.23	31076
Catch rate (kg./sea day)	131.64	194.2
Catch rate (kg./fishing day)	168.14	240.9
No. of gillnet fishing days	119	129
No. of longline fishing days	74	51
Catch rate of gillnets (kg./fishing day)	136.65	219.3
Catch rate of longlines (kg:/fishing day)	49.51	28
Total value of catch (Rs.)	392850.50	453359.65
Value per kg of catch (Rs/kg)	19.63	14.59
Value of catch per sea day at sea (kg/sea day)	2584.54	2833.50
Value of catch per fishing day (kg/fishing day)	3301.26	3514.42
Total operational cost (fuel, ice, water, repairs, crew wages and share)	405320.05	527732.58
Operational cost per kg of catch (Rs/kg)	21.76	16.98
Operational cost per day at sea (Rs/sea day)	2666.58	3298.33
Operational cost per fishing day (Rs/fishing day)	3406.05	4090.95

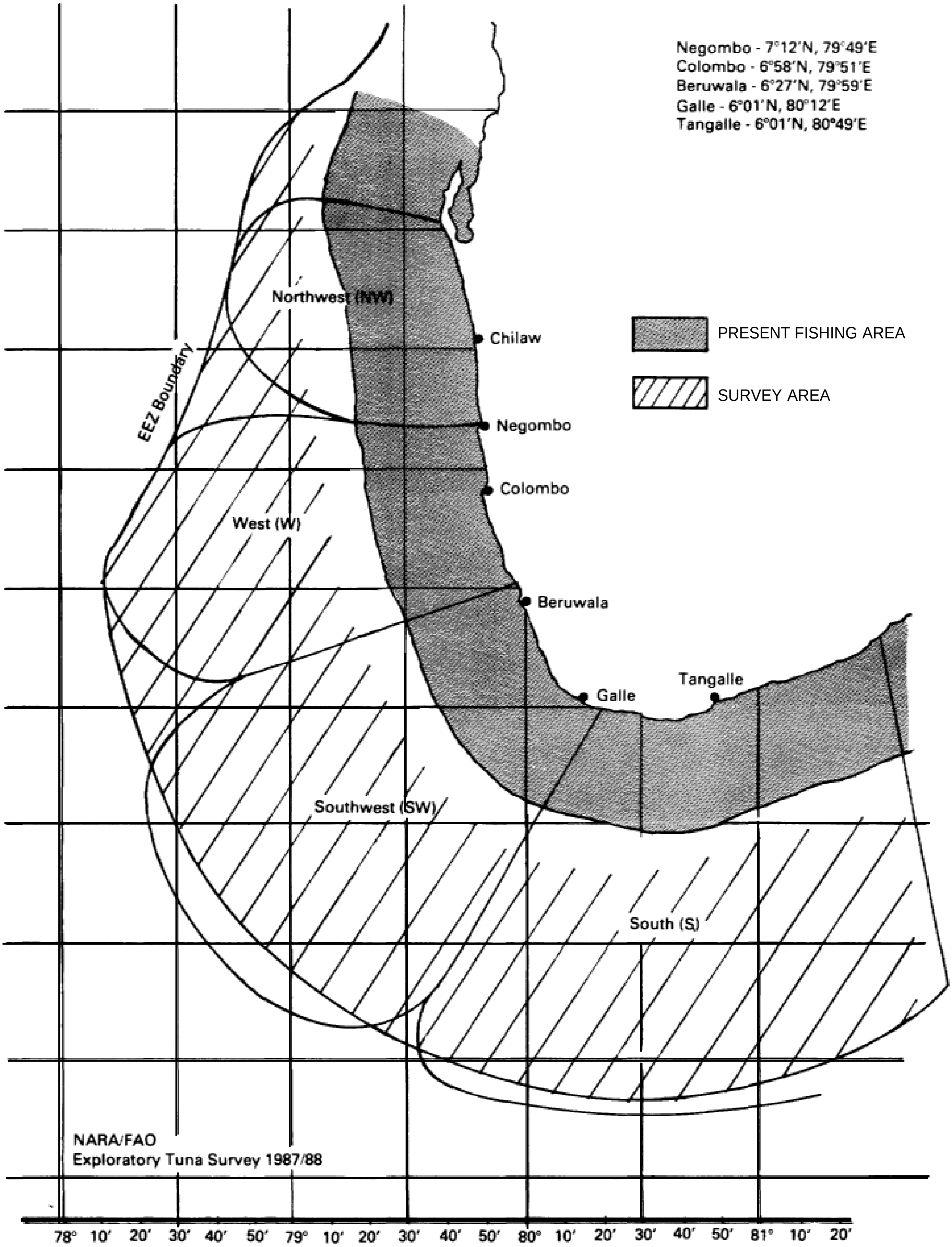

Fig.1 Stratification of the survey areas on the West and South Coasts of Sri Lanka

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Figure 2: General Arrangement – Abu Dhabi Boat NW 35

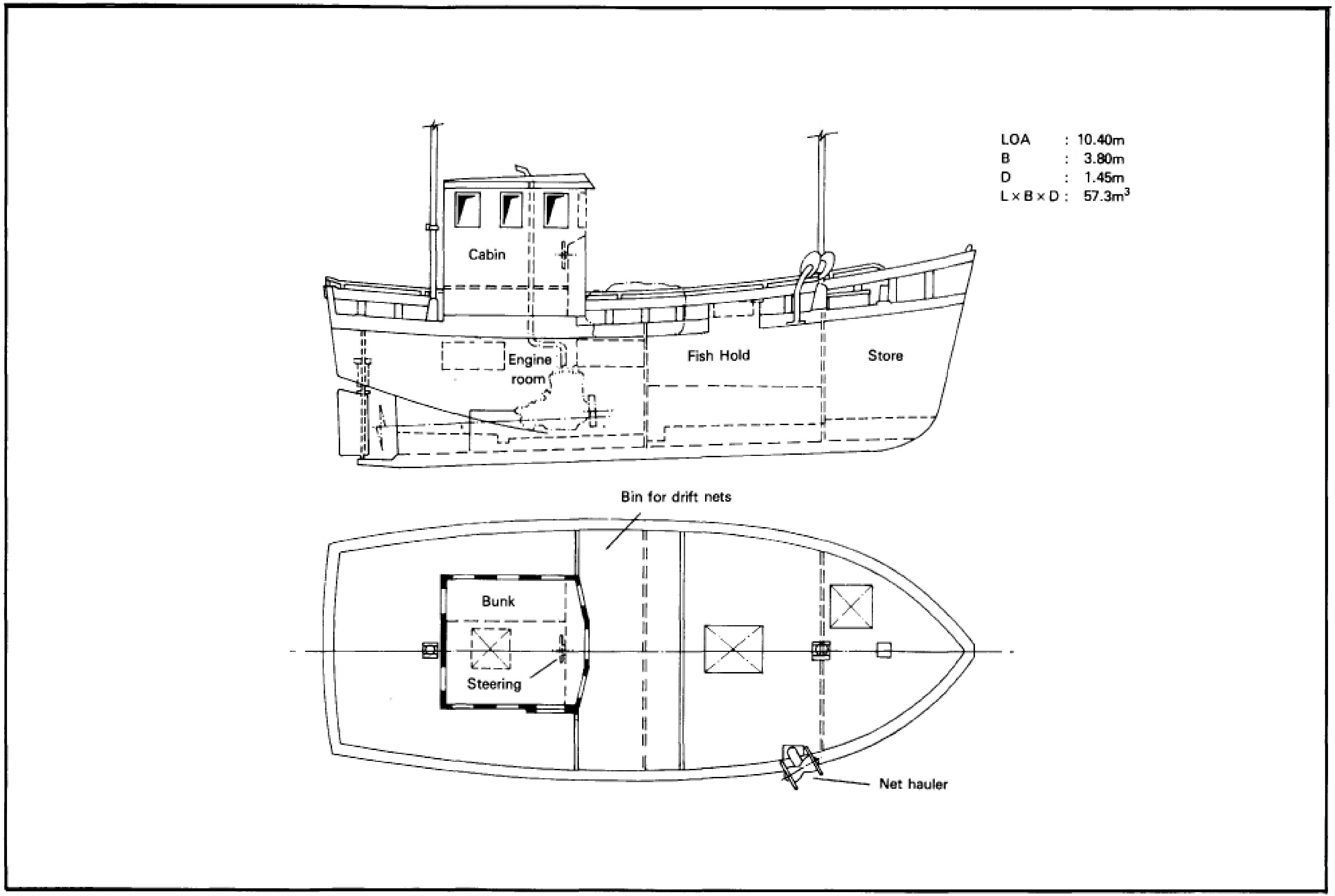

Fig. 3 Fishing gear used for the survey—drift gilinets

All dimensions in mm unless otherwise stated.

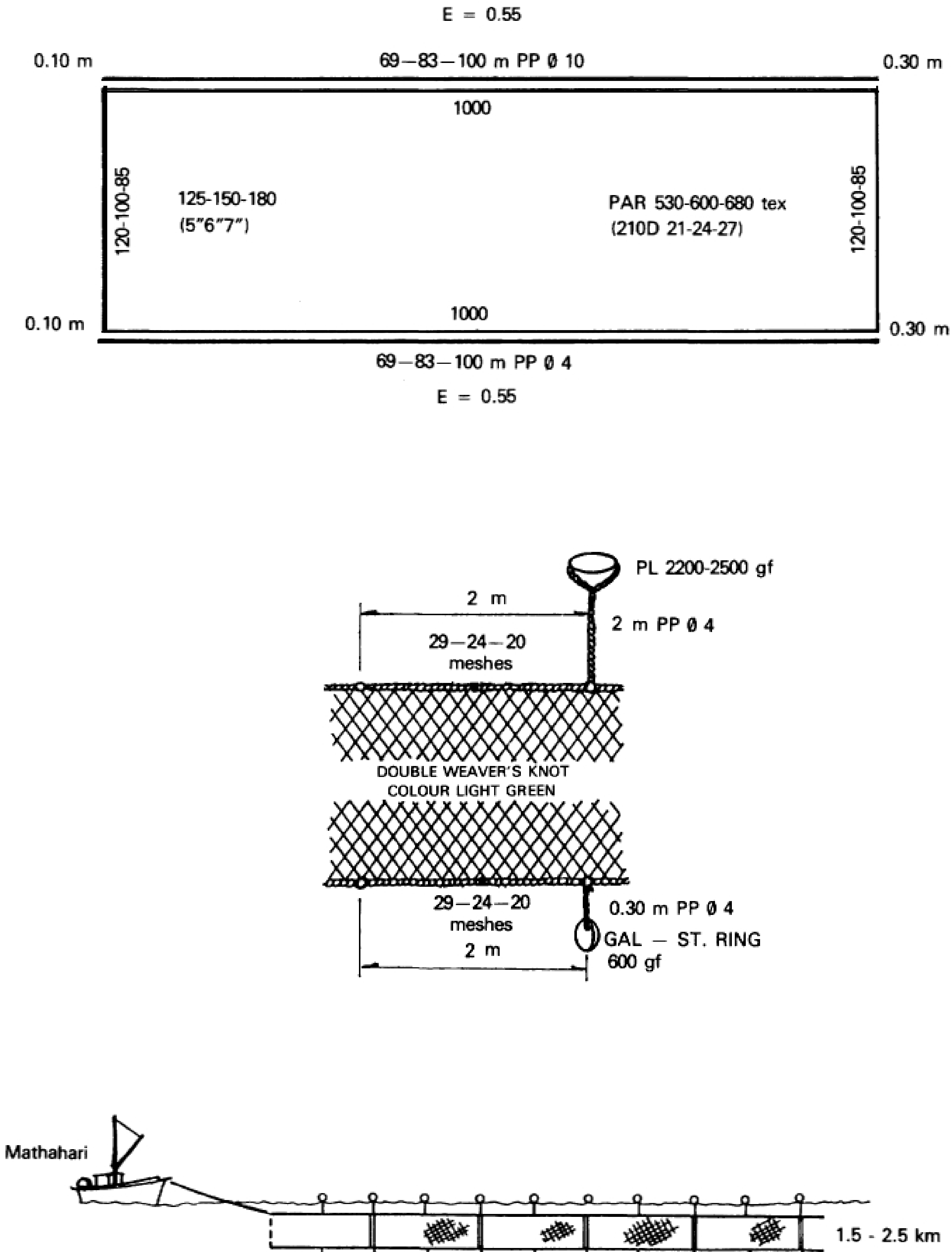

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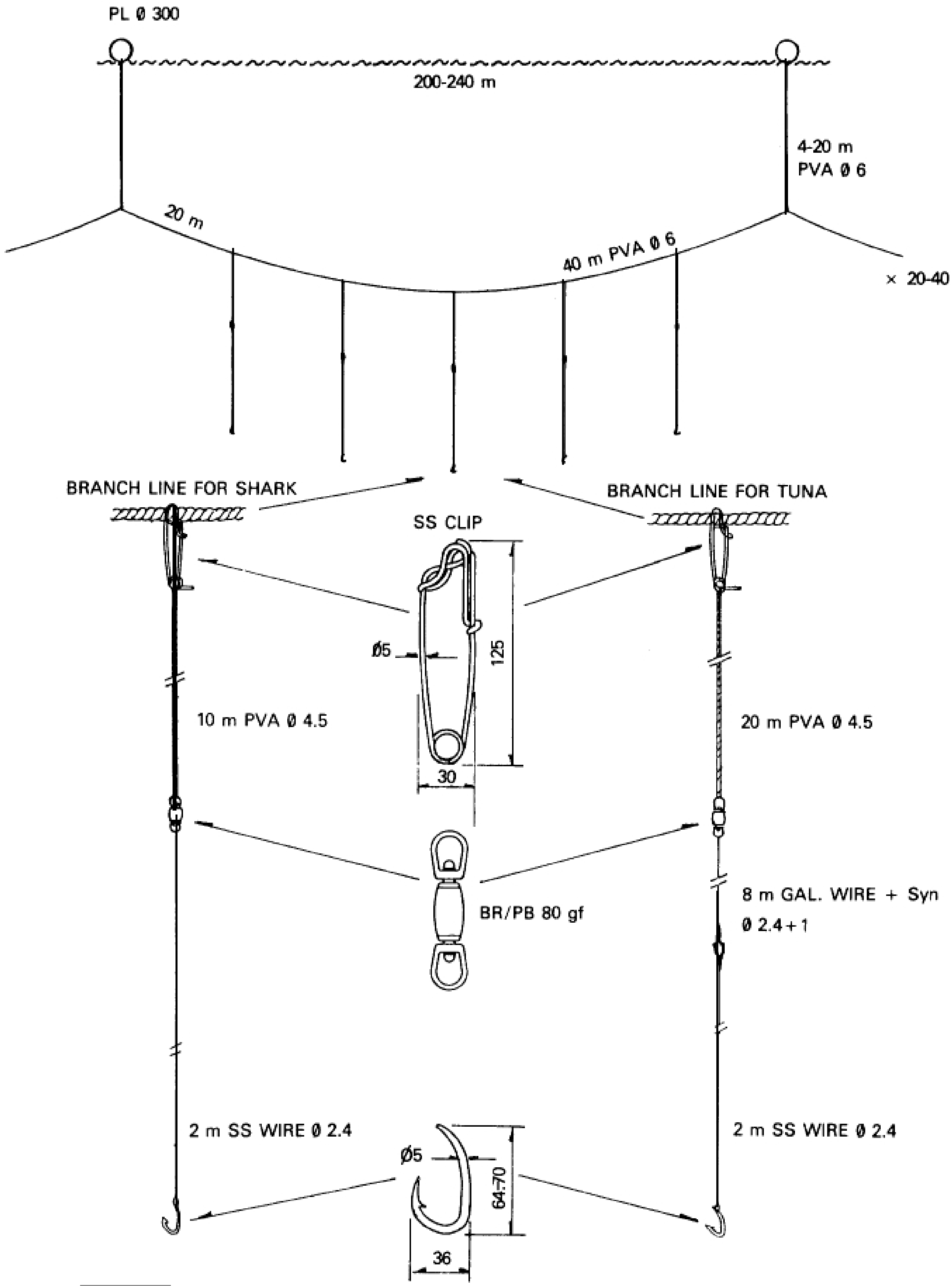
Fig. 4 Fishing gear used for the survey—long lines

All dimensions in mm unless otherwise stated.



