Reports on surveys with the R/V Dr Fridtjof Nansen.

A survey of the Coastal Fish Resouces of Sri Lanka, report no.II April - June 1979

Fisheries Research Station, Colombo
Institute of Marine Research, Bergen

DR. FRIDTJOF NANSEN

The fishery research vessel «Dr. Fridtjof Nansen» belongs to the Norwegian Agency for Development Cooperation (NORAD). It was designed and built for scientific and exploratory investigations of fishery resources of developing countries, under a joint plan with the Fisheries Department of FAO.

The first four years of operation from 1975 to 1978 include a survey of the pelagic fish resources in the NW Arabian Sea organized with FAO's Fisheries Department (1975-76), a survey off Pakistan under a bilateral agreement with this country, a survey of Mozambique waters organized bilaterally with the government of Mozambique (1977/78); a brief assignment off the Seychelles in July 1978 and finally surveys around Sri Lanka, off Burma and Bangladesh. All of these programmes formed part of and were sponsored by FAO's Indian Ocean Fisheries Development Programme. The Institute of Marine Research, Bergen is under a sub-contract with NORAD responsible for the operation of the vessel, and the various research programmes were planned and conducted jointly with the relevant fisheries research organizations in the countries concerned.

Results of the previous surveys have been reported on in a number of cruise- and progress reports under each programme.

REPORTS ON SURVEYS WITH THE R.V. "DR. FRIDTJOF NANSEN"

A SURVEY OF THE COASTAL FISH RESOURCES OF SRI LANKA, REPORT No. II, APRIL-JUNE 1979

By

J. Blindheim,[x] G.H.P. de Bruin[xx] and G. Sætersdal[x]

[xx] Fisheries Research Station, Colombo

[x] Institute of Marine Research, Bergen

Bergen/Colombo, December, 1979

CONTENTS

1. INTRODUCTION

A series of surveys of the fish resources of the waters around Sri Lanka with the fishery research vessel "Dr. Fridtjof Nansen" forms part of the programme for development cooperation between the governments of Norway and Sri Lanka. The first survey (Referred to as Survey I in the present report) was carried out in August - September 1978. The report on Survey I (Referred to as Report I in the present report) was issued in March 1979 (Sætersdal and de Bruin 1979).

In order to supplement the findings of Survey I and to study the resources in another season, a second survey was conducted during a two-months period in April - June 1979. The following scientific personnel participated in the cruise:

Institute of Marine Research Bergen	Fisheries Research Station Colombo
J. Blindheim	G.H.P. de Bruin
S. Brattås	P.G. Pereira
H. Gill	A. Ratnasekera
H. Kismul	J.R. Samarasinghe
H. Pettersen	

From the Institute of Marine Research Mr. G. Sætersdal participated from 3 to 13 June and Mr. G. Vestnes participated up to 1 May. From the Fisheries Research Station, Colombo, some further personnel also participated for shorter periods.

The above staff took part in the observational work and carried out analysis and processing of observations and data as far as it could be done onbord. Further evaluations and preparation of the present report has been done at the Institute of Marine Research, Bergen. The figures are drawn by Mr. H. Kismul.

2. WORK SYSTEMS AND EQUIPMENT

2.1 Work systems

Survey methods and observational procedures were the same as during Survey I.

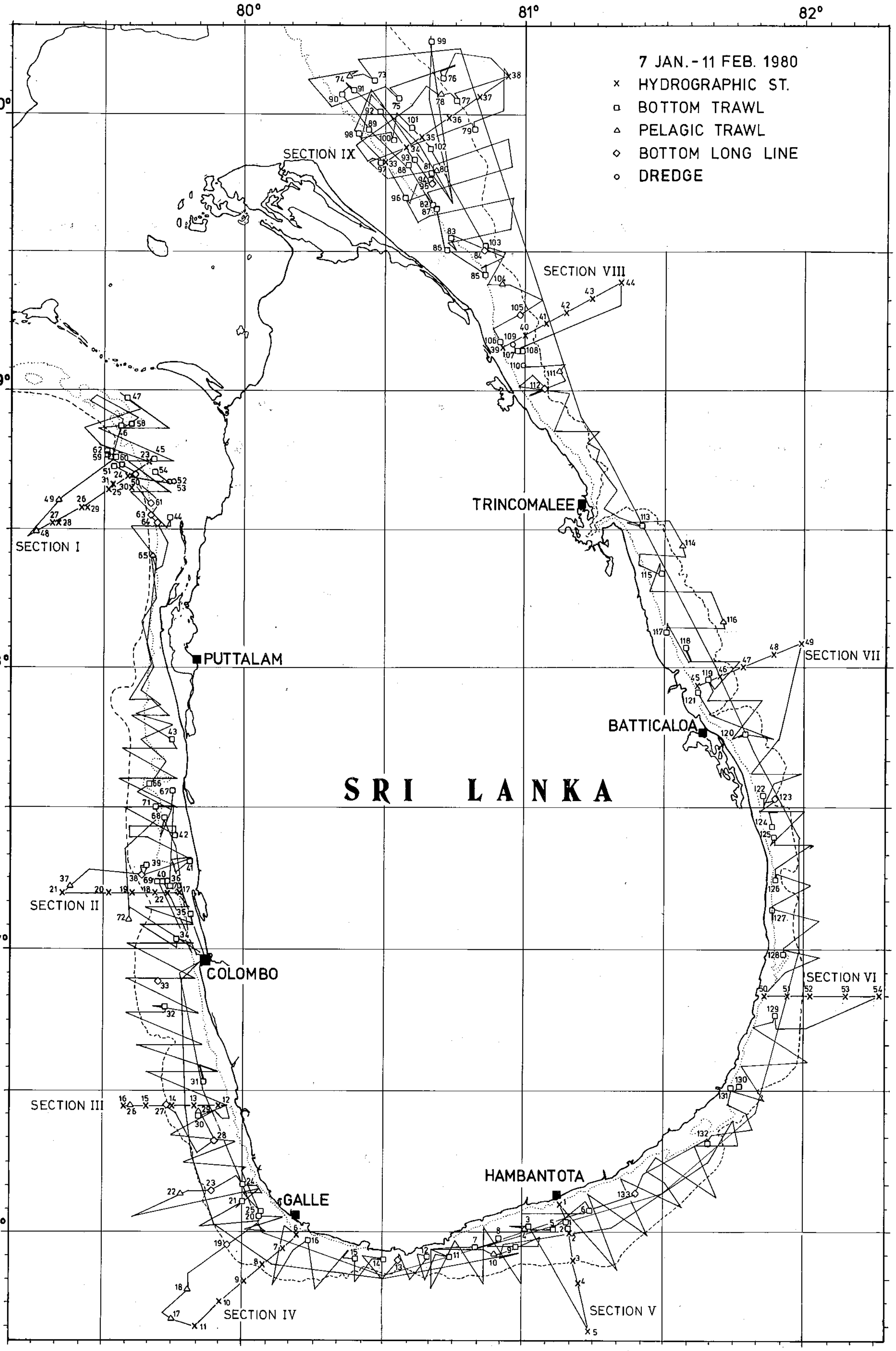


Fig. 1. Cruise tracks and stations worked in the period 23 April - 31 May.

The fish resources were observed acoustically and exploratory fishing was done for biological sampling and identification of acoustic recordings. Environmental factors were observed on hydrographic stations. As regards the scientific routines followed, reference is made to Report I which describes the scientific work systems in more detail.

The R/V "Dr. Fridtjof Nansen" worked in Sri Lankan waters from 23 April to 19 April 1979. During the period from 23 April until the end of May the shelf area was surveyed from the Gulf of Mannar, around the south coast to the Pedro Bank. Cruise tracks and stations from this survey are shown in Fig. 1.

The remaining time was utilized for more detailed work on the Pedro Bank, in the Hambantota area and on the shelf north of Colombo. Cruise tracks and stations from this part of the cruise are shown in Fig. 2.

During the cruise exploratory fishing took place on a total of 147 fishing stations. The number of stations operated with the different types of gear used were: Bottom trawl 94, pelagic trawl 13, bottom long line 31, gill nets 4, hand line/squid jig 4 and dredge 1.

Environmental observations were taken on 49 hydrographic stations.

2.2 Fishing gear

The trawl gear used was the same as during Survey I. The bottom trawl was a 96 foot head line shrimp trawl type which is adapted also to demersal fish trawling. The foot rope was equipped with 0.5 m rubber bobbins. The design of the net of this trawl is given in Appendix I.

The 1600 mesh pelagic trawl had dimensions of 16 x 16 fathoms around the trawl mouth. When fishing it was always equipped with a net sonde and the vertical opening was normally observed to be about 17 m. It was operated with 120 m bridles.

The bottom long lines used had the following specifications: Line: monofilament no. 120, snood: monofilament no. 80, hooks no. 8 with long leg. 200 hooks were used on the majority of the long line fishing stations.