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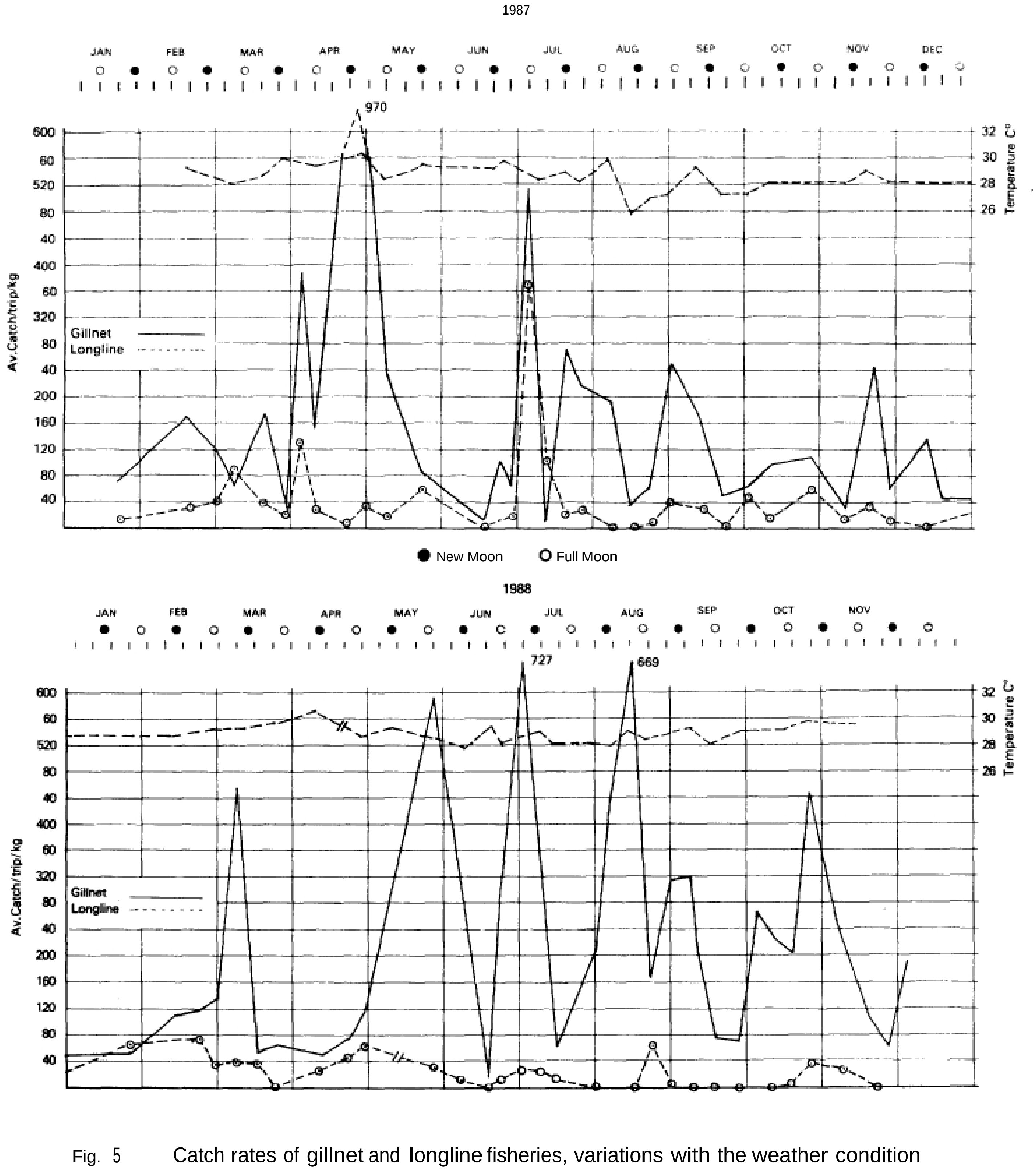

Fig. 5 Catch rates of gillnet and longline fisheries, variations with the weather condition and the lunar cycle

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Skipjack tuna

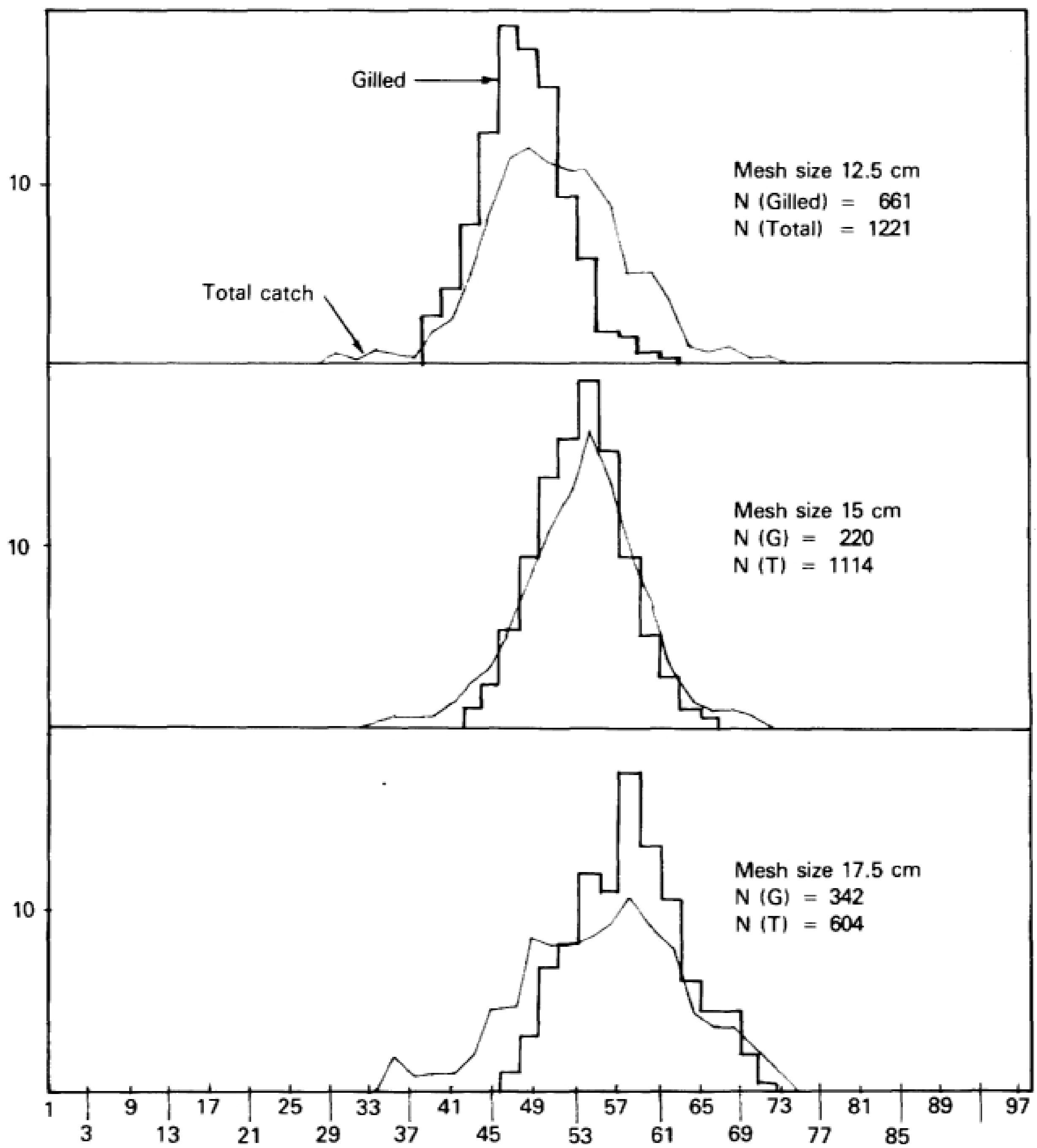

Fig. 6a Size selectivity (gilled and total) of skipjack tuna in gilinets of different mesh sizes

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Yellowfin tuna

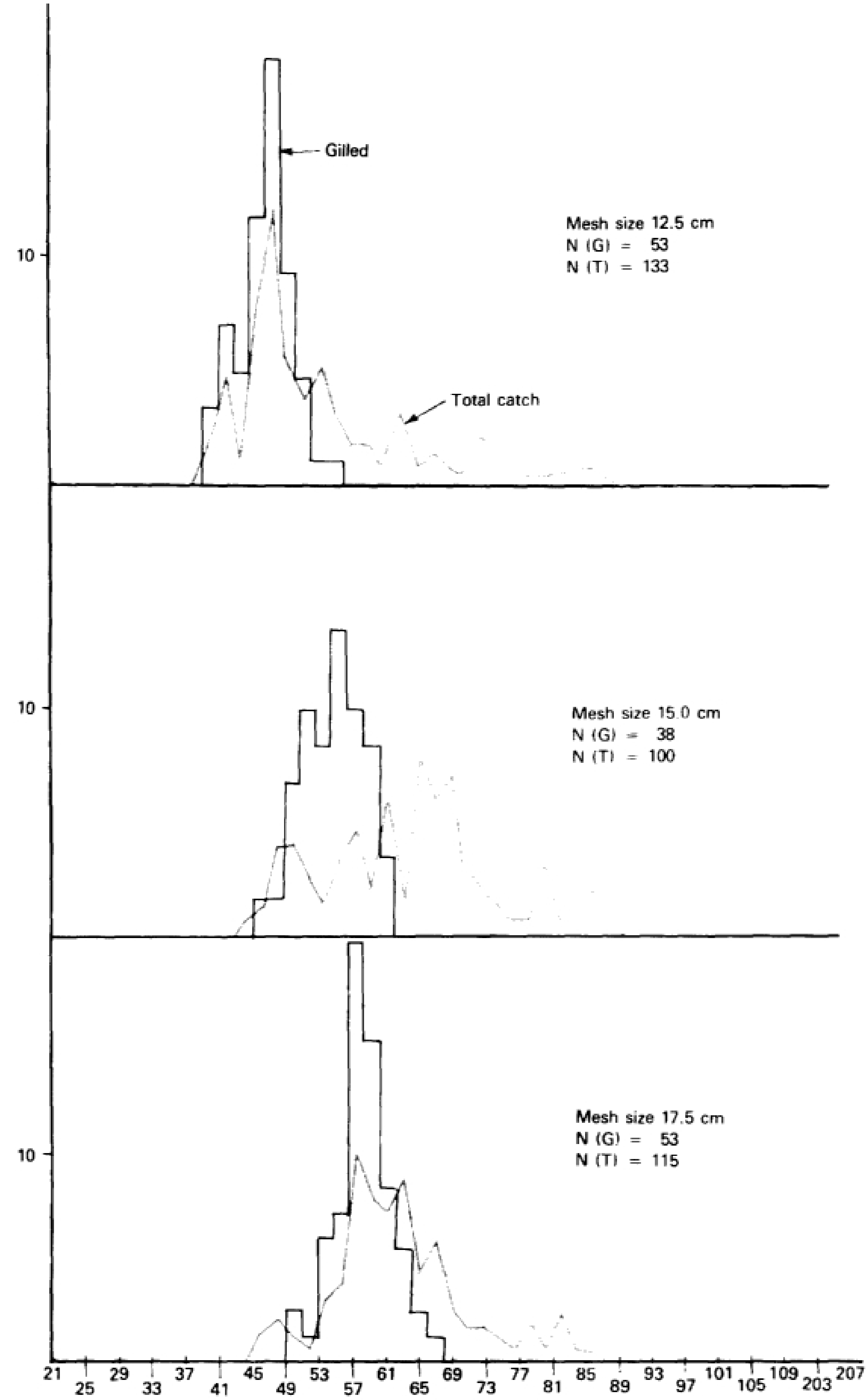
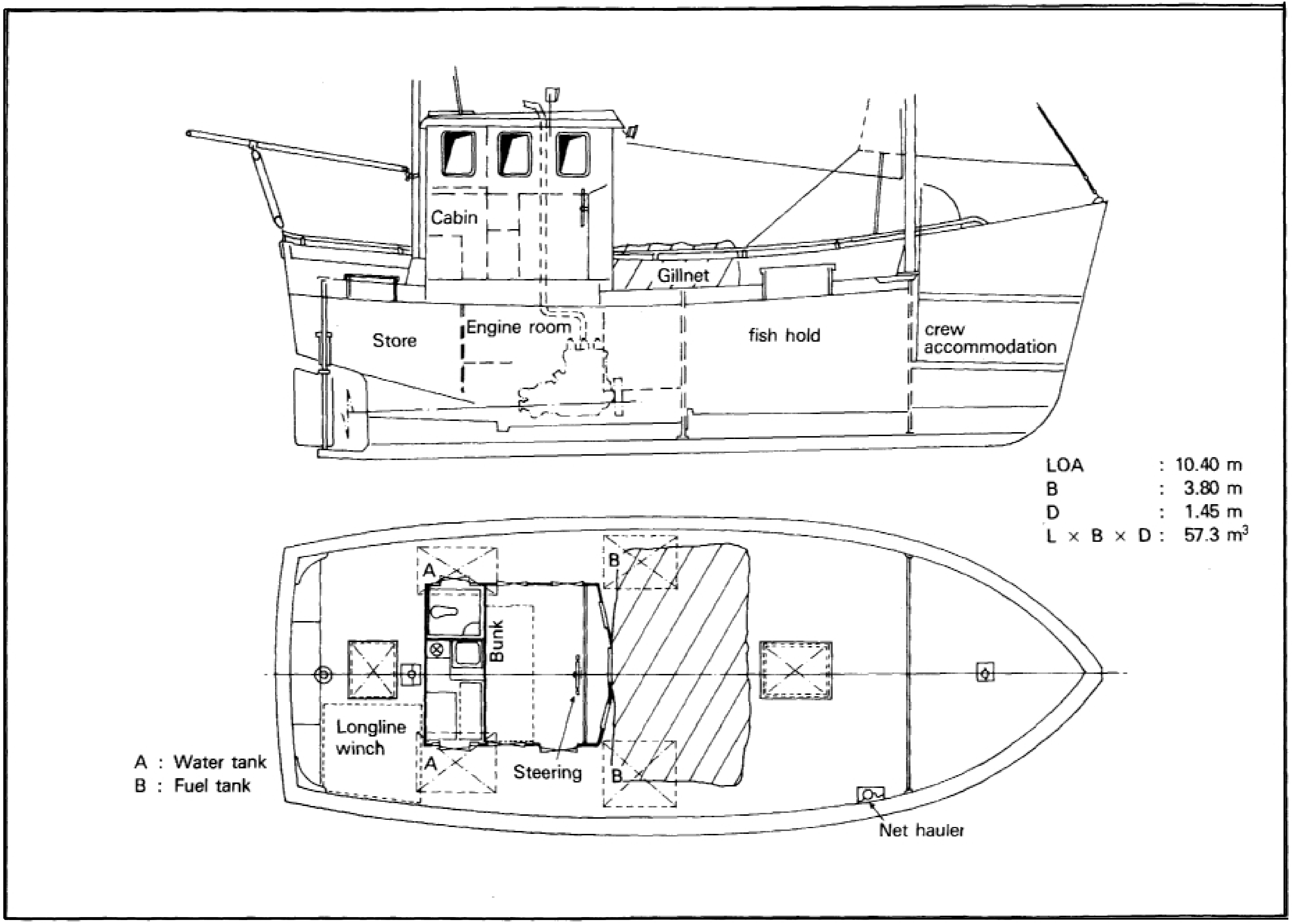


Fig. 6b Size selectivity (gilled and total) of yellowfin tuna in gilinets of different mesh sizes

Figure 7: General Arrangement—Improved version of Abu Dhabi boat



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Field Document 1

EXPLORATORY FISHING FOR LARGE PELAGIC SPECIES IN SRI LANKA

Techno-economic evaluation of Offshore Fishing Boats

by Oyvind Gulbrandsen
Consultant Naval Architect

1. Introduction

The Ministry of Fisheries initiated in 1982 the North West Coast Fisheries Project financed through the Abu Dhabi Trust Fund. From 1983 to 1987, seventy 10.4 m driftnetters-cum-drift longliners were constructed. The boats were issued with a 35% subsidy to individuals and 50% to cooperatives. The remaining loan was repayable over eight years with a 12.5% interest; this meant monthly repayments of Rs. 15,000. In the project document it was assumed that the driftnetters would each catch 100 t of fish per year. When the boats were put into operation the actual yearly catch proved to be substantially lower than predicted.