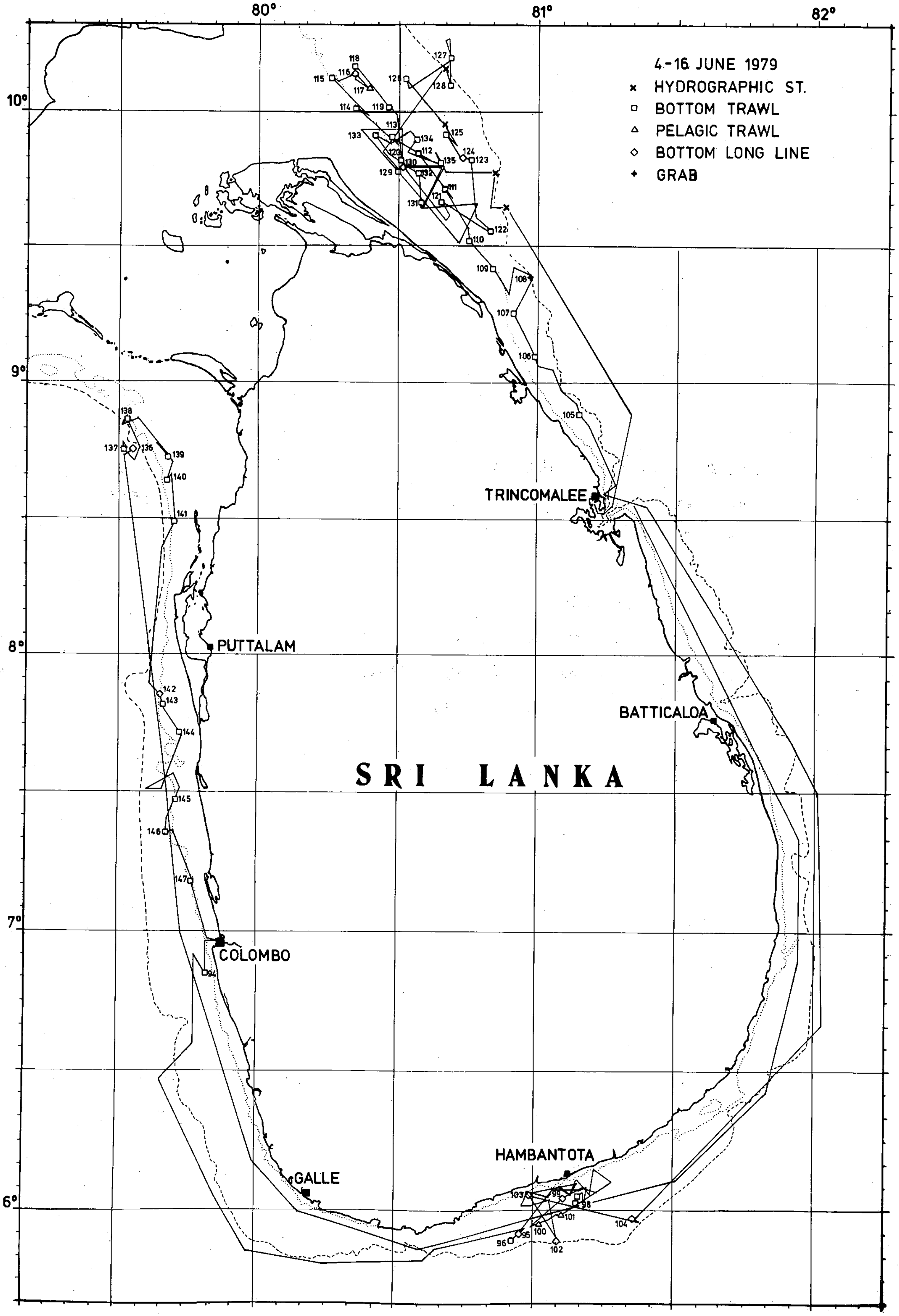


Fig. 2. Cruise tracks and stations worked in the period 1 - 19 June.

2.3 Oceanographic instruments

Nansen bottles were used for the oceanographic work. Temperature, salinity and dissolved oxygen were observed at standard depths to maximum 500 m. The depth and structure of the transition layer (thermocline) was also observed with a bathy thermograph. The salinity samples were analsyed onboard with an inductive salinometer. Dissolved oxygen was determined by the Winkler method.

2.4 Acoustic instruments

The vessel was equipped with two echo sounders, one operating at 38 kHz and one at 120 kHz. Two analog echo integrators were connected to the 38 kHz echo sounder which was the main tool for the acoustical survey work. Performance data and settings of the acoustic instruments are given in Appendix II.

Echo integrator values were recorded for each nautical mile sailed and averages over 5 nautical miles were worked out and logged. The echo integrator readings (unit: mm/nautical mile) are relative measures proportional to fish density. This means that one unit of 1 mm/nautical mile represents a certain number of individual fish per square nautical mile of the species recorded. A conversion factor or density coefficient is needed for conversion from the relative echo integrator values to absolute fish biomass. Since the performance of the echo sounder was modified under a recent refit of the vessel, a new density coefficient had to be established. The deduction of this coefficeint is given in Appendix II.

3. BOTTOM CONDITIONS

As during Survey I the echo recordings from course tracs within the shelf area were analysed with respect to the character of the bottom. The classification used was the same as during Survey I: (i) Even flat bottom, (ii) uneven bottom, (iii) very rough bottom, (iv) steep slope. The observations of the bottom conditions were combined with the findings from Survey I and are shown in Fig. 3.

Even though the survey grids from the two cruises in combination cover the shelf rather densely, Fig. 3 is still imperfect with regard to details.

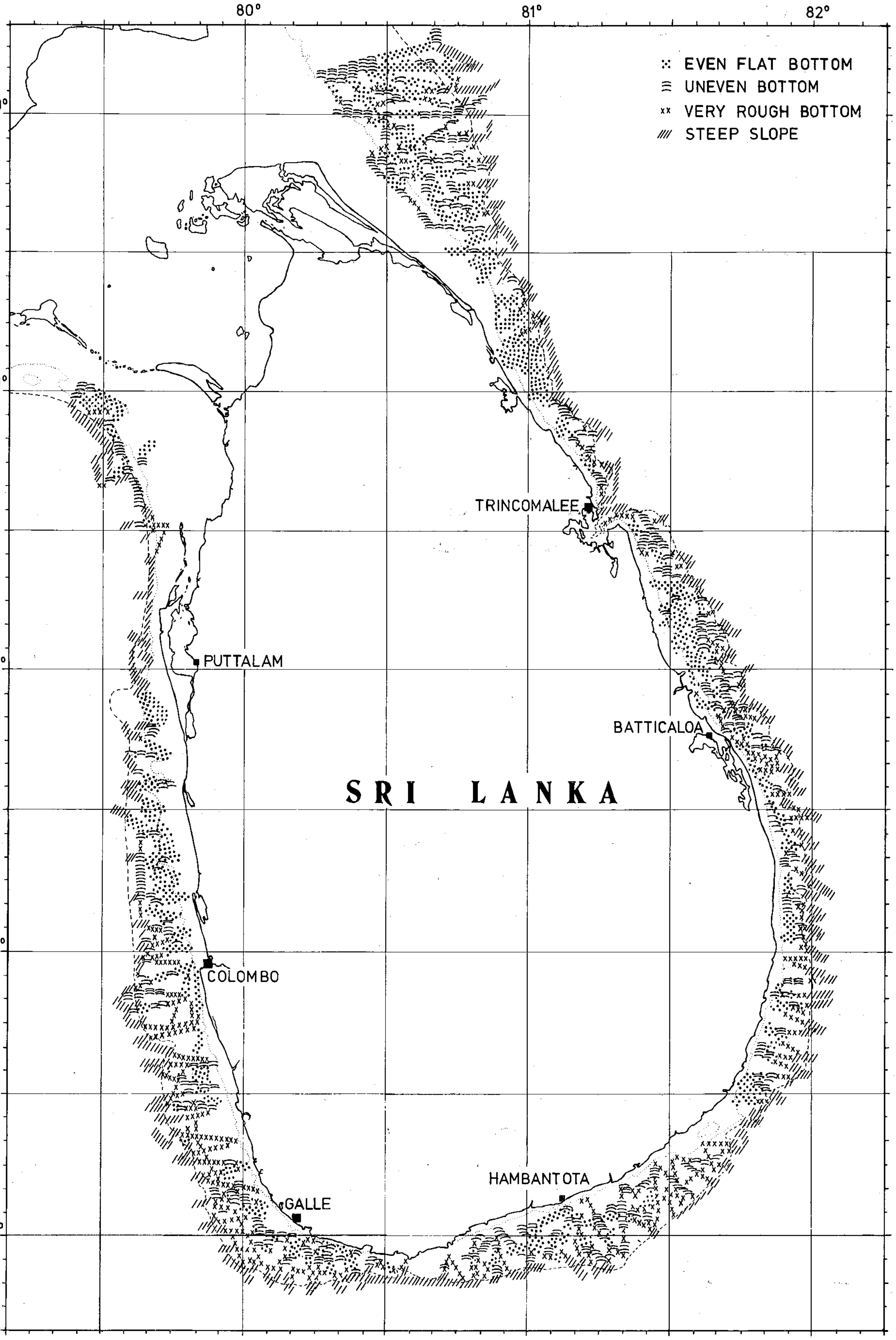


Fig. 3. Observations of the character of the bottom on the continental shelf.

With exception of a few limited areas an extremely steep slope is a characteristic feature along the entire stretch of the shelf edge. Predominance of rough and uneven bottom on the outer shelf is also a rather general feature.

In the Gulf of Mannar most of the inner part of the shelf area is too shallow to allow navigation with the "Dr. Fridtjof Nansen". A great part of the shelf area surveyed has, however, bottom smooth enough for trawling. Also much of the narrow shelf between Puttalam and Negombo has fairly even bottom.

On the south-west coast between Negombo and Galle, the relatively wide shelf is characterized by rough and uneven bottom. Only in inshore waters fairly flat areas occur, but there the bottom is in many cases too soft for trawling. Most of the demersal fish resources were distributed on the outer shelf where areas with bottom suitable for trawling are quite limited. Unfavourable bottom conditions formed decisive restrictions for the success of trawling experiments on the south-west coast.

Also on the Hambantota Banks the outer shelf is rough and offers very limited areas for trawling. Relatively wide areas with fairly smooth bottom are here found on mid-shelf, notably off Hambantota.

On the east coast south of Trincomalee fairly extended areas with rather even bottom are found from the mid-shelf part towards the shore. Between Trincomalee and Sangama Kanda Pt (7°N) there are, however, sponges and corals in some areas with flat bottom.

The shelf north of Trincomalee and the Pedro Bank generally has the smoothest bottom within the survey area. Bottom conditions are here more or less suitable for trawling over rather extended areas. Some areas of soft mud where the trawl will get stuck occur in certain shallow parts. The demersal fish resources were distributed on the inner shelf sometimes in areas with even flat bottom.

4. HYDROGRAPHY

The hydrographic programme was generally the same as during Survey I. Nine hydrographic sections were worked across the shelf as shown in Fig. 1. In addition 4 stations were taken on the Pedro Bank for observation of the depth of the oxycline (Fig. 2).

4.1 Water masses

Fig. 4 shows the T - S characteristics of the sections on the west coast. The temperature in the surface layer ranged between about 27.0 and 30.5°C, decreasing from north to south. The associated salinities ranged generally between 34.1 and 34.6 °/oo. The relatively low salinities are in this season due to Bay of Bengal water (Darbyshire 1967).

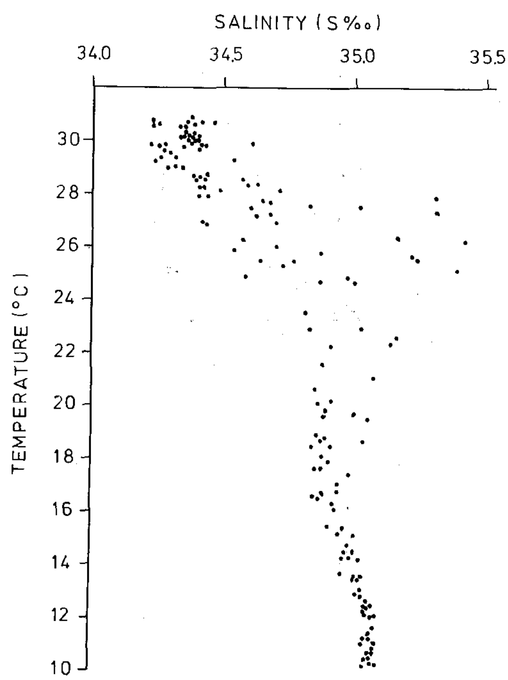


Fig. 4. T - S diagram for the sections on the west coast.

A salinity maximum with salinities ranging between 34.9 and 35.5 °/oo was observed in all four sections on the west coast at temperatures around 26°C. This salinity maximum is due to Arabian Sea water at the depth of the thermocline, formed in the northern Arabian Sea (Wyrtki 1973).

A second slight maximum in salinity was observed at a temperature about 12°C. This water mass, designated as Indian Ocean Equatorial water in Report I (Darbyshire 1967), attains its high salinity in the northern Arabian Sea where its source is outflow from the Aden and Oman Gulfs. Wyrtki (1971, 1973) refers to this water mass as North Indian high-salinity intermediate water.

This intermediate water was also observed in all sections on the east coast at depths greater than 150 m (Fig. 5). The surface water on the east coast was

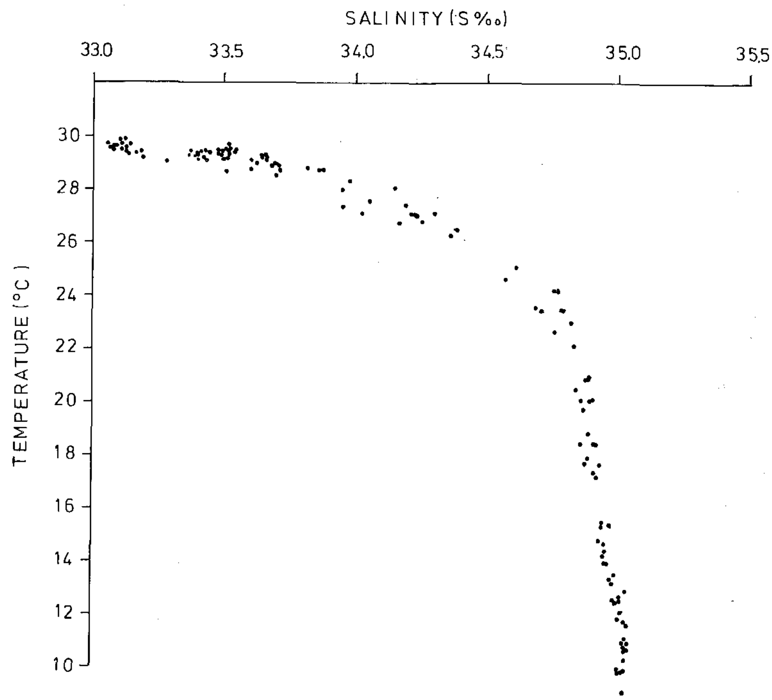


Fig. 5. T - S diagram for the sections on the east coast.

characterized by the low-salinity Bay of Bengal water with salinities mainly ranging between 33.0 and 33.5 °/oo and temperatures between 28 and 30°C. The bend of the T - S curves between 22 and 26°C in Fig. 5 indicate that there could be some slight effect of Arabian Sea water at the depth of the thermocline also on the east coast. Any salinity maximum due to this water was, however, not observed in any of sections VI - IX.

4.2 Hydrographic structure

In Fig. 6 Section IV off Galle is chosen to demonstrate the hydrographic features to the maximum observation depth. In the mixed layer above the thermocline, temperatures were mainly between 27 and 28.5°C, decreasing towards the shore. The main thermocline was observed at 80 to 100 m depth. Below the thermocline the temperature decreased gradually with depth and was close to 10°C at 500 m.

The salinity maximum associated with Arabian Sea water was quite pronounced in the upper part of the thermocline at about 50 m depth. In the lower part of the thermocline there was a salinity minimum with values between 34.8 and 34.9

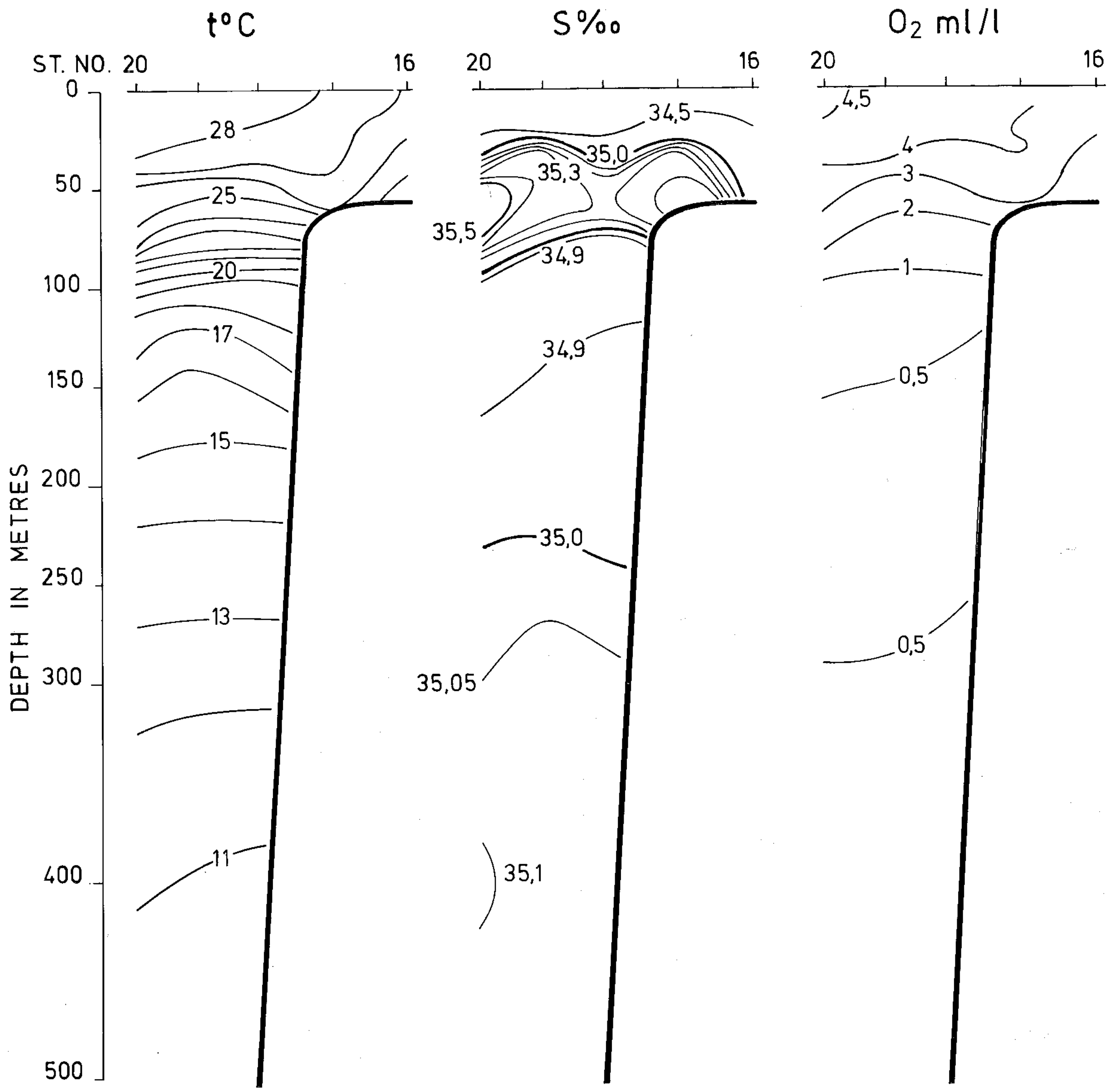


Fig. 6. Temperature, salinity and dissolved oxygen in section IV on the SW coast.

°/oo. From about 150 m depth the salinities increased towards greater depths and were close to 35.1 °/oo at 400 to 500 m. This is the intermediate Arabian Sea water and it was observed below 150 to 200 m depth in all sections. On the east coast its salinity was slightly lower and did not exceed 35.05 °/oo.

The features in the upper 150 m of the sections off the west coast and Section V off Hambantota are shown in Fig. 7. In the Gulf of Mannar and off the north-