Nevertheless the Abu Dhabi boats have played a leading role in the development of the offshore fisheries in Sri Lanka. In technical terms – capacity, endurance, etc. – it is the best boat available in the country for offshore pelagic fishing. That's the reason why such a boat, NW-35, was selected for the FAO/TCP exploratory fishing project.

Parallel with the exploratory fishing, another Abu Dhabi boat (NW-4) engaged in commercial fishing from Galle was monitored. This was done by a BOBP masterfisherman who was also responsible for the operation of SRL-15, a smaller offshore boat developed by BOBP. He also monitored a couple of other 32-34 ft offshore boats.

It is difficult to say how typical the NW-4 operations are for offshore boats in Sri Lanka, and the analysis should be seen as a case study rather than as a typical representative of the offshore fleet.

BOBP's data collection started in November 1987 and was discontinued end of October 1988. Data analysed in this report is up to 31 August 1988. During the period 1 November 1986 to 31 October 1987 data were recorded by the owner and are considered reliable.

2. Operational data

The basic data on catch earnings and costs for NW-4, NW-35 (systematic exploratory fishing) and the other boats monitored are given in Table 1.

The monthly catch for the NW-4 from January 1987 to 3 1 August 1988 have been plotted in Fig. 1. During 1987 the boat was equipped with 60 pieces (120 md x 500 ml) of large mesh driftnets and 40 bundles of driftlongline. On the 20th of December 1987 the boat lost 40 nets of which 20 nets were replaced so that from January 1988 the boat was fishing with 40 nets only. (The actual driftnet catches during 1988 have been multiplied by a factor 1.5 so that Fig. 1 and Fig. 2 represent the catch of a full complement of gear.) Fig. 2 shows the catch of driftnets, drift longline and trolling lines during 1988.

During the period 1.11.87 - 3 1.8.88 the catch of the different fishing gear would have been as follows :

Driftnets (60 nets)	37.4 t	78%
Drift longlines (40 baskets)	9.1 t	19%
Trolling lines (2 lines)	1.3 t	3%
Total	47.8 t	100%

The NW-4 did 30 trips with 180 sea-days, averaging six days per trip. In 1987 the average trip duration was four days. The reason could be better catches in 1987 because of a full complement of 60 nets. When plotting the catch per trip versus the duration of the trip (Fig.3) one will notice that the crew generally stay out until a catch of 1.8 t has been achieved. A few trips up to eight days have been made when the catches were low.

A normal daily fishing operation would be as follows :

Hour	Operation
1600-1645	Set 40 baskets of drift longline approx. length 9 km
1645-1800	Set 60 driftnets approx. length = 2.5 km
0200-0530	Haul - driftnets
0530-0730	Haul - drift longlines

The first fish caught in the nets could be dead for 12 hours in a water temperature of 280C and not of good quality when being put on ice. Further increase in the number of nets would aggravate this situation.

The fish caught on the longline, mainly shark and large tunas and billfish species suffer less quality deterioration in spite of longer soaking time.

To increase the catching ability of the offshore boats during the lean driftnet season, it appears feasible to increase the quantity of longline from 40 baskets to 80 baskets. Ordinary stowage in bundles or baskets will require too much deck space on a small boat. The only alternative appears to be to store the longline on a drum using clips for the branch and float lines. Previous experience with tuna longlining has shown difficulties in bait supplies. A system of freezer storage of the suitable bait types is a pre-requisite for a more intensive tuna longlining operation in Sri Lanka.

3. Technical Evaluation

3.1 Main Characteristics

Length overall LOA	10.4 m (34 ft)
Beam midship B	3.75 m
Depth moulded to deck D	1.54 m
Cubic number LOA x B x D	60 m^3
Draft aft	1.35 m
Fish hold volume	7.5 m^3
Fish hold capacity - fish and ice	5400 kg
Fuel capacity	500 l
Fresh water capacity	400 1
Light ship displacement	10.5 t
Nets and longline	1.3 t
Fish and ice 50%	2.7 t
Fuel 50%	0.2 t
Water 50%	0.2 t
Crew and effects 100%	0.4 t
Total dead weight	4.8 t
1/2 load displacement	15.3 t
Engine model YANMAR 3 ESDE	56 hp
Power/displacement	3.7 hp/t

Hull shape : The hull is based on a British North Sea type with high beam to length ratio. This gives a stable hull, but the great beam and rather blunt bow means that relatively high engine power is required. The draft is deep because the same hull had to be suitable for use as a trawler with a larger diameter propeller. Designed only for driftnetting, the draft could have been reduced from 1.35 m to 1.0 m which would have reduced the problem of entrance to Negombo and other small fishing harbours.

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Stability : The crew appreciate the stability of the boat provided by the great beam and the high freeboard. This gives a sense of security which has contributed to the Abu Dhabi boat's success in multiday offshore fishing.

Construction . The hull is strongly constructed and has stood up well to rough handling and lack of maintenance. The most serious damage reported has been on the rudder shoe when hitting the bottom during passage through shallow entrance to Negombo harbour. Due to increased siltation, boats now have to wait for high tide to pass the entrance.

The wooden fenders have suffered due to the boats being moored alongside each other without adequate protection with tyres. Replacement of wooden fenders is difficult.

Engine : The YANMAR 3ESDE engine has proven very robust and there are no boats out of commission because of major engine breakdown. The engine can be hand-started, an important safety feature which is much appreciated by the fishermen.

The engine ventilation system is insufficient, with two inlets but no outlets. The fishermen complain about the heat in the engine room which adversely affects the performance of the engine.

The YANMAR 3ESDE engine has an indirect fuel injection system giving a high specific fuel consumption compared with more modern engines. In combination with the high power required to push the heavy, beamy boat, this has resulted in a fuel cost per kg of fish caught being twice as high as smaller multiday boats (Table 1).

The two fuel tanks totalling 500 litres installed in the engine room do not give sufficient capacity. The boats now carry 200 litres extra fuel in two plastic drums on deck. With a total of 700 lt fuel, the endurance is 70 hours at an engine speed of 1600 rpm and a boat speed of about 7 knots.

Fish hold : Most boats have inadequate insulation resulting in high expenditure on ice. The boat takes 70 blocks of ice at 40-50 kg each giving a total of 3 t of ice. After a normal trip of 5 days about 500 kg is left in the fish hold. The fish hold has a net volume of 7.5m which would be required for the predicted catch of 100 t per year (45 trips of 2.2 tonne). The recorded catch of NW-4 indicates an average catch per trip of 1.6 t. From Fig. 3 it will be seen that the catch rarely exceeds 2 t. With a fish to ice ratio of 1: 1, a fish hold volume of 5mf3f would be sufficient, a saving in volume of 30%. Together with better insulation this would have reduced the ice consumption.

Crew accommodation : There are two bunks on the port side of the wheel house. Normally one crew member keeps watch while four are sleeping. Two crew members therefore have to sleep on the floor in the wheel house. Because of a cupboard it is not possible to stretch out the legs. For a boat staying out for 4-7 days this arrangement is highly unsatisfactory and shows a lack of concern for the comfort of the crew. By a better space utilization it should have been possible to provide sleeping space for four crew members.

Cooking facilities are adequate.

Fresh water capacity of 450 litres in two tanks under deck is adequate but many boats carry water in a plastic drum on the aft deck because it is more convenient for washing than using the galley pump.

No toilet facilities were provided. Many boats have fitted a simple cage on the outside of the stern to solve this problem. Some boats are fitted with awning over the aft deck. This is much appreciated by the crew.

Equipment : The net hauler was delivered by Lorenzen Mek Vertsted in Norway. There have been problems with breaking of the pedestal and high wear on the rubber. The crew complain of lack of a hauling power when there is shark in the net and of the need to change the hydraulic hoses and rubberize the power block every second year. A single V groove would have given a better grip than the present double groove.

A FURUNO SSB radio model FS 1000 is fitted. Being able to communicate with other boats and to the shore has increased the confidence of the crew. The radio can also be used for determining the position by calling up three direction finding stations at Hambantota, Beruwala and Wennapuwa.

General maintenance : Maintenance of the boats is extremely poor. Very few boats use anti-fouling paint, with the result that the growth of barnacles and seaweed increase the resistance of the boat and thereby the fuel consumption. The shipping charge in Negombo is Rs. 1,300 and six litres of anti-fouling paint would cost Rs.1,500. But most owners just scrape the hull and apply a brown paint costing Rs.500, evidently unaware of the effect of fouling on fuel consumption.

Economic evaluation

The *cost of building* a new 10.4 m Abu Dhabi boat today (Nov'88) is based on estimates given by two boatyards that have built the boat previously; Neil Marine and Cey-nor. The table below gives the cost as originally built and the estimated cost today.

		1982	1988
Hull		730,000	950,000
Engine Yanmar 3ESDE		150,000	530,000
Nethauler		70,000	90,000
SSB Radio		40,000	100,000
Electrical System		60,000	80,000
Equipment		86,000	100,000
Total :	Boat	1,136,000	1,850,000
	Fishing Gear (60 nets, 40 baskets longline)	200,000	280,000
Total		1,336,000	2,130,000

The yearly revenue is based on the data from the 10.4 m Abu Dhabi boat NW-4 operating from Galle. The data available over 22 months from 1.11.86 to 3 1.8.88 indicate that the total yearly catch, assuming a full complement of gear throughout, would have been about 64 t. The average fish price for 1988 is 19.5 Rs/kg, an increase from 14.3 Rs/kg in 1987. With the 1988 price the. total value of the yearly catch is Rs 1,248,000.

Return on investment

		Rs.
I. In vestment		
a) Hull		950,000
b) Engine		530,000
c) Equipment		370,000
d) Sub total		1,850,000
e) Fishing gear 60 driftnets (120 MD X 500 ML) 40 bundles of longline		280,000
f) Total investment		2,130,000
II. Annual Fixed Cost		
a) Depreciation of hull - 16 years		59,000
b) Depreciation of engine - 8 years		66,000
c) Depreciation of equipment, 12 years		31,000
d) Depreciation of fishing gear,4 years		70,000
e) Insurance 1.8% on boat, 5% on fishing gear		47,000
f) Total fixed cost		273,000
III. *Annual Variable Cost*		
a) Fuel and oil		203,000
b) Ice		97,000
c) Bait		2,000
d) Food for crew		61,000
e) Repairs hull, engine and fishing gear		45,000
f) Crew share		
Gross income	1,248,000	
– Expenses III a) b) c) d)	363,000	
Net income	885,000	
Crew share, 50% of net income		443,000
g) Tax 5% of gross income		62,000
h) Total variable cost		913,000

IV.	*Total annual cost IIf) + III h)*	1,186,000
V.	*Annual revenue* 64 tonne at Rs.l9.50/kg	1,248,000
VI.	*Net profit* V - IV	62,000
VII.	*Rate of return* (VI/I f) x 100%	3%

The conclusion is that the boat is not economically viable at present prices. A contributing factor is the high crew share being 50% of net returns. This is the same percentage used on smaller boats with far less investment per fisherman. With a crew of five men the earning per fisherman is Rs 88,000 per year. Other boats doing multiday fishing have an earning per fisherman around Rs 70,000. If the crew on the Abu Dhabi boat should earn the same, the crew share would be reduced from 50% to 40%. This would result in an increase in net profit from Rs 62,000 to Rs 151,000 and an increase in the rate of return from 3% to 7%.

To obtain finance from a bank, the rate of return must be a minimum of 15%, which means an annual net profit of Rs 320, 000.

With the present crew share of 50% of net income, the boat needs to catch an impossible 100t. A more realistic figure is 65t per year. The Abu Dhabi boat will not give a sufficient rate of return on investment with this catch.

With a 35% subsidy, the boat will give a 15% return on investment with a catch of 80 t which is also not realistic.

A new *boat* for offshore fishery would have to be an intermediate size between the larger and smaller multiday boats presently in use, the latter of which has proven to be economically viable. These boats, however, suffer from defects in the general arrangement especially regarding position of fish hold and crew accomodation. Further, the stability of many boats borders on the limit of IMO criteria because of the heavy net (1.2 t) being stored on top of the deck.

5. A new offshore boat

Requirements : The experience from the operations of the Abu Dhabi boats and smaller multiday boats should be utilized to define more clearly the characteristics of an offshore fishing boat for Sri Lanka. The following basic requirements must be satisfied :

i) Investment should not be considerably higher than on multiday boats presently used. Return on investment should be minimum 15% without subsidy.

ii) Carry 60 driftnets (120 MD x 500 ML) and 80 baskets of tuna or shark longline

iii) Have an endurance of 70 hours running at a cruising speed of 6.5 - 7 knots. Maximum distance covered 450 n miles.

iv) Maintain the quality of the catch up to 10 days.

v) Provide adequate accommodation for the crew.

Estimated catch : Based on data from the Abu Dhabi boat NW-4, the average yearly number of trips is 45 with a trip duration of 4.7 days. Total number of seadays per year is 225 days. Assuming that there is a trend towards longer trips, the new boat will have an average of 6 days per trip, with 40 trips/year. Average catch per sea day for the NW-4 is 288 kg. With increased amount of drift longline from 40 baskets to upto 80 baskets there should be an added catch. The catch per seaday is conservatively estimated to be 300 kg. 40 trips of average 6 days will give an average catch per trip of 1.8 t and a yearly catch of 72 t.

Fish ho/d capacity : The fish hold needs to have a capacity 50% higher than average catch of 1.8 t per trip that is 2.7t. Should the catch be stored in chilled seawater it would give a superior quality of preservation. Normally, the stowage rate in chilled seawater is 750 kg fish per m^3 of hold volume. Large tuna and shark will have a lower stowage rate of 600 kg fish per m^3 of hold volume. The required volume is therefore 4.5 m^3.

With good insulation it should be possible to achieve a ratio of 1.3 t of ice to 1.0 t fish. About 2.3 t of ice will be needed per trip. Should ice be used for preservation, a separate ice hold will be an advantage to keep down the melting rate. The ice hold should have a capacity of 3 m^3. The fish hold should therefore be divided into two compartments, one of 3 m^3 and the other about

2 m^3 giving a total of 5 m^3. Each compartment must be divided by longitudinal fixed and removable partitions to reduce damage to fish when rolling.

Ice consumption can be reduced by installing a refrigeration unit. If ice consumption can be halved, from 90 t to 45 t per year, the saving would be Rs 36,000 per year. Assuming an investment of Rs 100,000 and a depreciation over 8 years with a yearly fuel cost of Rs 4,000 and a repair cost of Rs 5,000, the net profit would be Rs 75,000 or 15% on the investment.

General Arrangement : Based on the required fish hold capacity and the space for crew, driftnets and drift longline, a proposed general arrangement plan for a new offshore boat is shown in Fig 4. (Table 2 gives the main characteristics compared with existing craft). The main features are :

a) Engine placed further aft by changing the hull shape. Draft reduced to 1 .O m (0.35 m less than the Abu Dhabi boat).

b) Fish hold moved further aft to avoid bow trim in loaded condition.

c) Driftnets stored in a net hold forward of the fish hold to improve stability. The driftnet weighs 1.2 t when soaked and will decrease stability when stored on deck.

d) Deckhouse offset to port to give free passage on one side, four bunks in deck house.

e) Longline drum placed on aft deck with space for stowage, marker buoys and shooting operation.

f) Storage space for fishing gear and accessories forward and aft.

g) Air inlet and air suction outlet from engine compartment above the roof of the deckhouse.

Because of the fish hold being further aft the lines of the forebody can be made finer to reduce resistance and thereby fuel consumption.

Engine : An engine of 35-43 hp would be suitable. At present there is available a Yanmar 3TDG engine of 39 hp costing Rs.275.000 including all accessories. Required engine power is based on experience with existing boats as shown in the table below

Craft	Installed power (hp)	1/2 Load displce ment (t)	Installed (hp/t)	Service Power (hp)	Service fuel consumption (1/h)	Service speed (knots)	Litre per n.m.
SRL-15	20	5.9	3.4	12	3.2	7	0.5
Abu Dhabi 10.4 m	56	15.1	3.7	34	8.0	6.5	1.2
New offshore boat	39	10.0	3.9	23	5.5	6.5	0.85

Equipment : For hauling of 60 gillnets totalling 2.5 km a hydraulic hauler is a great advantage. The required pull is 500 kg and a single groove rubber sheave should be selected to get a better grip than from the double groove sheave used on the Abu Dhabi boat.

A hydraulic *drift longline drum* to store 80 baskets of drift longline (18 km) should be installed on the aft deck. The drift longline drum should operate on the same hydraulic system as the net hauler.

A *SSB Radio* will be required for communication, emergency calls and for direction finding.

Hull cost : Estimated hull cost is based on cost of boats being built at present.

Craft	Dimensions LOA x B x D * (m)	Cubic Number (m^3)	1988 cost (Rs)	Cost per CU.NO. (Rs/m^3)
SRL-15	9.75 x 2.67 x 0.9	23	290	12.600
Neil Marine 34	10.4 x 3.12 x 1.08	35	350	10.000
Blue Star Marine 32	9.70 x 3.44 x 1.22	41	415	10.000
New offshore boat	11.0 x 3.25 x 1.20	43	473	11.000

* LOA Length overall
B Beam at deck level
D Depth moulded from rabbet line to deck at side

Economic evaluation of new offshore boat

		Rs.
I. *Investment*		
a) Hull	480,000	
b) Engine	280,000	
c) Equipment		
Net hauler	80,000	
Drift longline drum	50,000	
SSB radio	100,000	
Electrical	70,000	
Miscellaneous	30,000	
Total	330,000	330,000
d) Complete boat		1,090,000
e) Fishing gear		
60 driftnets (120 MD x 500 ML) 4100 Rs/net	248,000	
80 baskets of drift longline at 900 Rs/basket	72,000	
Total	320,000	320,000
f) Total Investment		1,410,000
II. *Annual Fixed Cost*		
a) Depreciation of hull - 16 years		30,000
b) Depreciation of engine - 8 years		35,000
c) Depreciation of equipment - 12 years		28,000
d) Depreciation of fishing gear - 4 years		80,000
e) Insurance, 1.8% on boat 5% on gear		36,000
f) Total fixed cost		209,000
III. *Annual Variable Cost*		
a) Fuel and oil, 40 trips/year 350 litre/trip. 8.30 Rs/litre + oil = 10% of fuel cost		128,000
b) ice 1.3 tonne ice/l tonne fish = 93 tonne x Rs.800/tonne		75,000
c) Food for crew		61,000
d) Bait for tuna drift longlining		50,000
e) Hull maintenance 2% of I(a)		10,000
f) Engine and equipment maintenance 5% of I (b) and (c)		31,000
g) Fishing gear maintenance 1% of I (e)		3,000
h) Crew share		
Gross income :		
72,000 kg x 19.50 Rs/kg =	1,404,000	
– Expenses III (a)(b)(c)(d)	314,000	
Net income	1,090,000	
Crew share 50% of net income		545,000
i) Tax 5% on gross income		70,000
j) Total variable cost		973,000

IV. *Total annual cost* II (f) + III (j)	1,182,000
V. *Annual revenue*	
72,000 kg x 19.50 Rs/kg	1,404,000
VI. Net *profit V* - IV	222,000
VII. *Rate* of *return* VI/I (f) x 100%	15.7%

The rate of return is satisfactory. With a more "normal" crew share of 40% used in mechanised boats in other countries, the rate of return would have been 25%. The income per fisherman would still be Rs 90,000 per year which is well above average for multiday offshore boats.

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Table 1: Comparative Data on 10.4m Abu Dbabi Boat NW4 and other Multiday Boats

Boat Type	10.4m Abu Dhabi NW-4	10.4m Abu Dhabi NW-35	9.7m BOBP SRL-15	32 ft Neil Marine NM-237	32 ft Neil Marine/BOBP SRL-34
Period of catch recording and base of operation	1.11.87-31.8.88 Galle	1.11.87-31.8.88 Galle & Negombo	1.11.87-31.1.88 Galle	1.2.88-31.8.88 Galle	1.5.87-30.11.87 Beruwela
Duration (months)	10	10	10	7	7
Trips (no)	30	28	44	36	45
No. of seadays (no.)	180	144	181	130	104
Seadays/trip (no.)	6.0	5.1	4.1	3.6	2.3
Gillnets 500 meshes (no.)	40	60	43	44	44
Catch gillnets (t)	24.9	22.4	21.3	22.2	11.3
Catch longline (t)	9.1	1.5	3.0	1.7	4.1
Catch trolling lines (t)	1.3	0.6	1.5	1.4	1.1
Total catch (t)	35.3	24.5	25.8	25.3	16.5
Catch rate per sea day (kg)	196	170	143	195	160
Value of catch (Rs)	687,039	446,182	530,885	537,000	306,967
Value per kg (Rs)	19.60	18.20	20.60	21.20	18.50
Fuel cost (Rs)	144,984	114,300	40,122	42,021	27,366
Fuel cost per kg of fish (Rs)	4.11	4.67	1.56	1.66	1.65
Cost of ice (Rs)	75,950	62,005	23,850	26,500	20,680
Cost of ice per kg of fish (Rs)	2.15	2.53	0.92	1.05	1.25
Cost of food+misc (Rs)	66,600	40,564	60,090	48,700	22,179
Cost of food + misc per kg of fish (Rs)	1.89	1.66	2.33	1.92	1.34
Net earning (Rs)	399,505	229,313	406,823	419,779	236,742
Net earning per sea day (Rs)	2219	1592	2248	3229	2276
Crew Share (Rs)	199,753	114,657	203,412	209,890	118,371
Crew (no)	5	5	4	4	4
Crew share per kg of fish (Rs)	5.66	4.68	7.88	8.30	7.17
Crew member earning/seaday (Rs)	222	159	281	404	285

EXPLORATORY FISHING FOR LARGE PELAGIC SPECIES IN SRI LANKA
(BOBP/REP/47)

The following may please be noted in BOBP Report No. 47 issued in April 1991.

Page 33 should read as follows :

Table 2 : Main Characteristics of Present Multiday Boats

	Length overall LOA (m)	Beam moulded B (m)	Depth moulded D (m)	Cubic number LOAxBxD (m^3)	Draft maximum T (m)	Fishhold inside volume (m^3)	Displacement 1/2 load (tonne)	Engine Power (hp)	Hp/ tonne
34 ft Abu Dhabi	10.4	3.73	1.54	60	1.35	7.5	15.1	56	3.7
SRL-15	9.75	2.67	0.90	23	0.98	2.1	5.9	20	3.4
Neil Marine, 32 ft	9.75	3.12	1.08	33	0.90	2.6	6.0	30	5.0
Neil Marine, 34 ft (Superfine)	10.4	3.12	1.08	35	0.90	4.0	N.A.	45	N.A.
Blue Star Marine, 32 ft	9.70	3.44	1.22	41	1.20	5.7	N.A.	45	N.A.
New Offshore boat	11.0	3.25	1.15	40	1.00	5.0	10.0	39	3.9

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Table 2: Main Characteristics of Present Multiday Boats

	Length overall LOA (m)	Beam moulded (m)	Cubic number LOAxBxD (m^3)	Draft maximum T (m)	Fish-hold volume (m^3)	Displace-ment l/2 load (t)	Engine power (hp)	Power dis-placement ratio (hp/t)	
34 ft Abu Dhabi	10.40	3.73	1.54	60	1.35	7.50	15.1	56	3.7
SRL-15	9.75	2.67	0.90	23	0.98	2.10	5.9	20	3.4
Neil Marine, 32 ft	9.75	3.12	1.08	33	0.90	2.60	6.0	30	5.0
Neil Marine, 34 ft (Superfine)	10.40	3.12	1.08	35	0.90	4.00	6.0	45	N.A.
Blue Star Marine, 32 ft	9.70	3.44	1.22	41	1.20	5.70	N.A.	45	N.A.
New Offshore boat	11.00	3.25	1.15	40	1.00	5.00	10.0	39	3.9

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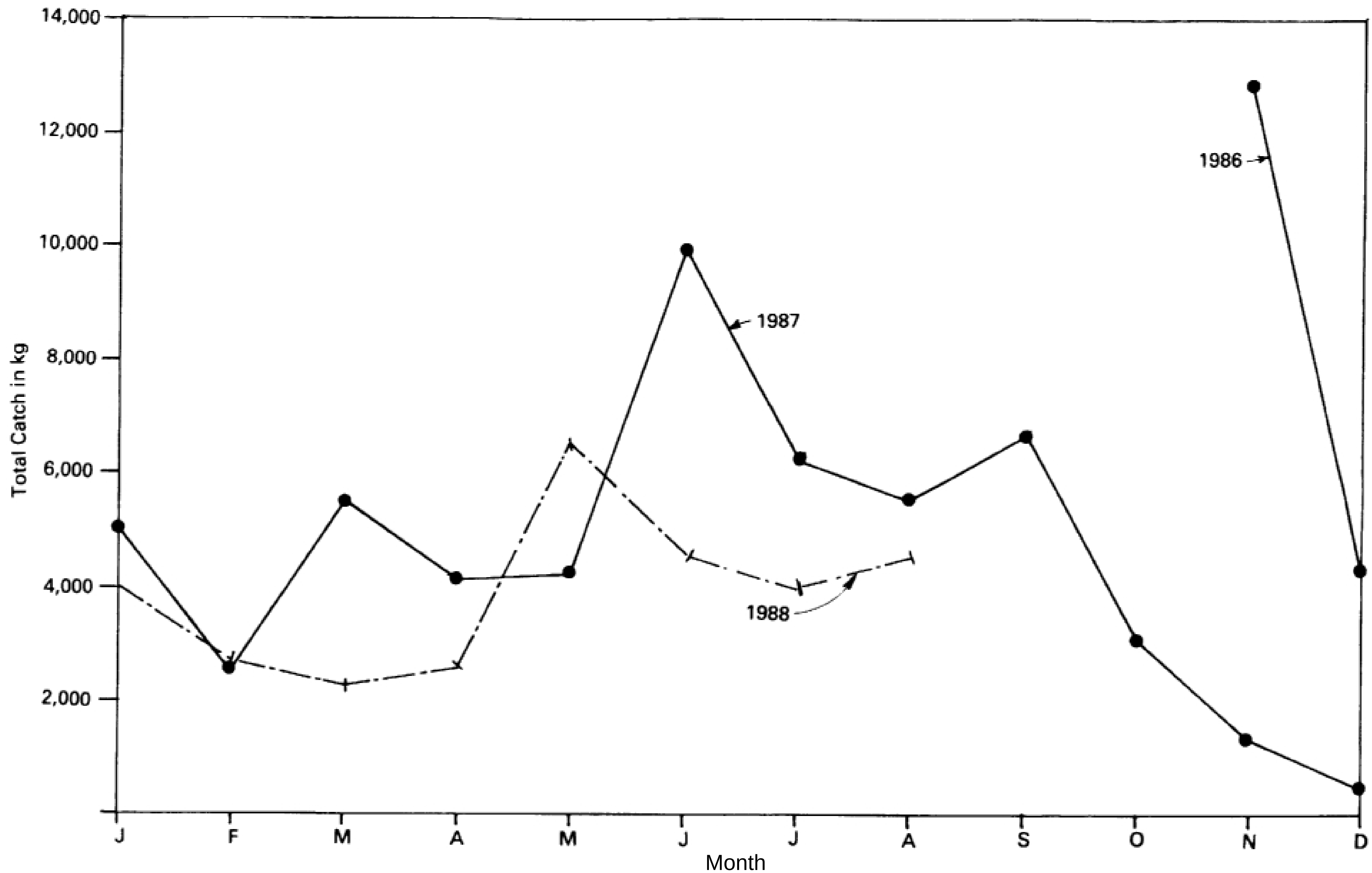