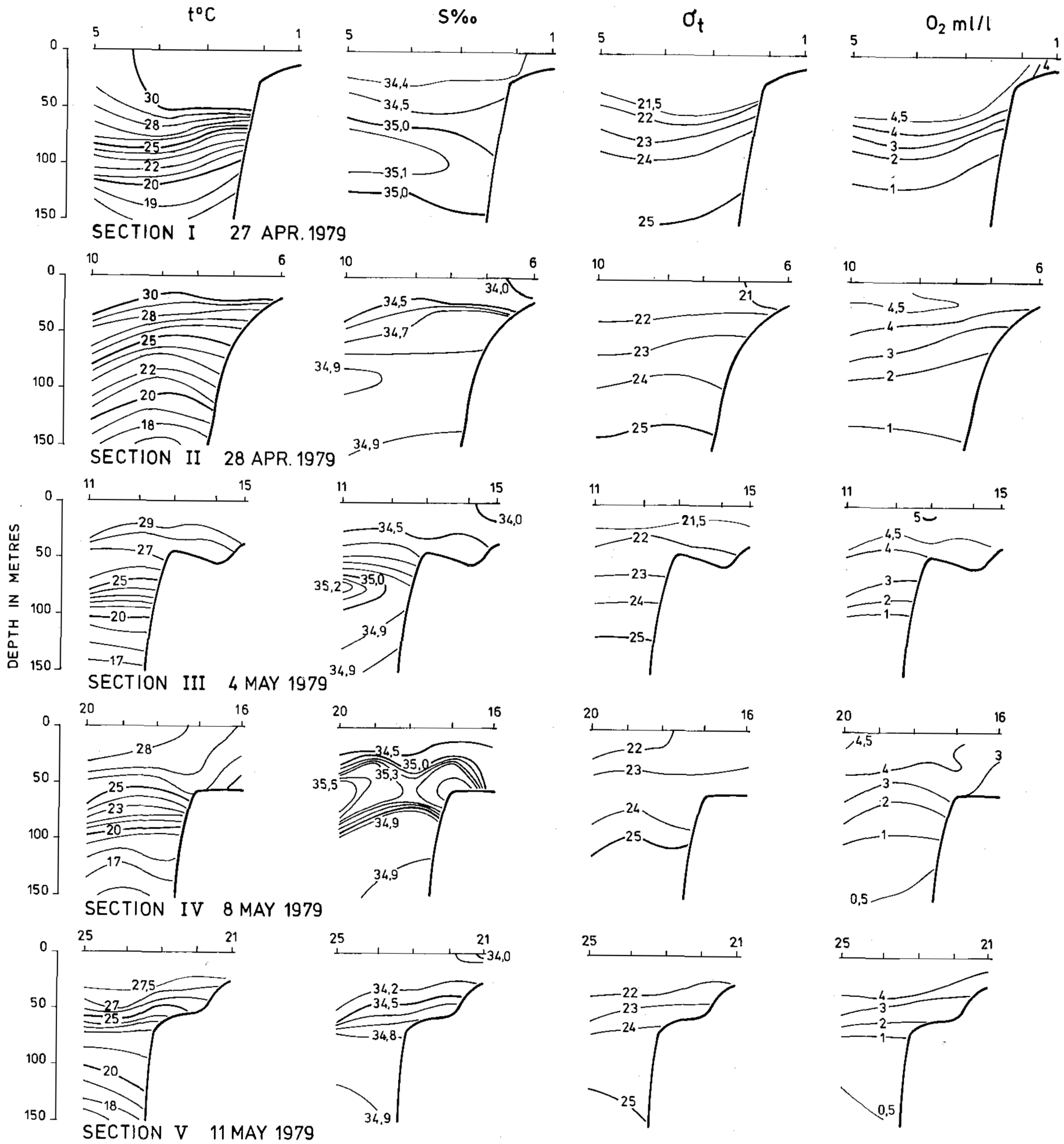


Fig. 7. Temperature, salinity, density (σ_t) and dissolved oxygen in the upper 150 m of sections I-V.

west coast (Sections I and II) the major part of the mixed layer was heated to temperatures above 30^{o}C. The salinity was below 34.5 ^{o}/oo, increasing towards the salanity maximum in the thermocline. This represents a seasonal contrast to the observations made in this area during Survey I (Report, I, Figs. 6 and 8). At that time there was a salinity manimum in the thermocline and there was a mixed layer with salinity above 34.9 ^{o}/oo and temperature between 24 and 26^{o}C. This suggests that low- salinity Bay of Bengal water occupies the mixed layer in the Gulf of Mannar during the NE monsoon season. The Low-salinity

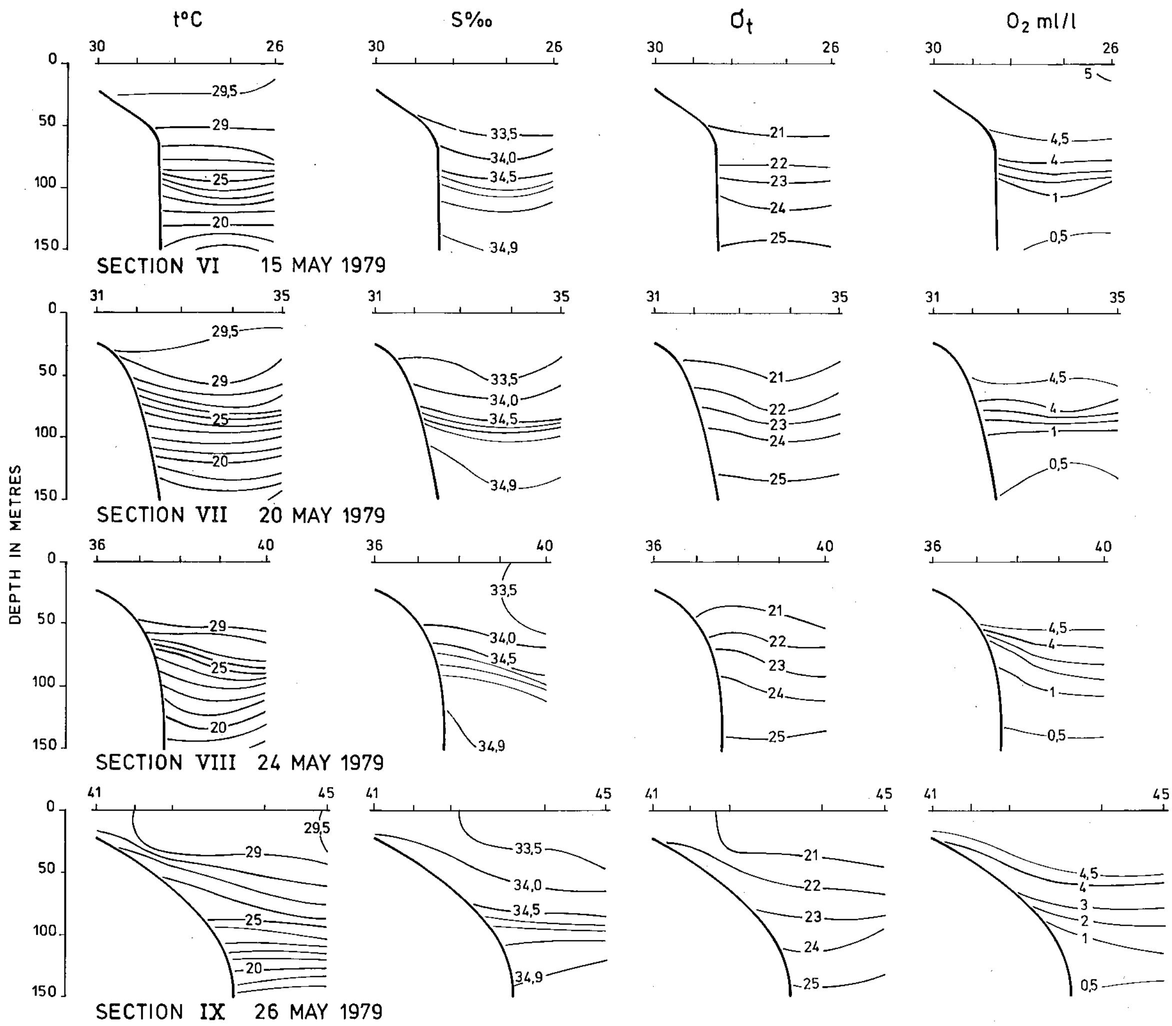


Fig. 8. Temperature, salinity, density (σ_t) and dissolved oxygen in the upper 150 m of sections V-IX.

water formed along the west coast of India during the SW monsoon has, however, more effect at the depth of the thermocline than in the mixed layer.

On the west coast there was a general southward temperature decrease in the mixed layer. Off the south coast (Section V) the temperatures were below 28°C.

The salinity maximum due to Arabian Sea water at the depth of the thermocline was observed in all sections on the west coast, mainly in their offshore part. In Section IV where it was most developed, high-salinity water covered most of the shelf and on the outer station of the section its salinities exceeded 35.5 $^{\circ}$/oo. Off the south coast such a salinity maximum was not observed. This shows that the monsoon current carries the bulk of the Arabian Sea water towards SE at some distance from the shelf of Sri Lanka.

The conditions on the east coast are elucidated in Fig. 8. The hydrographic structure was characterized by only two water masses. Bay of Bengal surface water occupied the mixed layer. Along the entire stretch of the east coast its temperatures were between 29^{o} and $30^{o}C$ and its salinity about $33.5^{o}/oo$. Below the thermocline there was a gradual change with depth towards the characteristics of the intermediate Arabian Sea water.

The depth of the thermocline was now somewhat greater than during Survey I. This was most pronounced on the east coast where the main thermocline was situated at 80 to 110 m depth, about 40 to 60 m deeper than during Survey I. On the west and south coasts the main thermocline was observed somewhere between 50 and 100 m and the difference from Survey I was small.

4.3 Currents

During the survey the surface currents were estimated from the ships drift and assessed visually on fishing stations. In the Gulf of Mannar the currents were weak and irregular. From about Negombo a southward drift was observed, its speed increasing towards south. Off the south-west and south coasts there was quite strong current towards south-east and east. On several fishing stations its speed was assessed at two to three knots. Along the major part of the east coast there was a southward drift. North of Trincomalee, and particularly on the Pedro Bank, there was, however, strong current towards the north both in May and in June. These current observations were in general agreement with the USN Atlas of surface currents of the Indian Ocean (Anon 1970) eccept on the north-east coast where the currents according to the atlas should be southerly from May on.

4.4 Dissolved oxygen

Also during the present cruise there was a well defined relationship between temperature and dissolved oxygen content. The warm mixed layer was fairly well aerated with contents mainly above 4 ml/l. The oxycline was observed at the depth of the thermocline. Below the oxycline the oxygen content was low, everywhere below 1 ml/l.

Average $T - O_2$ curves for the west, south and east coast are shown in Fig. 9. The figure shows that at temperatures below about $27^{o}C$ there was some difference between the west and the east coast. This difference was greatest at

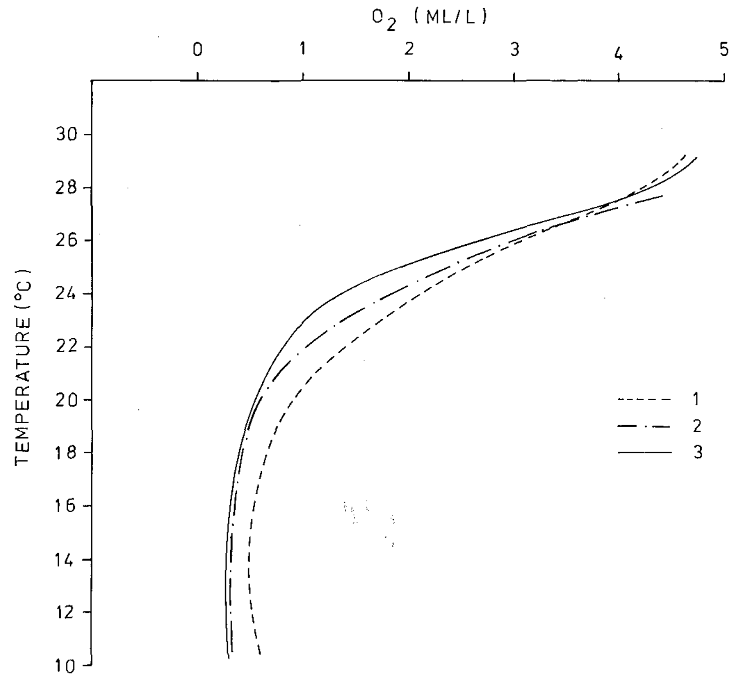


Fig. 9. Smoothed T - O_2 diagrams for 1) Sections I-IV on the west coast, 2) Section V on the south coast, 3) Sections VI-IX on the east coast.

temperatures between 21° and 25°C. In this temperature interval the oxygen content was between 0.5 and 0.75 ml/l lower on the east coast than on the west coast. A similar but smaller difference was also observed on the south coast. Associated with this difference the oxycline on the east coast was situated higher in the thermocline than what was the case on the south and west coasts.