Fig.1 Monthly Catch—10.4m Abu Dhabi Boat NW. 4

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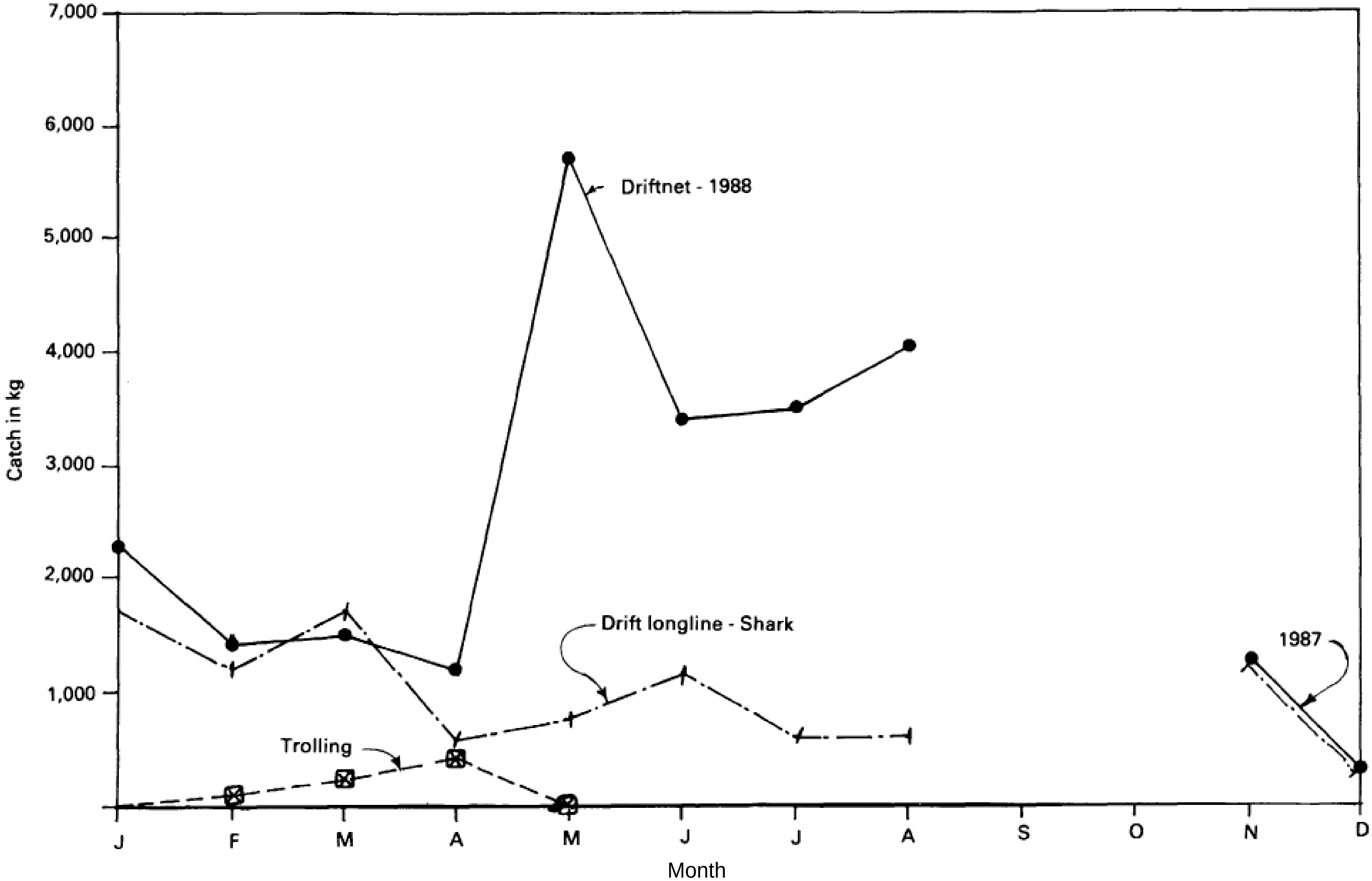
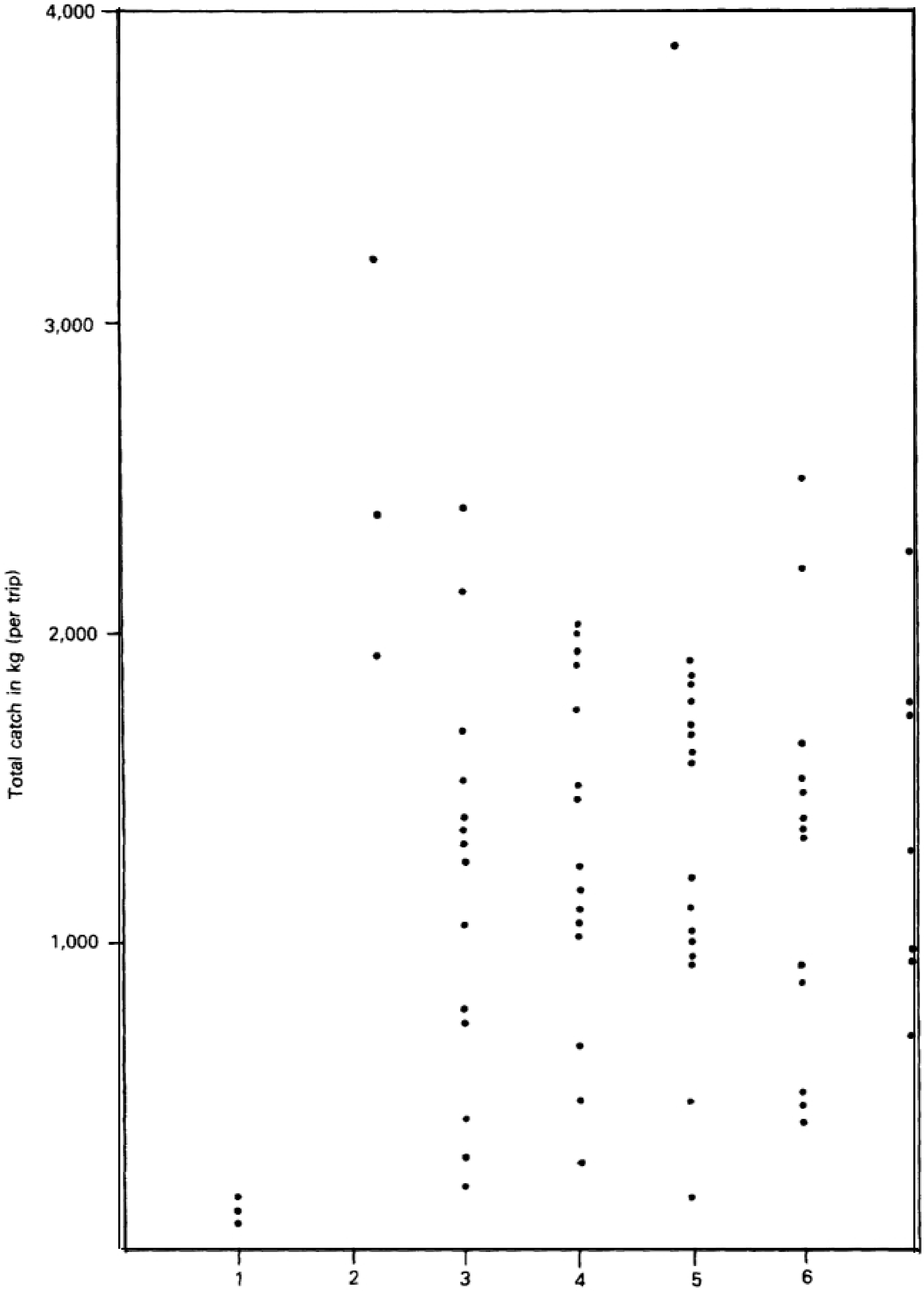


Fig. 2 Catch, gearwise—10.4m Abu Dhabi Boat NW. 4

Operating from Galle Nov.'86 to Oct.'88
Total = 80 trips



Number of seadays per trip

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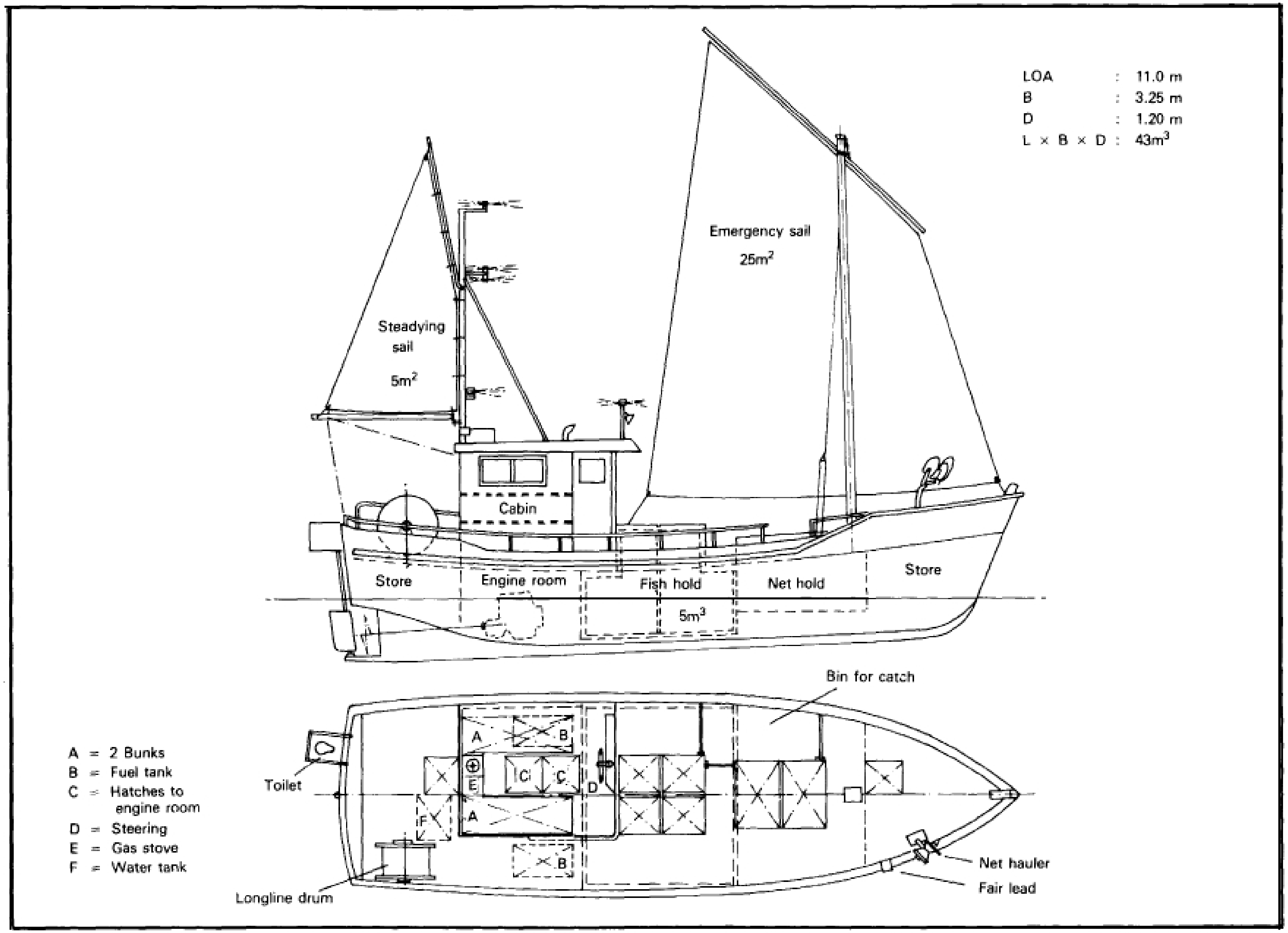
Fig. 3 Catch—and seadays per trip—10.4 m Abu Dhabi Boat NW. 4

Fig. 4 General Arrangement - New Offshore Boat



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Field Document 2

EXPLORATORY FISHING FOR LARGE PELAGIC SPECIES IN SRI LANKA

Biological Report

by Rekha Maldeniya
National Aquatic Resources Agency
Sri Lanka

1. Materials and Methods

1.1 *Size Composition* – Samples of major species of tunas and one species of pelagic shark were selected randomly for their length measurement. The length measurements for each species were stratified according to gear, sub area, fishing range and month.

1.2 *Sex ratio and gonad maturity* – These were investigated for skipjack and yellowfin tuna and sex ratios were determined for two species of sharks. Sex was identified by examination of the gonads of randomly chosen numbers of fish of the two species of tuna and by examining the secondary sexual characters of the two shark species. For the tunas, the gonad weight, fish length, area of capture and fishing season were noted. The gonads were preserved for laboratory examination of maturity stage according to the seven stages scale (Table 1) based on the morphology of the ovary and ova diameter. The Gonado Somatic index (GSI) was taken as GSI =

$$\frac{\text{Weight of gonad}}{\text{Total length of fish}^3} \times 10^5$$

1.3 *Stomach contents* – Stomach contents of the two major tuna species and one shark species were examined. The contents were preserved for laboratory analysis of volume of items, for identifying the species and estimating their numbers.

1.4 *Parasites* – These were observed in relation to their location on and in the body of the tuna species, numbers present in different fishing areas and seasons. Species identification was done with the help of the University of Sri Lanka.

2. Results

2.1 *Size composition of major species* – Length frequency distribution of skipjack tuna in the gillnet fishery shows that a size range of 30 to 82 cm has been sampled, with over 90% fish within the 40 to 70 cm range. Fig. 1 shows the area-wise length frequencies of skipjack in the gillnet fishery, for the two years, 1987 and 1988. Small skipjack of less than 34 cm were found mainly in the 'South-West'. There are also signs of model progressions from 'South-West' to 'Northwest' and 'south'. The quarterly length frequency distribution shows that small skipjack of 'South-West' were observed mostly during the second and third quarters, suggesting possible recruitment of skipjack off the South-West, followed by a movement northwards and southwards. Recruitment seems to be occurring predominantly in the southwest during the second and third quarters as seen from the data for 1988.

The size composition of yellowfin caught in gillnet, longline and troll lines is shown in Fig.2. Yellowfin in gillnet catches measured 32 to 152 cm with a majority within the 44 to 76 cm range. Troll catches comprised of immature fish (48 to 64 cm) as well as adults (104 to 160 cm). Longline catches were all adults (120 - 145 cm).

A seasonal shift in modal size was evident in the North-West area only (Fig.3). The continuity in the size groups taken by trolling lines, gillnet and longline tends to indicate that the juvenile yellowfin, showing a seasonal shift northwards, commences to spread into deeper water and becomes available to the longline fishery, as hypothesized by Sivasubramaniam(l970).

Frigate tuna, bullet tuna and kawakawa were the smaller tuna varieties predominant in the catches. The size composition of these species in the gillnet catches is shown in Fig. 4.

Sharks ***(C.falciformis)*** caught during the exploratory fishing were of the following size ranges (Fig. 5) :

Gillnet	61 - 293 cm TL
Longline	63 - 145 cm TL

A much wider size range was observed in the gillnet catches, and the size range caught by longlines was not larger than that in the gillnets.

2.2 Reproductive biology

Reproductive biological studies were conducted only on skipjack and yellowfin tunas, two of the main species caught during the survey.

A total of 1440 skipjack examined during 1987 and 1988, showed a male-to-female sex ratio of 1:0.97. Females outnumbered the males during the south-west monsoon months of June to October. Size distribution of skipjack by sex showed that the proportion of females was greater in sizes less than 57 cm and that of males was more in sizes over 59 cm. This is in agreement with the earlier report by Amarasiri and Joseph(1988).

The Gonado-Somatic index estimated for female skipjack is given below, correlated to the maturity stages established.

	Maturity stage	*No. samples scanned*	*Gonado-Somatic Index*	*Standard Deviation*
I.	Immature	30	1.58	0.95
II.	Early developing	124	4.6	1.45
III.	Late developing	112	9.73	2.1
IV.	Mature	98	14.25	2.9
V.	Gravid or running	7	16.17	2.01
VI.	Partially spawned	43	7.98	3.05
VII.	Spent	5	3.83	1.98

Frequency distribution of ova diameter showed five distinct groups of ova - immature (0 - 0.08 mm), developing (0.08 - 0.38 mm), mature (0.32 - 0.52 mm), gravid (0.54 0.68 mm) and running (1.02 mm) (Table 1). Maturity studies indicated the presence of a relatively high percentage of mature, spawning and spent fish in most months. Separation of female skipjack into "immature" and "mature" fish (Table 2) suggest that spawning commences just before the south-west monsoon (in March/April) and would prevail until the end of the monsoon (Sept/Oct).

Occurrence of partially spent fish during this period may be indicative of spawning pulses within the long spawning period. Length at maturity studies yielded 50% maturity at 45.4 cm for female skipjack. Amarasiri and Joseph (1988) reported 42.0 and 43.2 cm for the male and female skipjack tuna, respectively.

The 408 yellowfin examined showed a male to female ratio of 1:0.91. Unlike in the case of skipjack, males outnumber the females during the south-west monsoon months. Females were dominant in February, April, October and November, Size distribution of yellowfin by sex show more males beyond a length of 112 cm. There was no marked difference in the sex among the juveniles. Fish below 100 cm were generally immature and the smallest fish with mature ova measured 112 cm. Since only a few specimens of large mature fish were sampled, no estimation of size at first maturity was attempted for yellowfin. These results are in agreement with earlier findings by Maldeniya and Joseph (1988). Sex ratios for two species of sharks, based on 189 individuals examined, were as follows :

C. falciformis	F : M	1 : 0.82
C.longimanus	F : M	1 : 0.55

2.3' Food and Feeding - Stomach contents of the main tuna and shark species were analysed for feeding habits and the prey species identified visually were categorised into fish, crabs, squids, shrimps and 'other items' (larvae of crustacean, copepods, etc.)

A total of 614 stomachs of skipjack tuna were examined during the two years and 35% of these were categorised as 'full' stomachs. The percentage composition of the major food items observed in 1987 and 1988 were as follows :

Major food item	*Percentage Composition*	
	1987	*1988*
Fish	35.9	34.7
Squids	30.7	28.0
Shrimps	31.5	33.3
Crabs	1.3	3.1
Other items	0.6	0.9

A fairly consistent pattern of composition was observed for the two years. A higher percentage of full stomachs were observed during the peak fishing season which is the south-west monsoon period (Fig. 6). Small shrimp (Acetes spp) was a very significant food item during the peak fishing season. Small frigate tuna (20%) was the major fish food item identified in the stomachs.

Only 17% of the 315 yellowfin stomachs examined were found to be full. Gut contents in others were in advanced stages of digestion in almost all cases and only large prey species like frigate tuna could be identified.

Gut contents of 306 sharks, all belonging to C. *falciformis,* were examined in 1988. 83% had empty stomachs and 10% had only baitfish. Most of the prey items in the rest were also in an advanced stage of digestion with over 50% of unidentifiable items. The remaining prey items consisted of squids (21%), frigate tuna (13%), crabs (7%) and skipjack (5%). Other unidentified items accounted for the rest.

3. *Parasites* — Parasites present on fish are sometimes useful in identifying fish stocks, functioning like a tag. Besides that, parasitism on valuable fish can affect the value of the fish. Qualitative and quantitative assessment of major parasitic forms on skipjack and yellowfin tunas were made during the biological investigation. Identification of the species of parasites was done with the assistance of the staff of the University of Sri Lanka.

In skipjack, an external parasite was found on the membrane between the spines of the first dorsal fin, as 'yellow dot' and has been identified as a sessile parasitic trematode of the genus *Didymocystis.* More than 70% of this parasite was found between the 1st and 2nd and 2nd and 3rd spines (Fig.7). Fish sampled from the West and South-West (Fig. 8) had more of this parasite, compared to fish sampled from other areas. Relatively higher numbers were also found on fish sampled during June to September 1987 and May to August 1988 — during the South West monsoon period.

A round, whitish and worm-like parasite, identified as a larval form of a cestode belonging to the genus *Tentacularia,* was found on gills, in the mouth, body cavity, gut and in muscles. The largest proportion was located within the body cavity. Large numbers of this parasite were also found during the south-west monsoon period. Further, presence of large numbers of this parasite coincided with the presence of larger amounts of shrimps *(Acetes* spp) in the stomachs of skipjack (Fig. 9).

A brown coloured (2.0 - 2.5 cm long) parasite located in the gill cavity of yellowfin, with its head buried in the gill filaments, was identified as a copepod of the genus *Pseudoeyeus.* These were observed mainly from October to January (Fig. 10) and mainly on juvenile yellowfin tuna of 35-58 cm length range.

References cited

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MALDENIYA, R and JOSEPH, L (1988) On the distribution and biology of yellowfin tuna *(T.albacares)* from the western and southern coastal waters of Sri Lanka; BOBP/REP/41; pp 108 - 122.

SIVASUBRAMANIAM, K (1970) Surface and subsurface fisheries for young and immature yellowfin tuna *(T. albacares)* around Ceylon; Bull. Fish. Res. Ceylon Vol. 21 No. 2 pp. 113 - 122.

Table 1 : Classification of the maturity stages of ovary in skipjack and yellowfin tunas

Maturity Stage	Description
I. Immature	Ovaries are small threadlike, much elongated, round in cross section with no apparent vascularization, fairly turgid. Max. ova diameter 0 - 0.08 mm Mean G.S.I.* 1.58
11. Early developing	Ovaries increase in size, are shaped like hollow tubes, pinkish, yellow, vascularization slightly visible. Max. ovadiameter 0.08 - 0.24 mm Mean G.S.l.* 4.6
111. Late developing	Ovaries are increasingly rounded, tightly packed, cream or yellow. The branching of blood vessels increases, they are clearly visible. Ova visible through the ovarian wall. Max. ova diameter 0.16 - 0.38 mm Mean G.S.l.* 9.73
IV. Mature	Ovaries are yellow or yellowish pink, well vascularized and have a thin wall through which the much larger eggs can be seen, eggs are translucent, light orange. Max. ova diameter 0.32 - 0.52 mm Mean G.S.l.* 14.3
V. Gravid	Ovaries are orange or yellowish pink, well vascularized and have a thin wall, soft and delicate. The branching of blood vessels increases and they are fuller with blood. The thin skin shows many free large eggs inside. If the wall is damaged, eggs disperse. Max. ova diameter 0.54 - 0.68 mm Mean G.S.l.* 16.2
VI. Partially spawned	Ovaries are reddish brown or orangish brown. Blood vessels still prominent. Ovaries are soft, somewhat flabby and contain some large degenerating eggs. Still large ova can be seen through the ovarian wall. Max. ova diameter 0.47 - 0.58 mm Mean G.S.I.* 8.0
VII. Spent	Ovaries are soft and flabby. Brown or reddish brown. May still have a few degenerating ripe eggs. Ova cannot be seen through the ovarian wall. Max. ova diameter 1.02 mm Mean G.S.l.* 3.8

* G.S.I. = Gonado-Somatic Index

Note : The values for max ova diameter and mean GSI relate only to skipjack.

Table 2 : Monthly percentages of immature and mature ovaries in the samples of skipjack tuna

% Maturity

Year	Month	No. of Samples (Female)	"Immature" Maturity Stages I - III	"Mature" Maturity Stages IV - VII
1987	January	—	—	—
	February	8	62.5	37.5
	March	21	42.9	57.1
	April	13	38.5	61.5
	May	11	36.4	63.6
	June	41	41.5	58.5
	July	29	37.9	62.1
	August	63	42.9	57.1
	September	72	45.8	54.2
	October	18	61.1	38.9
	November	9	66.7	33.3
	December	7	57.1	42.9
1988	January	10	70.0	30.0
	February	11	63.6	36.4
	March	35	54.3	45.7
	April	23	43.5	56.5
	May	18	38.9	61.1
	June	58	43.1	56.9
	July	37	40.5	59.5
	August	90	45.6	54.4
	September	11	39.6	60.4
	October	38	55.3	44.7
	November	18	55.6	44.5
	December	—	—	—

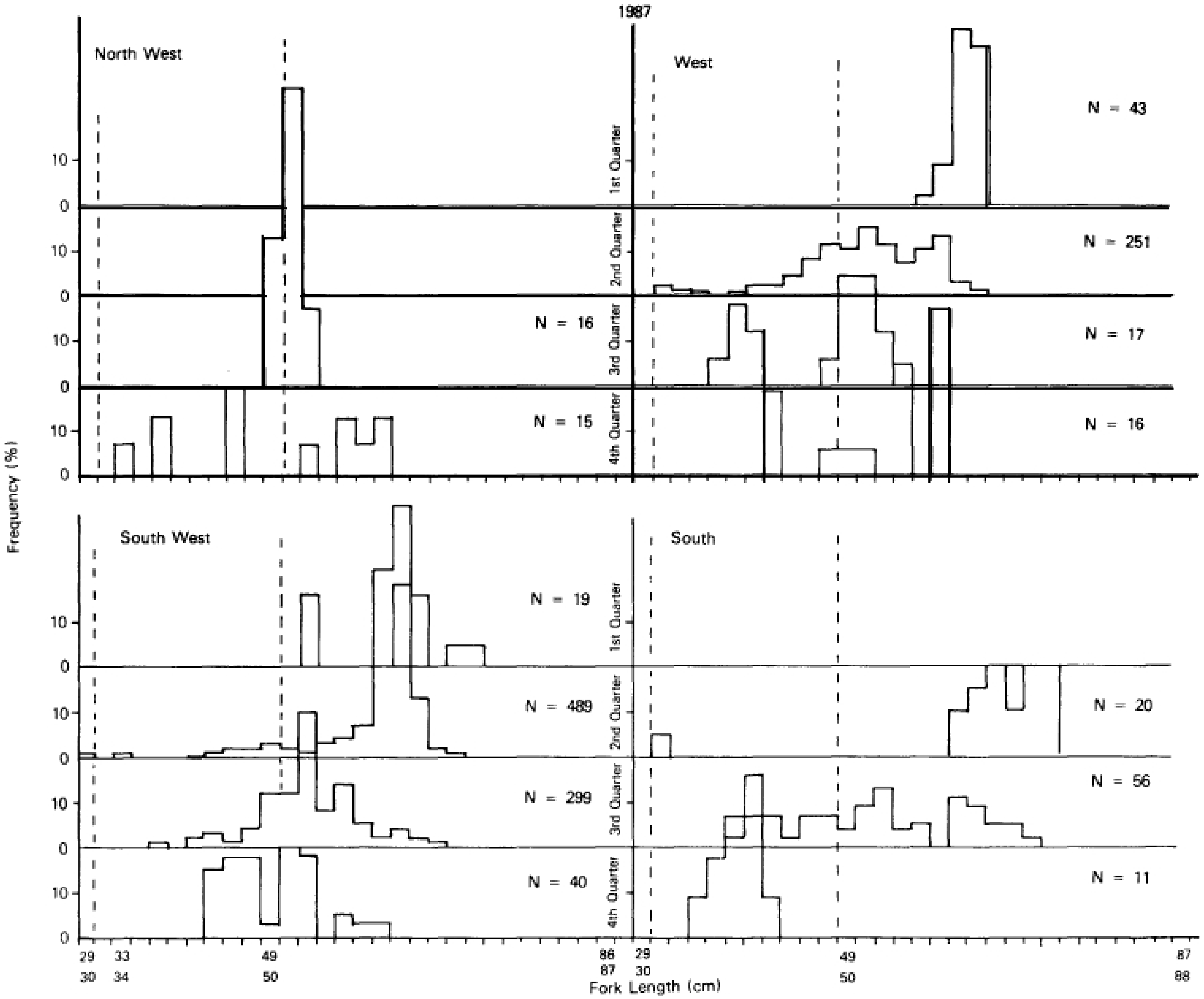

Fig 1(a) Length frequency distribution of skipjack tuna in different sub areas during the four quarters of 1987

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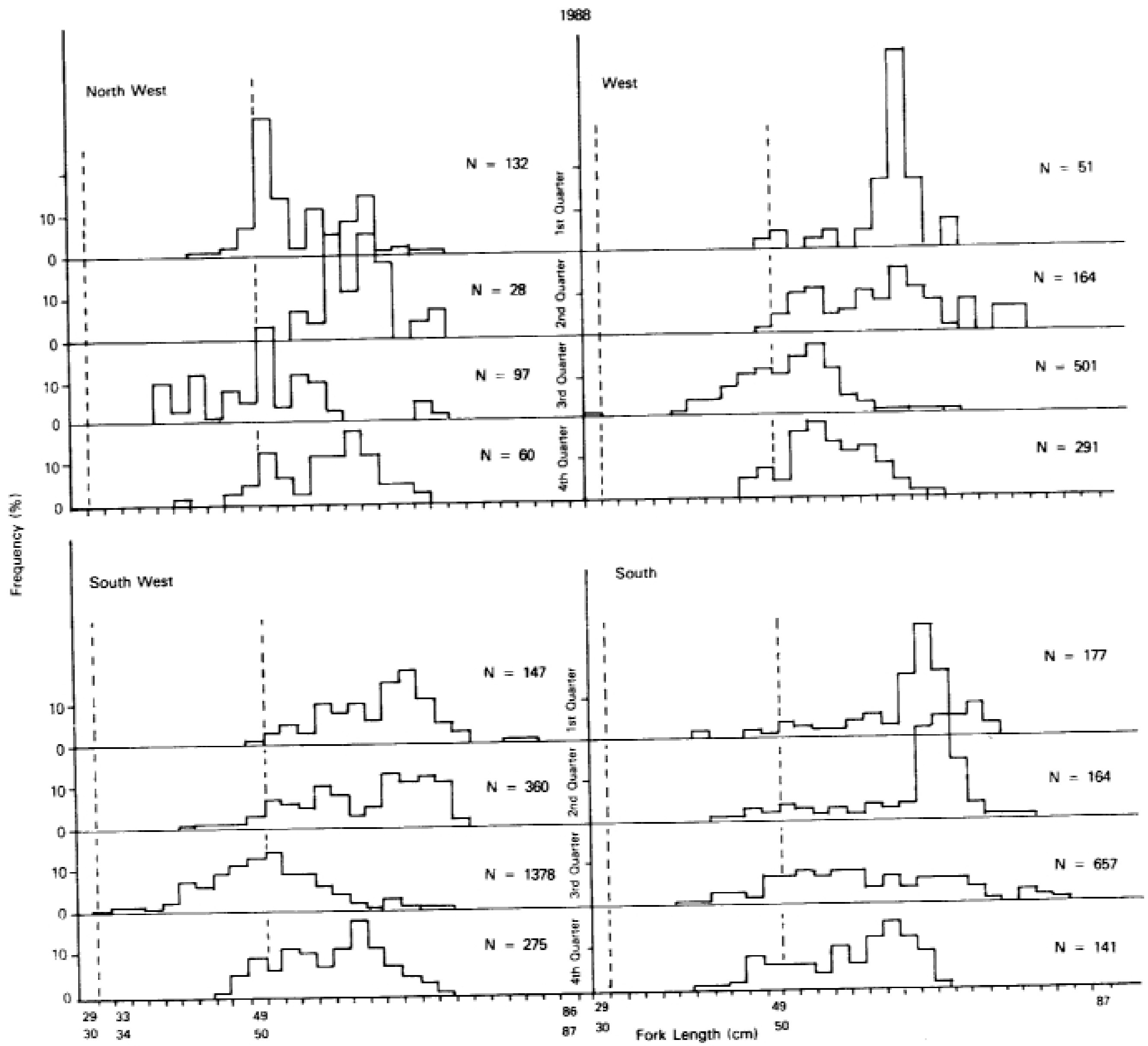

Fig 1(b) Length frequency distribution of skipjack tuna in different sub areas during the four quarters of 1988

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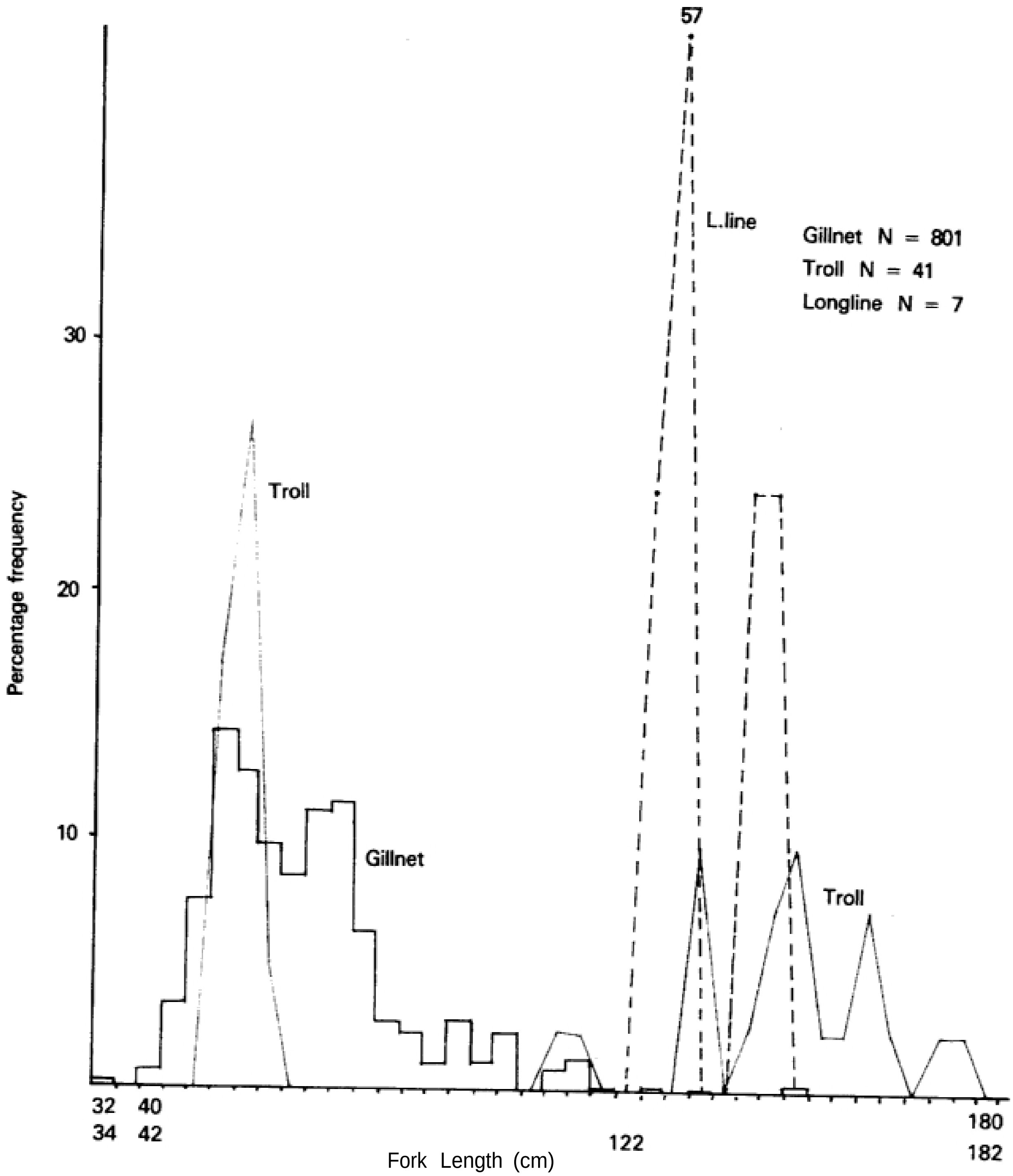