To supplement the information on the oxygen conditions on the Pedro Bank, four hydrographic stations were taken in addition to Section IX. The observations on these stations agreed well with the section.

5. SURVEY RESULTS

5.1 Coverage, interpretation and classification og echo recordings

As mentioned under 2.1 the shelf area was systematically surveyed during the period 23 April - 30 May. Course tracks and positions of fishing stations with specification of type of gear are shown in Fig. 1. In order to obtain comparable results, care was taken to follow the same procedures and routines as during Survey I. The comments connected to the survey methods in Report I are, therefore, valid for the present survey, and only a few main points are repeated here: Fish very close to the bottom and in the surface layer, above the depth of the transducer of the echo sounder are not available for observation in this system. For navigational reasons only waters deeper than 10 m could be surveyed. The extreme inshore waters and the large shallow area in the north, the Palk Bay and adjacent waters could thus not be covered.

Interpretation of the echo recordings was done in the same manner as during Survey I and fish recordings were classified in three main categories:

a) Schools and agregations of apparently larger fish near the bottom and in mid-water. These are ascribed to demersal or semi-demersal fish such as snappers, breams, groupers, jack mackerel etc. This type of recording was by far the most common also during the present cruise (Fig. 10).

b) Single fish traces or small schools of bigger fish closer to the surface waters. These recordings are thought to derive from tunas and tuna-like fish (Fig. 11). They were less common and probably often "lost" in dense plankton recordings near the surface.

c) Recordings of true larger schools or dense layers mostly in upper water layers (Fig. 12). These will most often derive from pelagic schooling fish, usually of smaller size e.g. clupeoids, scads. This type was very rarely observed druing the present survey and only occurred in a few locations. It is possible that dense plankton recordings in some places may have obscurred also such recordings.

For ready reference an example of each category of fish recordings is given in Fig. 10 - 12. Reference is further made to Report I where the three categories are amply illustrated.

During the processing of the echo recordings and integrator readings contributions interpreted to be from plankton organisms and mesopelagic fish where seperated from the above groups. The abundance of plankton, based on integrator out-puts, was at about the same level as during Survey I. The highest levels were observed in the Gulf of Mannar with integrator values up to 300 - 400 mm/nm. Considering the whole survey area, plankton recordings were generally most dense in the vicinity of the shelf edge.

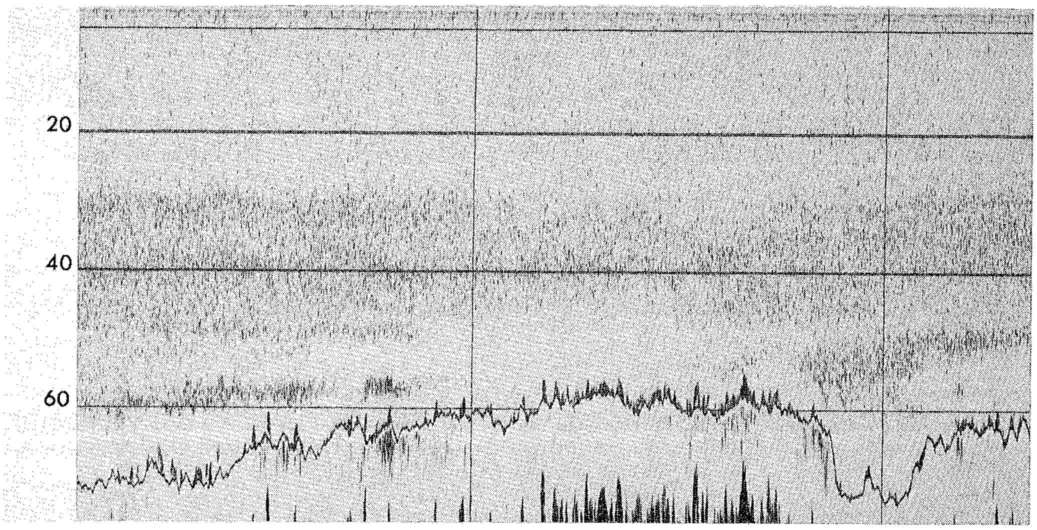


Fig. 10. Example of "Type A" echo recordings of demersal and semi-demersal fish.

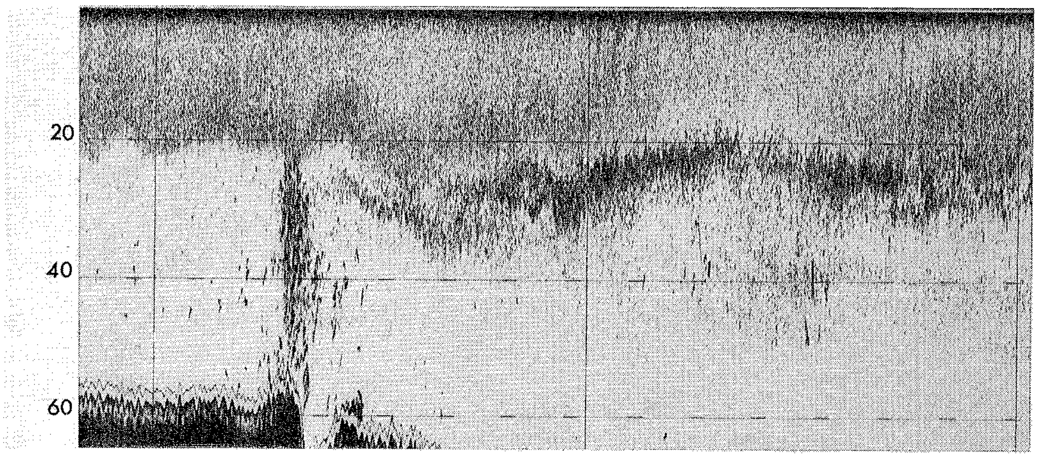


Fig. 11. Example of "Type B" echo recordings of dispersed pelagic fish.

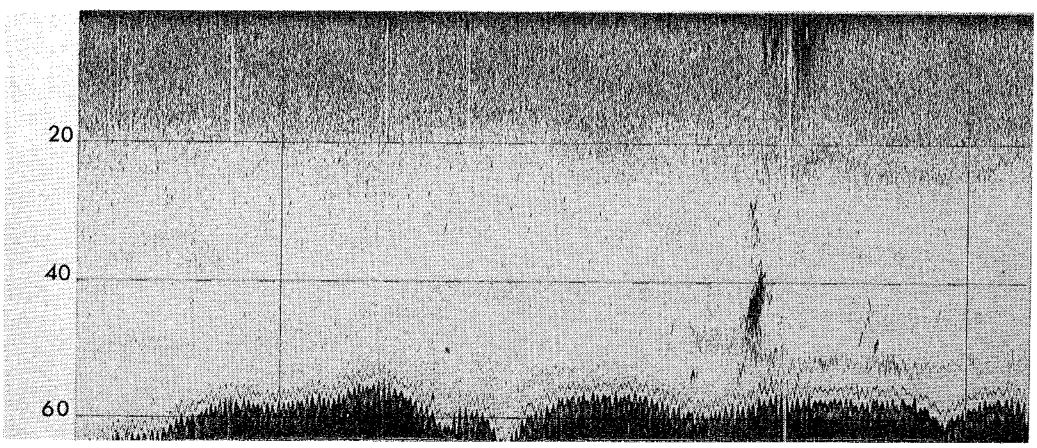


Fig. 12. Example of "Type C" echo recordings of schooling small pelagic fish among recordings of dispersed larger pelagic fish (Type B).

Mesopelagic fish was recorded beyond the shelf, mainly on the west coast, but only in small quantities.

5.2 Fish distribution and abundance

The echo integrator values ascribed to the three categories of fish were plotted along the survey tracks in charts and distribution charts were prepared by interpolation. Three levels of echo abundance are indicated in the charts. During the present cruise separate charts were prepared for the three categories of fish. The contribution from Type C was, however, so small that it was combined with Type B. The chart for Type A is shown in Fig. 13 while Fig. 14 shows the distribution of pelagic resources.

Some agregations of fish consisted evidently of a mixture of species belonging to more than one category, but the cases were few and it is likely that Type B was more often classified as Type A than the opposite.

The main features of the distribution of the resources had many similarities with the distributional pattern observed during Survey I. In general the most abundant resources were found on the west coast. Relatively high level of abundance was observed in several concentrations along this coastal stretch. The density rates were here somewhat higher than during Survey I.

In the Hambantota area, between Dondra Head and Little Basses reef, the two coverages of the present cruise indicated a distribution similar to that observed during survey I. The abundance was, however, significantly lower than during Survey I.

Along the east coast the resources were evenly distributed and no dense concentrations were observed. As a whole the abundance was at a slightly lower level than during Survey I.

The abundance of Type B, and particularly Type C, was at a considerably lower level than during Survey I. The distribution of these categories is shown in Fig. 14 and it is seen that the densest concentrations were observed in the Gulf of Mannar, off Colombo and off the south-east coast.

Recordings classified as Type C were derived only from some quite insignificant aggregations in a few places on the west and south-east coast.

5.3 Assessment

5.3.1 Assessment of fish biomass

A density coefficient for conversion of integrator deflection to fish biomass is worked out in Appendix 2. Based on averages of length and weight for groups of species given in Table 1, the density coefficient for demersal and semi-demersal fish, Type A, is found to be 14 tonnes/mm nm^2 (One unit of integrator deflection indicates a fish density of 14 tonnes per square nautical mile). For pelagic fish of Type B and C the density coefficient is 8 tonnes/mm nm^2.

The echo abundance plotted in the distribution charts as shown in Figs. 13 and 14 has been integrated over area by planimetry and indices for the subareas are given in Table 2. A second assessment was prepared for the Hambantota banks and the Pedro bank based on the observations made in June. On the Hambantota banks the main distribtuional features were found to be very similar to the situation in May. Also the abundance was similar and the assessment gave the same results as in May.

Table 1. Summary of length measurements by species or species groups. Fork lengths.

Cm	Breams	Groupers	Snappers	Sweet lip	Drepane punct.	Surgeon fish	Aprion vir.	Caranx	Baracuda	Scombroidae	Indian macker.	Sardines	Misc.
5- 9	16												
10-14	216							72				45	28
15-19	116	2	5					30	4		33	27	47
20-24	31	2	11					119	49	1	68	1	72
25-29	40	5	2	2	3	8		73	44	1			96
30-34	65	9	7	2	35	20		69	17				65
35-39	81	14	19	2	82	29		31	5	2			74
40-44	126	15	49	34	42	49		26	17	5			31
45-49	180	11	71	54	6	62		16	7	2			35
50-54	146	24	62	71		39		10	5	1			10
55-59	81	74	64	83		2	1	13	8				21
60-64	17	66	57	44			3	12	8	9			22
65-69	20	18	31	13			4	5	4	7			22
70-74	23	13	9	2			1	6	3	7			6
75-79	4	4	3				2	2		3			7
80-84	1	5						2		4			13
85-89		5								1			6
>90		7							1				2
N	815	274	390	307	168	209	11	486	172	43	101	73	557

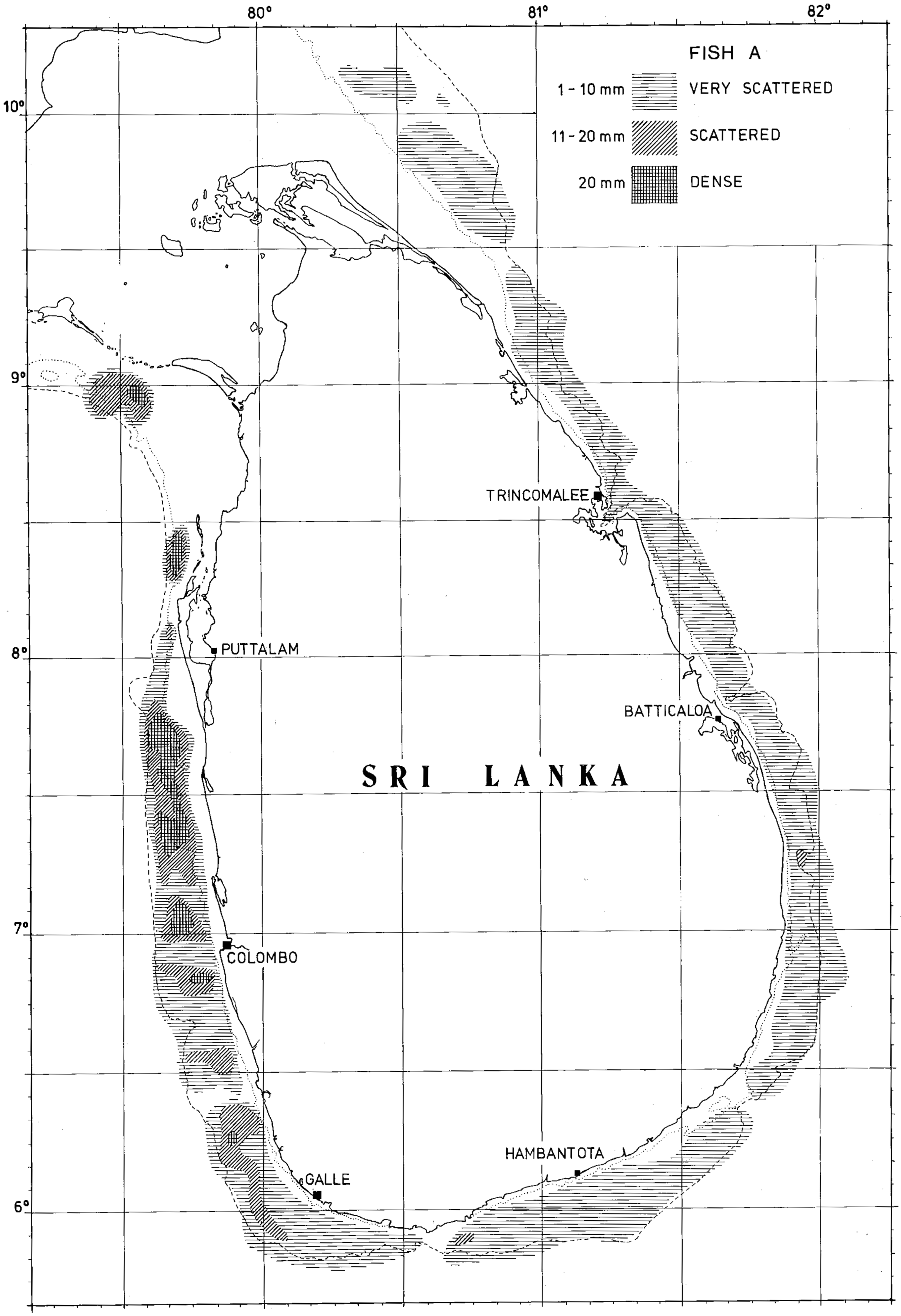


Fig. 13. Distribution of echo intensity of recordings classified as demersal and semi-demersal fish (Type A), 23 April - 31 May. Indices of abundance by levels of integrator deflection (mm per nautical mile).

On the Pedro Bank the fish resources were observed as shown in Fig. 16 in somewhat denser concentrations in June than in May. The assessed abundance was also slightly higher.

Table 2. Indices of integrated echo adundance and assessments of standing biomass.

Area	Demersal		Pelagic		Total
	Index of echo abundance	Estimated biomass 1000 tonnes	Index of echo abundance	Estimated biomass 1000 tonnes	
I. NW coast	9150	100	2800	20	120
II. SW coast, Negombo - Galle	9400	130	2200	20	150
III. Hambantota Banks	2300	30	400	5	35
IV. E coast, $6^{\circ}20'N$ - $8^{\circ}20'N$	2900	40	2150	15	55
V. Trincomalee - Mullaittivu	1200	20	80	5	25
VI. Pedro Bank	850	10	700	5	15

5.3.2 Area I, the North-west Coast

This area was surveyed from 24 - 30 April as shown in Fig. 1. Additional fishing experiments were made from 15 - 17 June, Fig. 2. The estimated abundance of fish biomass amounts to 120 000 tonnes. Particularly high concentrations, in fact the highest encountered during the entire cruise (Fig. 13), were observed off Karaitivu and in an area northwards from Negombo.

As shown in Table 1 most of the fish recordings were classified as demersal and semi-demersal fish. This was supported by the composition of the trawl catches. In this area the proportion of small fish, particularly breams of lengths less than 20 cm, was greater than in any of the other areas.

Compared with Survey I the resources were more abundant than in August 1978. This may be part of a seasonal trend, but it should also be noted that the area was incompletely covered in the first survey apart from the deep-water lobster ground.

The results of the fishing experiments are summerized in Table 3 and details for each fishing station are given in Appendix Table I. Two trawl hauls were

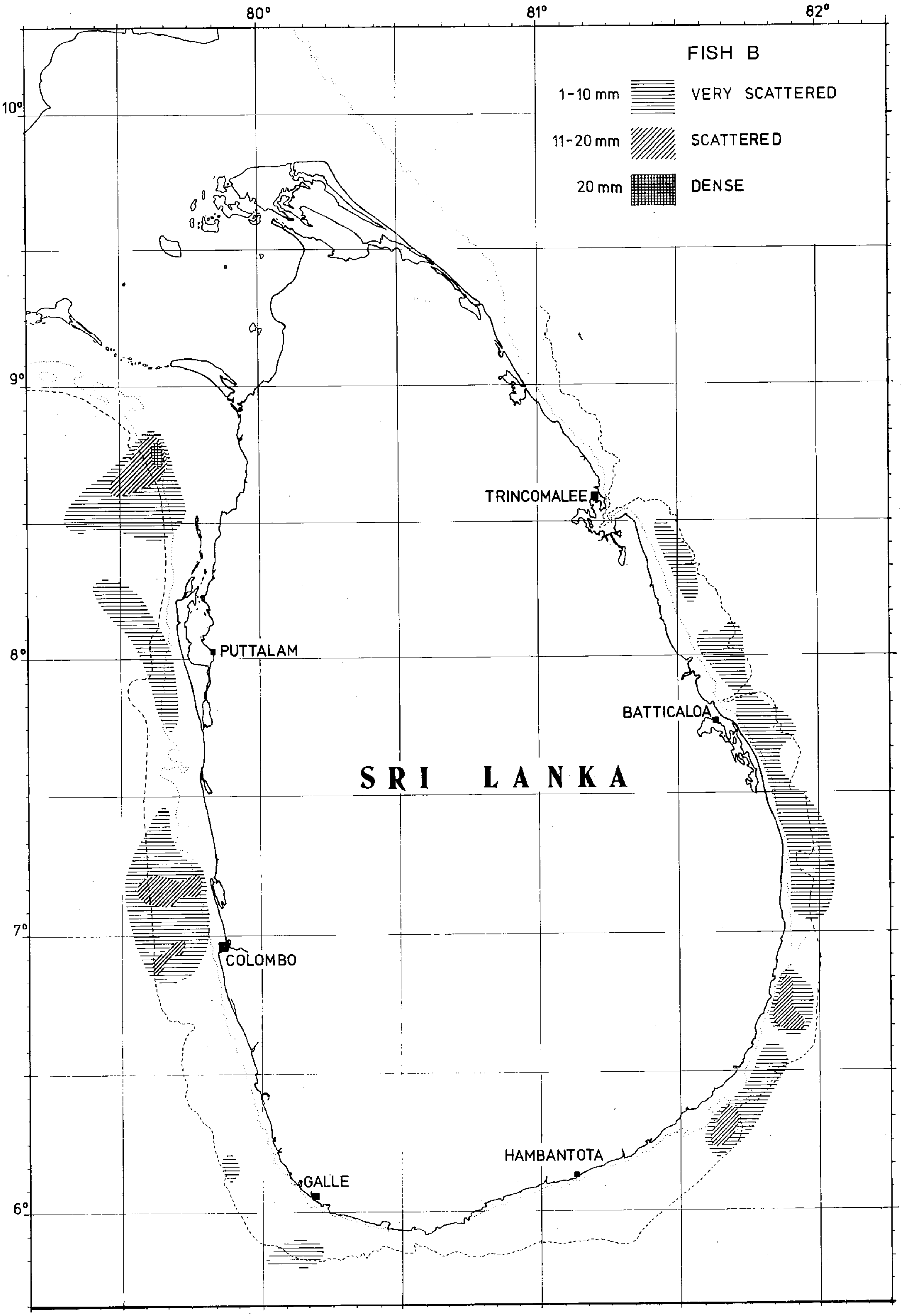


Fig. 14. Distribution of echo intensity of recordings classified as pelagic fish (Type B and Type C), 23 April - 31 May. Indices of abundance by levels of integrator deflection (mm per nautical mile).

Table 3. Summary of fishing stations in Area I, NW coast north of Negombo.