Fig. 2 Size composition of yellowfin in gilinet, troll line and longline catches

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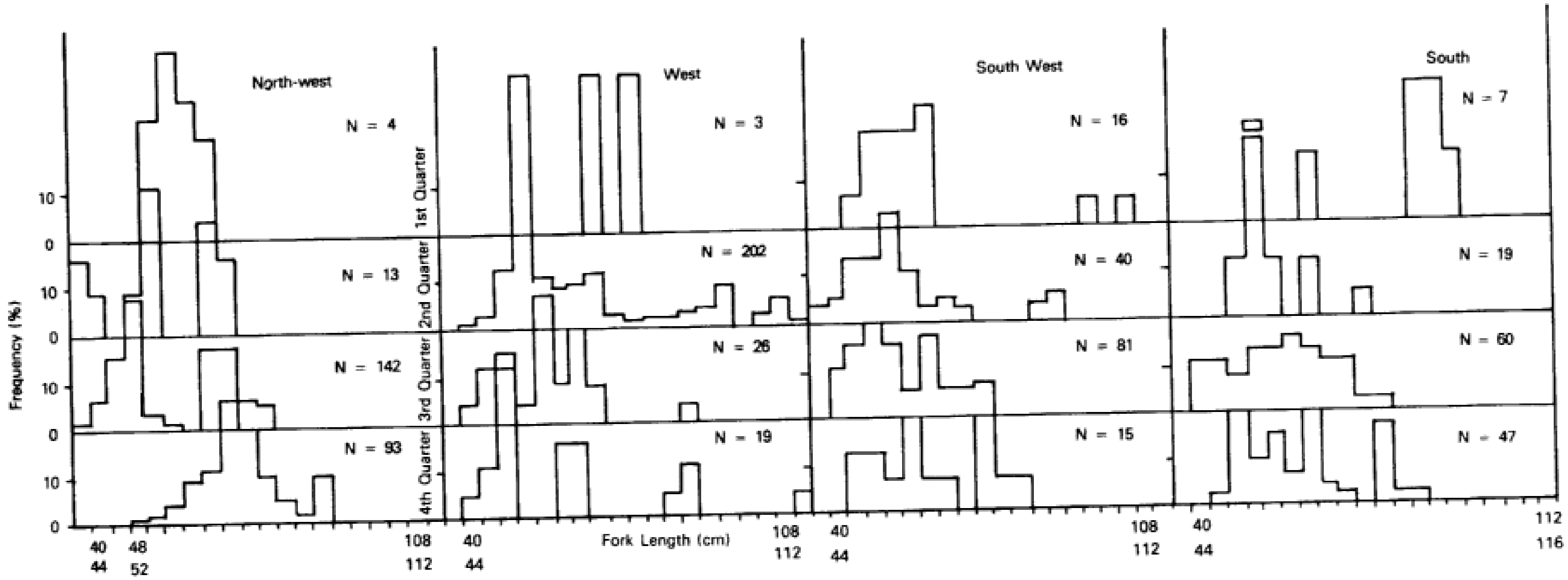

Fig.3 Length frequency distribution of yellowfin tuna in different sub areas during four quarters 1987/88 (pooled data)

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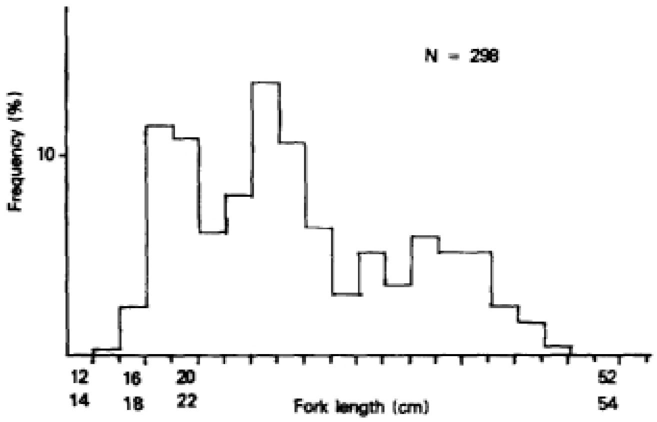

Fig. 4a Size composition of frigate tuna in gilinet catches

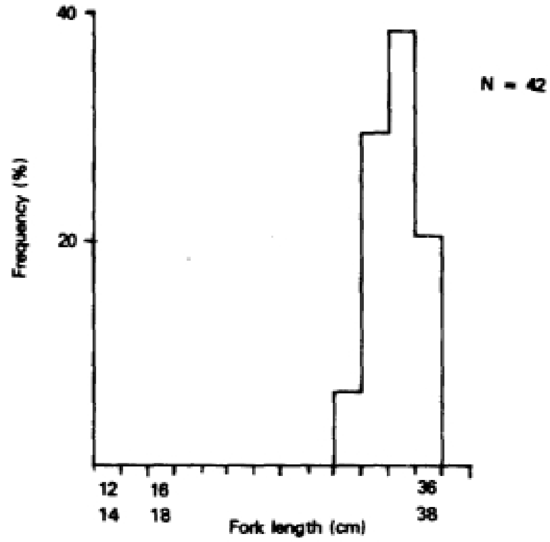

Fig. 4b Size composition of bullet tuna in gilinet catches

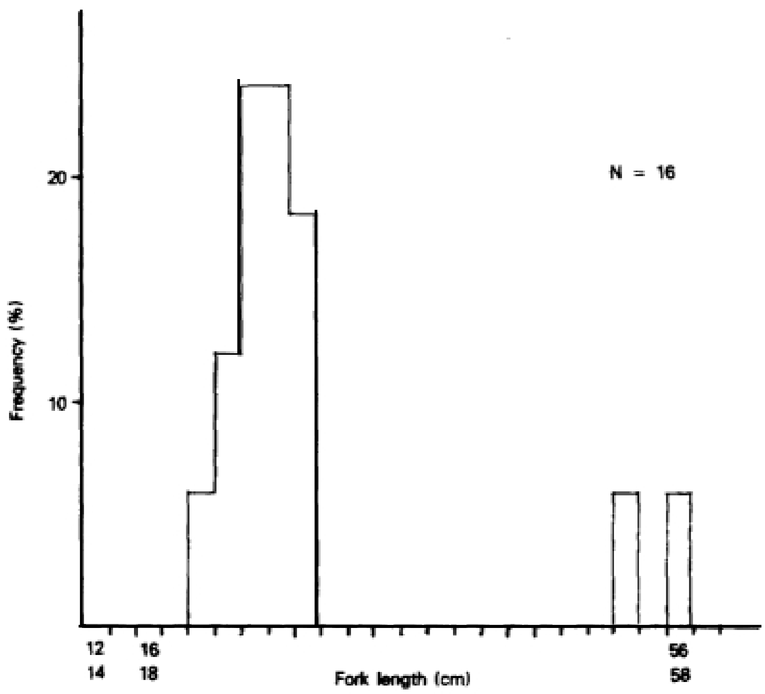

Fig. 4c Size composition of kawakawa in gillnet catches

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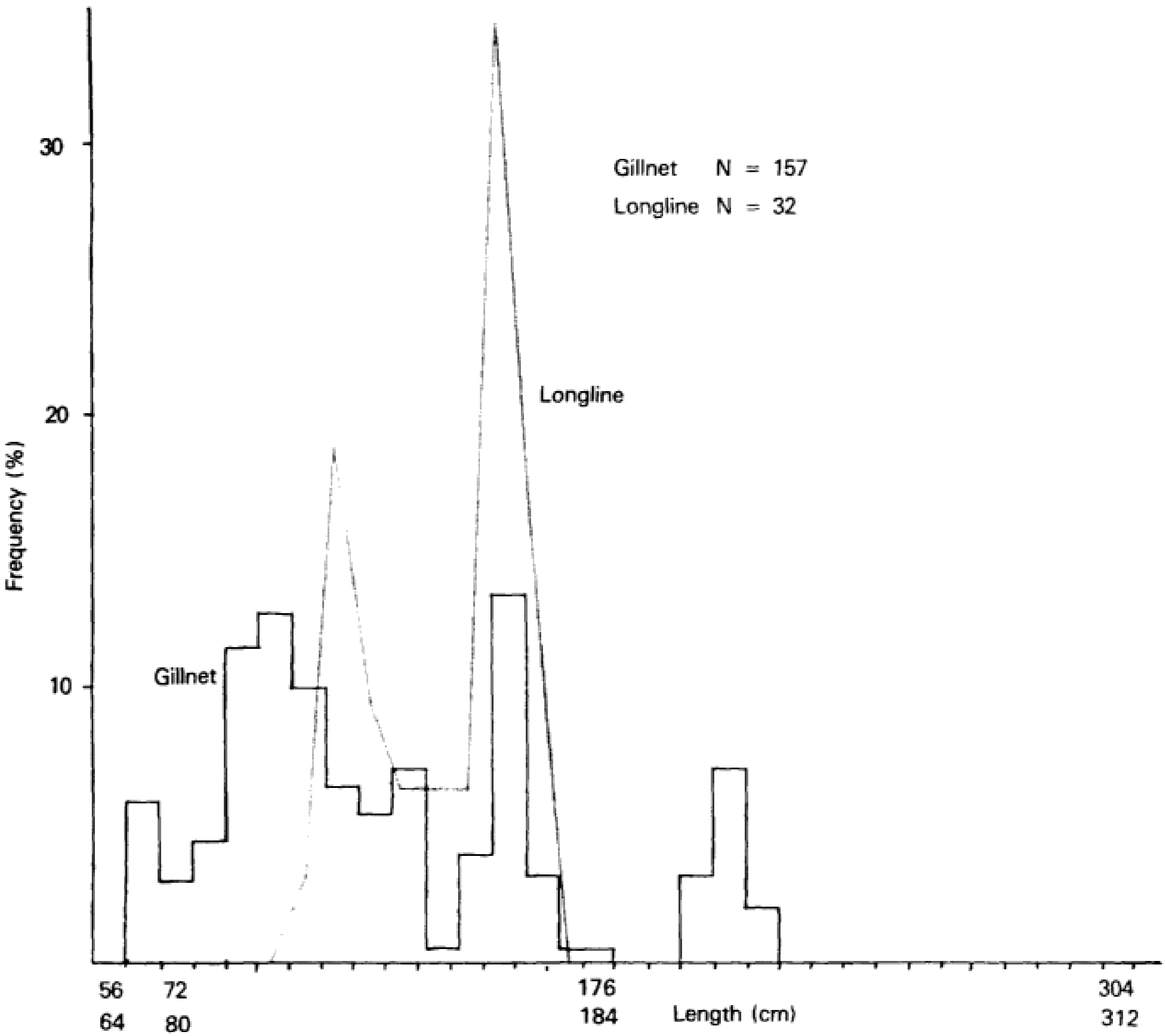

Fig. 5 Size composition of silky shark in gilinet and longline fishery

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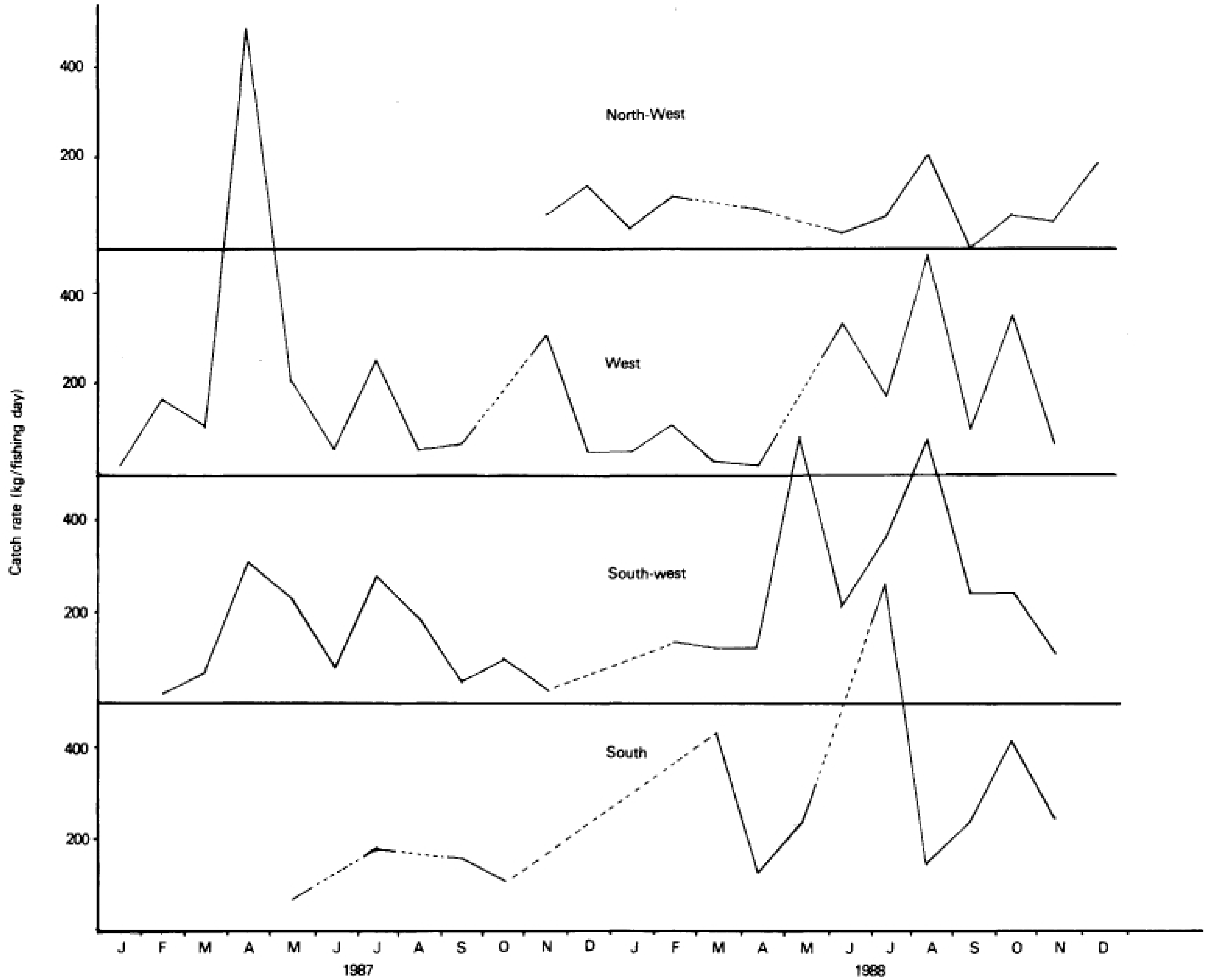

Fig. 5(b) Monthly variations of gilinet catch rates for all species in different sub areas

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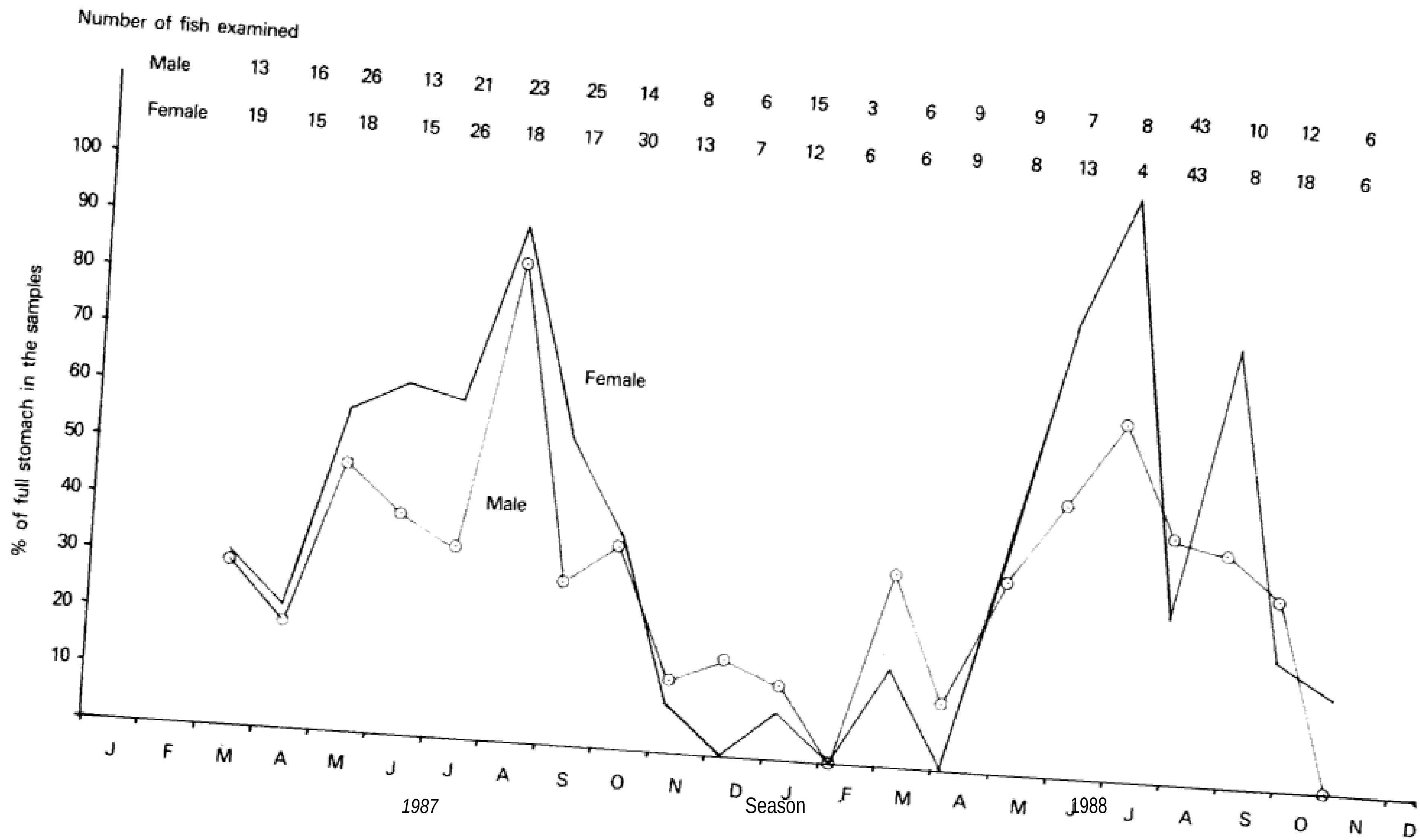

Fig. 6 Monthly variations in the Percentage of skipjack tuna samples with full stomach by sex

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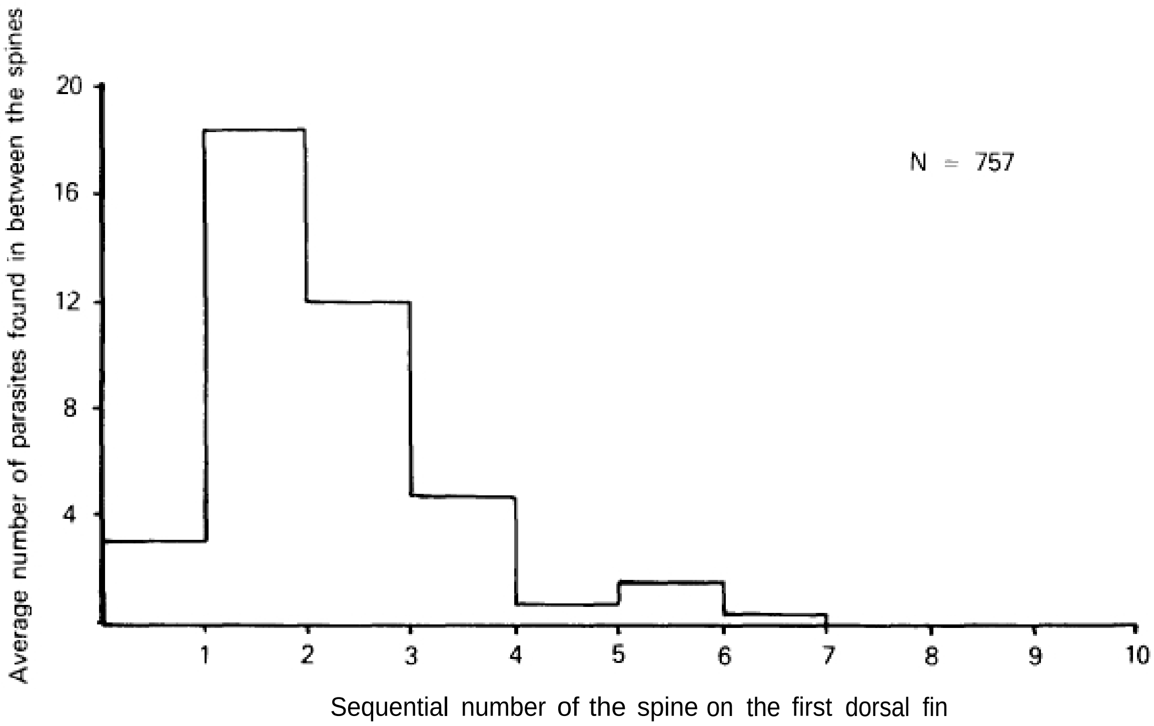
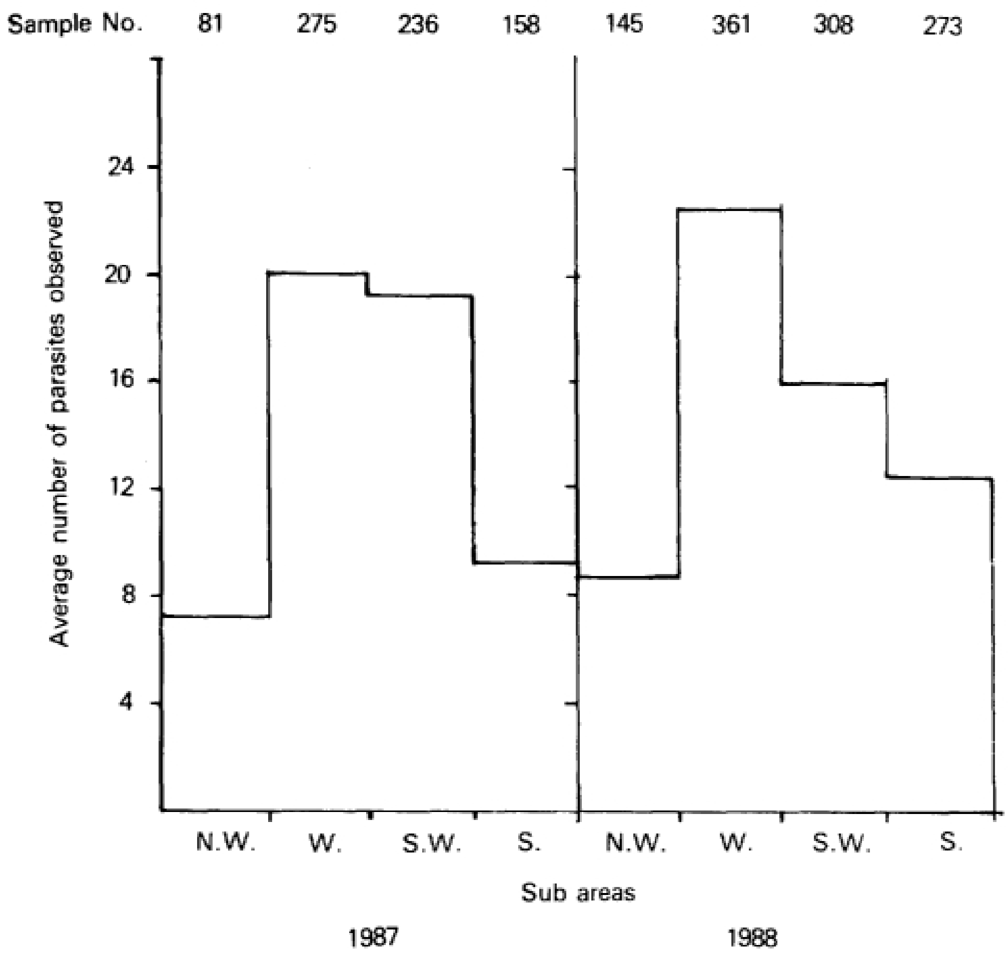


Fig.7 Distribution pattern of "yellow dot" parasite on the dorsal fin of skipjack tuna



<< .8 Variations in the average number of "yellow dot" parasite on a fish, by sub areas, as observed in 1987 and 1988

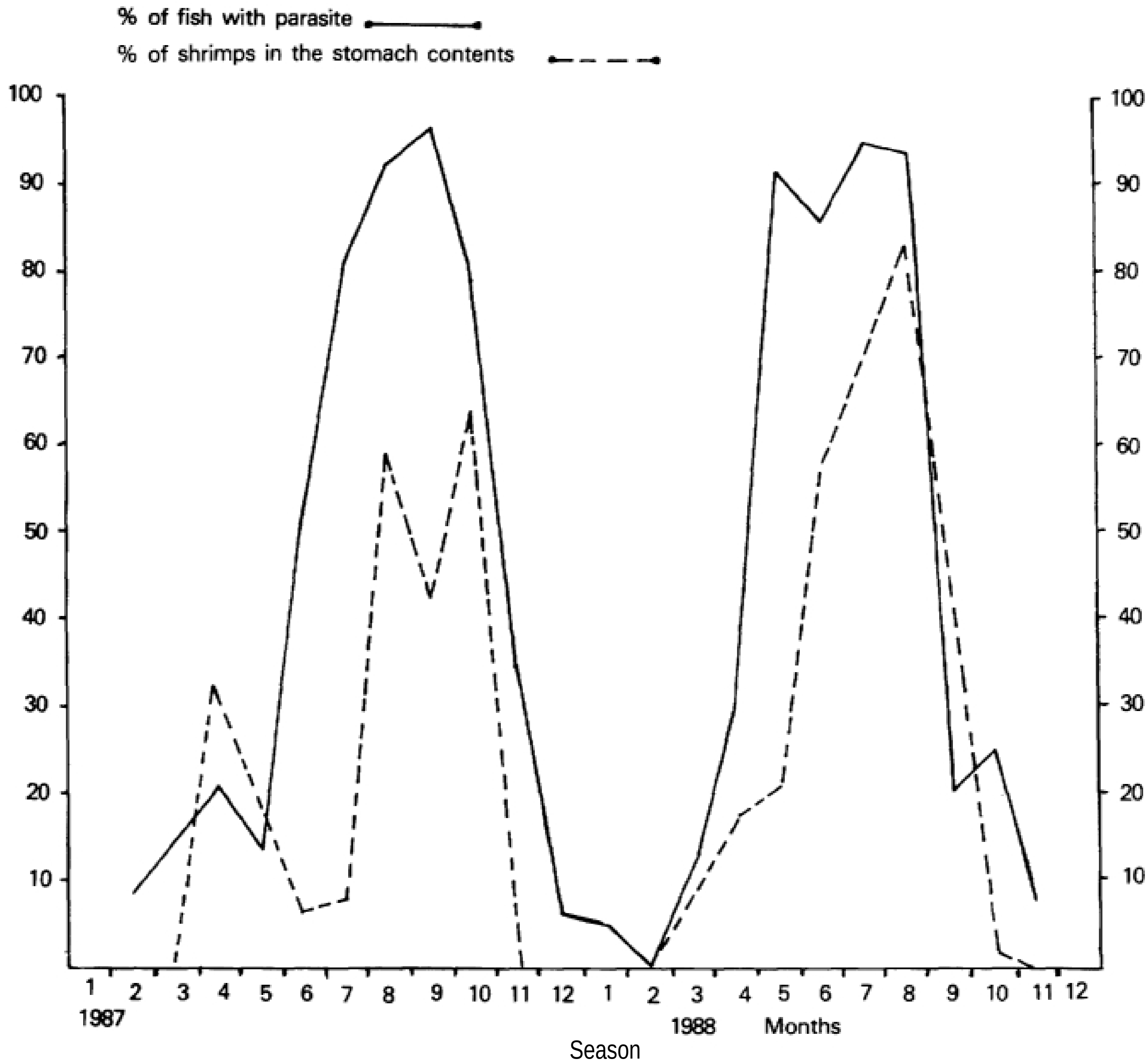


Fig.9 Monthly variations in the percentage of fish with parasites and the percentage of crustacean (shrimp) in the stomach contents of skipjack tuna

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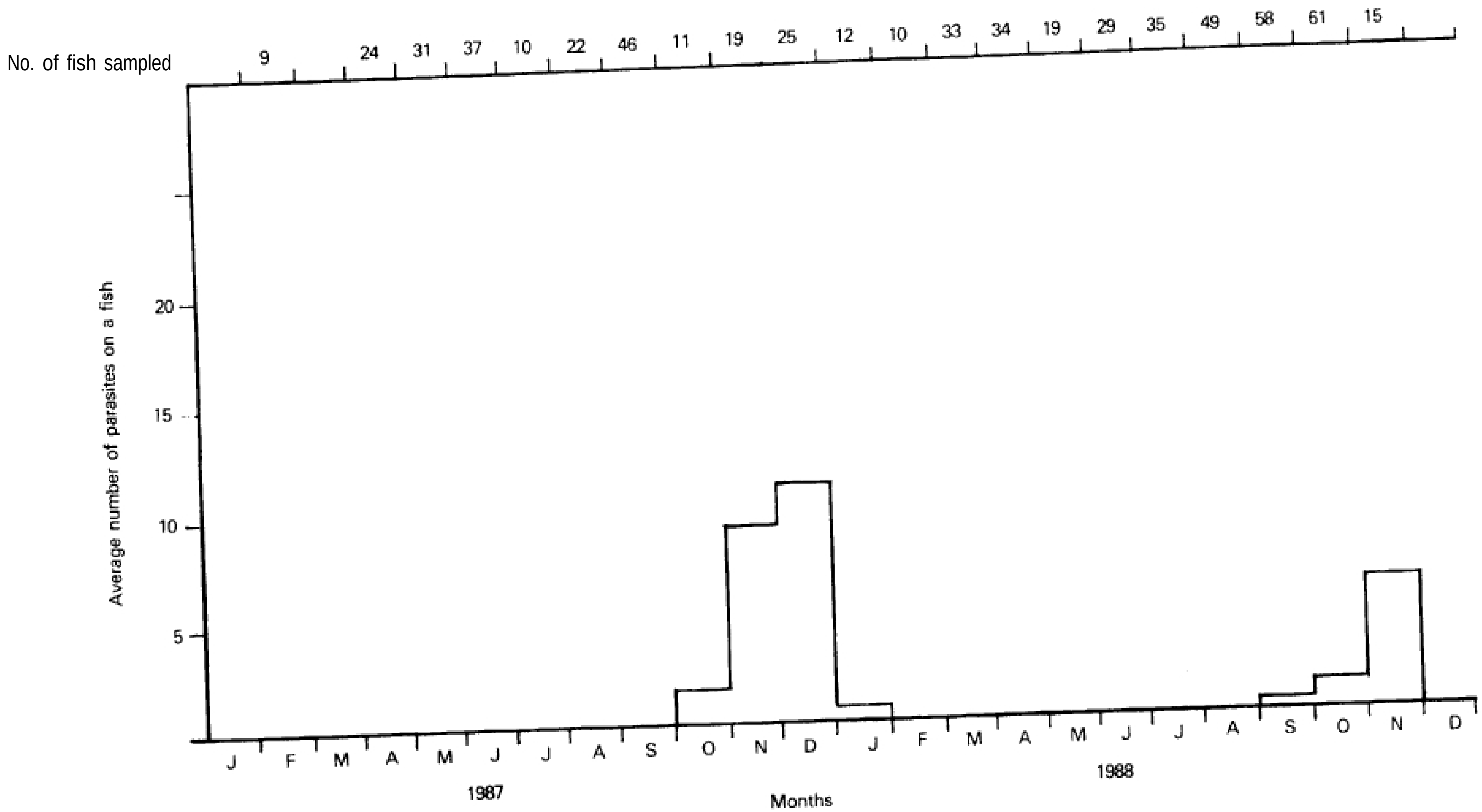

Fig.10 Seasonality in the occurrence of *Pseudoeyus* sp parasites in yellowfin tuna

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Woking Papers (BOBP/WP/., .) are progress reports that discuss the findings of ongoing BOBP work.

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A list of publications since 1984 follows.

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