Bottom trawl (Catch per hour, kg)

Station no	Total catch	Snappers breams groupers etc.	Trevallys mackerel etc.	Small pelagic	Sharks rays	Other commercial	Other non-commercial
1	225	172	17			19	17
3	790	706	26		58		
4	308	262			25	21	
6	457	340			55	24	40
7	300	121	12		23	53	90
8	185	120			22	27	16
138	246	134	8		95		9
139	179	109	45		25		
140	2005	1459	133			413	
141	496	305				110	79
143	104				80		24
144	375	107	37		75	42	114
145	22	6	12			3	1
146	130	72	2			23	30
2	2275	Lobster 229, shrimps 246, deep-water fish 1800.					
137	2250	Lobster 102, shrimps 115, deep-water fish 2030.					

Pelagic trawl (Catch per hour, kg)

Station no	Total catch	
5	37	Semipelagic fish

Bottom long line (Catch kg)

Station no	No hooks	Total catch	Snappers breams groupers etc.	Sharks
136	200	63	60	3
142	200	1		1

Table 4. Summary of fishing stations in Area II, SW coast, Negombo - Galle.

Bottom trawl (Catch per hour, kg)

Station no	Total catch	Snappers breams groupers etc.	Trevallys mackerel etc.	Small pelagic	Sharks rays	Other commercial	Other non-commercial
10	322	117			161	22	22
11	55	40	11			4	
12	65	40	21			4	
17	43	34	9				
20	0						
21	18	18					
23	68	8				60	
25	0						
29	1330	493	528	196			113
94	1		1				
147	1168	427	520			111	100

Pelgagic trawl (Catch per hour, kg)

Station no	Total catch	Trevallys mackerel etc.	Small pelagic
9	32		32
13	1		
19	0		

Bottom long line (Catch kg)

Station no	No hooks	Total catch	Snappers breams groupers ets.	Trevallys etc.	Shark rays
24	200	9	9		
26	200	169	169		
28	200	54	34	18	2
30	200	3	3	185 hooks lost	

taken on the deep sea lobster ground which was studied in more detail during Survey I.

As shown in Table 2 the catch rates of lobster, shrimp and deep sea fish in these two hauls were at the same relatively high level as previously. Otherwise the bottom trawl fishing on the shelf yielded generally high catches of valuable food fish and thus confirm the acoustic observations.

5.3.3 Area II. The South-west Coast from Negombo to Galle

Area II was surveyed during the period 3 - 10 May. Relatively high values of echo intensity were observed, particularly just north of Colombo and off Galle (Fig. 13 and 14). The densest concentrations were generally observed on the outer part of the shelf on rough bottom. Sampling of the densest concentrations with bottom trawl was to a great extent restricted by the poor bottom conditions. The fish distribution is similar to that observed in Survey I with denser patches off Negombo, Colombo and further south towards Galle.

The assessment of the resources in the area amounted to 150 000 tonnes. Of this 130 000 tonnes were classified as demersal and semi-demersal fish (Table 2). The total estimate was about 70 000 tonnes lower than that of Survey I. The resources classified as Type A were, however, at about the same level in both surveys and the difference is due to a marked decrease of the pelagic resources, Type B and particularly Type C.

Table 4 summarizes the results of the fishing trials. The catch rates are as mentioned above not representative of the abundance of fish in this region because of the large areas of rough bottom. The hauls exceeding one tonne per hour were made off Negombo and Galle. The main catch consisted of demersal and semi-demersal fish both on trawl and long line. The latter gave some promising yields.

5.3.4 Area III, The Hambantota Banks

This rather wide shelf area, limited by the narrow part off Dondra Head to the west and Little Basses Reef to the east, was surveyed during the period 10 - 14 May and again from 4 - 6 June. The recordings were generally at a relatively low level. The highest echo intensities were mainly observed on

Table 5. Summary of fishing stations in Area III, Hambantota Banks.

Bottom trawl (Catch per hour, kg)

Station no	Total catch	Snappers breams groupers etc.	Trevallys mackerel etc.	Small pelagic	Sharks rays	Other commercial	Other non-commercial
31	229	115			17	97	
33	255	255					
37	12	10				2	
96	42	38				4	
97	199	99			100		
98	104	103	1				

Pelagic trawl (Catch per hour, kg)

Station no	Total catch	Trevallys mackerels etc.	Small pelagic	Other commercial
38	0			
42	1	0-group		
100	31	1	3	27
101	13		8	5

Bottom long line (Catch kg)

Station no	No hooks	Total catch	Snappers* breams groupers etc.	Trevallys mackerel etc.	Sharks rays	
32	200	89	89			
34	200	169	169			
35	200	0				
36	200	49	49			
39	200	212	180	21	11	
40	200	27	27			
92	100	10			10	
95	200	0				
99	200	8	7		1	
102	200	13	13			
103	200	29	7	12	10	
104	200	1	1			

Table 6. Summary of fishing stations in Area IV, East coast and Batticoloa Banks.

Bottom trawl (Catch per hour, kg)

Station no	Total catch	Snappers breams groupers etc.	Trevallys mackerel etc.	Small pelagic	Sharks rays	Other commercial	Other non-commercial
41	461		122	303		36	
43	201	8	18	155			20
45	798	567				231	
47	394	121			180	93	
48	15			2		13	
50	12	11					1
51	15	15					
52	157	126	10			21	
55	160	45	15	30		40	30
56	69		53	13		3	
57	40	9	6			7	16
58	158	119	7			32	
59	467	26	325	42		37	27
61	144	91	51			2	

Pelagic trawl (Catch per hour, kg)

Station no	Total catch	Trevallys mackerels etc.	Small pelagic	Other commercial
42	1		1	
53	1			1
54	0			

Bottom long line (Catch kg)

Station no	No hooks	Total catch	Snappers breams groupers etc.	Trevallys mackerel etc.	Sharks rays	Other commercial
44	200	37	16	10	4	7
46	110	34	24	6	4	
49	100	14	10	2	2	
62	200	4		4		
91	100	20	7	13		

the outer shelf, also here on rough bottom. The estimate of the resources was only about 35 000 tonnes as against 100 000 tonnes during Survey 1. Of this only about 5000 tonnes were classified as pelagic fish and was observed near the Little Basses Reef. The reduced abundance is first of all evident in the pelagic fish.

As shown by Table 5 catch rates and catch compositions confirm these findings. The few pelagic trawl hauls conducted gave only insignificant catches, while those with bottom trawl and long line were of the same level or even somwehat higher than during Survey I. The catch rates in some of the fishing experiments with bottom long lines would be considered good in a commercial fishery.

5.3.5 Area IV. East Coast and Batticaloa Banks

This rather narrow shelf was surveyed from 14 - 21 May. The resources were evenly distributed over the shelf but recordings were generally of moderate abundance. Again the Type A species accounted for the major part of the fish biomass. These were assessed at about 40 000 tonnes while pelagic species of Type B were estimated to only 15 000 tonnes. The total assessment is only about half of the estimate from Survey I and again the difference is mainly due to the very small quantities of pelagic fish, notably Type C, while the demersal resources were almost at the samel level as during Survey I. Table 6 shows in summary the results of the fishing operations in the area. The highest catch rates come from bottom trawl hauls in very shallow waters whereas fishing with pelagic trawl and long-lines only yielded low catches.

5.3.6 Area V. Trincomalee - Mullaittivu

This area was surveyed from 21 - 24 May. Distribution and abundance of the resources were similar to those in Area IV. On the shelf the fish was generally recorded close to the bottom. Some recordings classified as Type B were recorded off the shelf. The total fish biomass was estimated at about 25 000 tonnes of which 5000 tonnes were classified as pelagic resources. Also this was about half the amount of the assessment from Survey I, mainly resulting from a lower abundance of pelagic resources. Recordings classified as small pelagic species were not observed in this area. Results of the fishing operations are summarized in Table 7. The catch rates with bottom trawl were moderate or low, and most derive from extreme inshore waters.

Table 7. Summary of fishing stations in Area V, Trincomalee to Mullaittivu.

Bottom trawl (Catch per hour, kg)

Station no	Total catch	Snappers breams groupers etc.	Trevallys mackerel etc.	Small pelagic	Sharks rays	Other commercial	Other non-commercial
64	2		2				
67	341	64	33		200	44	
68	362	196	59	9		89	9
69	172	98	48	13		13	
70	4		4				
71	266	188	30	42			6
74	238	50	94	27		67	
105	143	128	11				4
106	256	214	37	5			
107	120		2	116		2	
109	34	17		3		14	

Pelagic trawl (Catch per hour, kg)

Station no	Total catch	
73	1	Small red prawns

Bottom long line (Catch kg)

Station no	No hooks	Total catch	Snappers breams groupers etc.	Trevallys mackerel etc.	Shark rays	Other commercial
63	100	34	30			4
66	200	35	35			
72	100	17	17			
90	100	0				

Table 8. Summary of fishing stations in Area VI, Pedro Bank.

Bottom trawl (Catch per hour, kg)

Station no	Total catch	Snappers breams groupers etc.	Trevallys mackerel etc.	Small pelagic	Sharks rays	Other commercial	Other non-commercial
75	0						
76	273	199	36			23	15
77	36	15	3		6	12	
78	27	1	16			3	7
79	28	28					
80	1953	1220	89		120	404	120
81	10		3		7		
83	150			150			
84	55			40		15	
85	8					1	7
86	141	117	3			17	4
87	539	364	60			115	
88	294	177	37			80	
89	0						
110	174	92		15	30	24	13
111	194	174	12			8	
112	424	108	53			212	51
113	45		27		6	12	
114	94	73	18			3	
115	310	279	29			2	
118	208	135			50	23	
119	93	53	21	11		8	
120	1644	1158	34			396	56
121	52	6	46				
122	224		69	6	149		
123	20					10	10
125	27			4		13	10
126	15	13				1	1
127	29					21	8
128	2	2					
129	512	126	99		237	27	23
131	60	9	4	6		41	
132	686	595	33		4	54	
133	257	148	40		50	6	13
134	258	32	211		4	2	9
135	148	84	24	3		19	18

Pelagic trawl (Catch per hour, kg)

Station no	Total catch	
117	5	Fish larvae, plankton

Bottom long line (Catch kg)

Station no	No hooks	Total catch	Snappers breams groupers etc.	Trevallys mackerel etc.	Sharks rays
126	200	24	22		2
124	150	4	1		3
130	70	24	24		

5.3.7 Area VI. The Pedro Bank

The area, between 9° 30'N and the border towards the Indian economic zone, was surveyed from 24 - 29 May and from 9 - 12 June. The fish resources were distributed on the inner part of the bank, mainly at depths less than 40 to 50 m. The recorded echo intensities were low also here, generally at about the same level as in areas IV and V. Some spots of higher densities were, however, observed. Demersal resources were assessed at hardly 10 000 tonnes and were again the most important component of the total fish biomass which was estimated at 15 000 tonnes. The highest echo intensities were observed at depths around 20 m. Fairly dense concentrations were recorded very close to the bottom as illustrated in Fig. 15 which shows the recordings as a thickening of the bottom line. Such concentrations were always distributed over a very limited area, never more than a few square nautical miles. In such spots trawl experiments yielded fairly good catches, Table 8. The catch from the concentration recorded in Fig. 15 was close to two tonnes per hours tow (fishing station no. 80).

On the outer part of the bank the recordings were poor and the fishing operations were in support of this observation. In this area trawl catches were at an insignificant level.

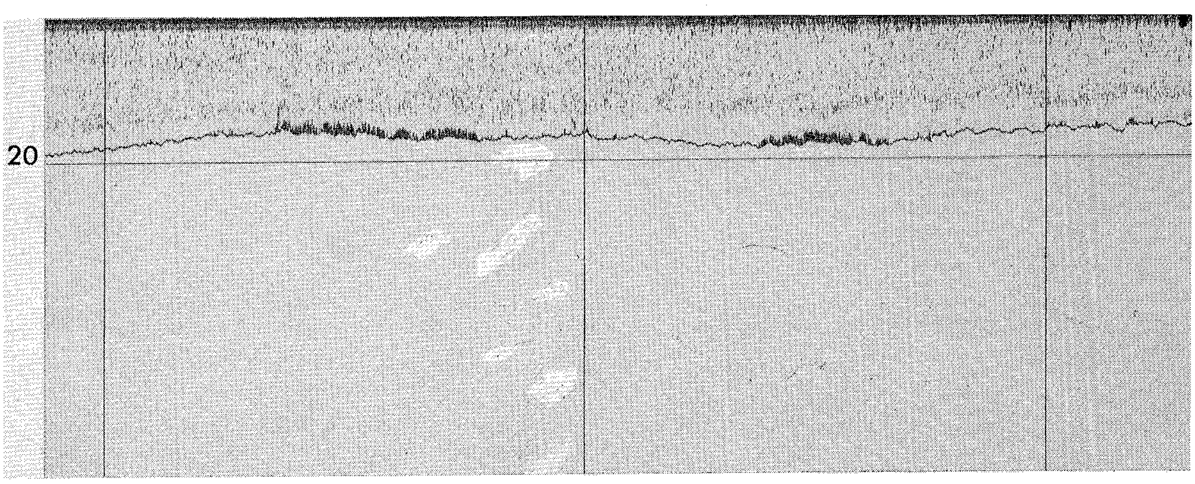


Fig. 15. Echo recordings of demersal fish very close to the bottom on Trawl station 80. Catch per hour was 1950 kg.

The hydrographic observations on the bank showed that the content of dissolved oxygen was below 2 - 3 ml/l (Fig. 8) at depths greater than 50 to 60 m. The lack of the most common demersal species on the outer part of the bank suggests that they prefer well oxygenated waters.

Comparing with Survey I there was also in this area a considerable decrease in the total biomass. The most striking difference was the low abundance of small pelagic schooling fish which were observed in abundance during Survey I.

5.3.8 Estimate from the trawl survey

On the greater part of the shelf the densest fish concentrations were observed on rough bottom where sampling with bottom trawl was impossible. An assessment based on trawl catches would therefore not be representative for the true distribution and abundance of fish.

On the Pedro Bank, however, the number of trawl hauls was great enough to warrant an estimate of demersal fish biomass from trawl catches. The whole sub-area was fairly well covered and sampling with bottom trawl could also be expected to be reasonably representative since the demersal resources were recorded close to the bottom, mainly within reach of the trawl.

With a net sonde the vertical opening of the trawl was measured to about 5 m. The distance between the wing ends was about 15 m and warp angle measurements indicated that the gear covered a track about 55 m between the trawl doors when operated with 40 m bridles.

The area, A, covered by the trawl was taken to be the distance between the wing ends multiplied by the length of the tow. The fish biomass, B, per square nautical mile on the trawl stations was calculated as

$$B = \frac{C}{A\ F}$$

where C is catch, A is area covered by the trawl net expressed in square nautical miles, and F is the catch efficiency coefficient of the trawl, i.e. the ratio between catch and quantity of fish in the path of the trawl net.

The estimate is, of course, highly dependent on the efficiency coefficient. As a first approximation Saville (1977) suggests F equal to 1.0 to give a lower limit of the proportion of the stock which is catchable by the trawl. Reliable data on trawl gear efficiency is scanty. The few data available indicate that an efficiency close to 1 can be expected only for very sluggish species. Based on tests Harden Jones et al. (1977) arrived at an efficiency coefficient of 0.61 for plaice (Pleuronectes platessa L.). Dickson (1974) claims that the efficiency for roundfish will be considerably less. In similar trawl surveys coefficients ranging from 0.3 to 1.0 have been applied (Budnichenko et al. 1977, Birkett 1978). In a trawl survey off Mozambique, Sætre and Silva (1979) used 0.5 as the efficiency coefficient for the type of bottom trawl used on "Dr. Fridtjof Nansen". This is also in agreement with general conclusions from the FAO Indian Ocean Programme (Anon 1979). An efficiency coefficient of 0.5 for the present survey has therefore been applied.

Catch per square nautical mile on trawl stations are listed in Table 9. The values for trawl stations on the Pedro Bank were plotted in a chart and values for the whole bank area were determined by interpolation between the trawl stations. The resulting distribution chart is shown in Fig. 16 together with the distribution chart based on the acoustic survey made in June. Indices of abundance in the charts correspond to equal levels of fish density. As demonstrated by the figure the two distributional patterns are closely related. The main difference is a patch of dense concentrations on the outer shelf in the acoustic map. These resources were observed on rough bottom and could not be sampled by the trawl.

Based on the trawl survey the demersal resources on the Pedro Bank were assessed at 8000 tonnes. This result agrees fairly well with the acoustic assessment in June which was 11 000 tonnes. Here it is worth noting that the estimate based on the trawl survey includes only fish within 5 m from the bottom. Although the demersal resources on the Pedro Bank were generally observed close to the bottom, a part was recorded in mid water above the reach of the trawl. Nor was the dense patch in the outer part of the area included in the trawl based assessment.

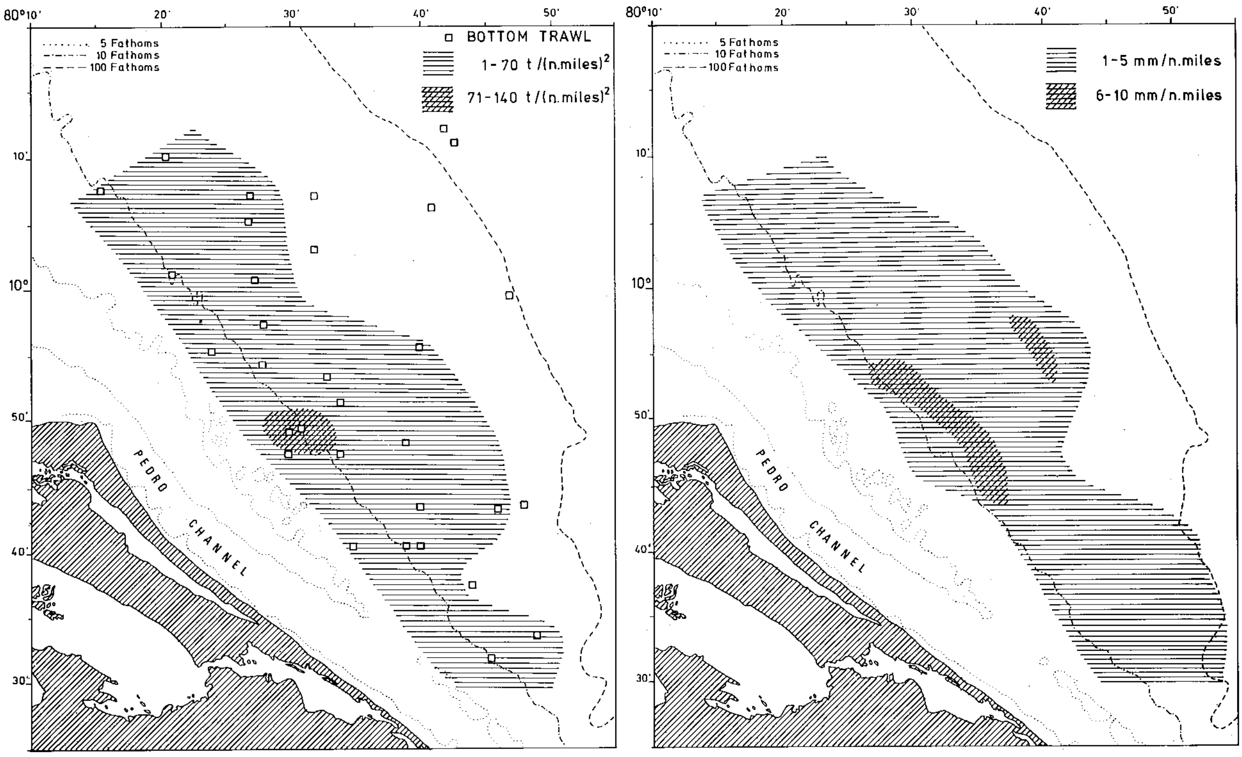


Fig. 16. Distribution of demersal and semi-demersal fish on the Pedro Bank 9 - 12 June. Left: Distribution based on trawl survey with indices of fish density in tonnes per square nautical mile. Right: Distribution of echo intensity by levels of integrator deflection. (m m per nautical mile). 5 mm per nautical mile correspond to 70 tonnes per square nautical mile.

5.3.9 Comparison of trawl data with acoustic data

As described above, the biomass estimates obtained from the trawl survey and the acoustic survey on the Pedro Bank corresponded fairly well. For the rest of the survey area a similar comparison is not possible due to the non-representative distribution of trawl stations. A comparison of "acoustic estimates" of fish biomass per unit area in the localities of trawl stations will, however, give some general information on the relation between acoustic observations and trawl samples. Catch per square nautical mile as given in Table 9 was compared with an assessment of the echo recordings obtained during the tow. Only recordings less than 5 m from the bottom were included in the assessment to correspond with the vertical opening of the trawl. Integrated "fish echo intensity" for each tow was obtained from the total integrator output through the ordinary evaluation of the type of recordings shown in the echo diagrams. The resulting acoustic assessments are also given in Table 9.

In Fig. 17 these two types of estimate are plotted against each other. Separate plots are shown for trawl stations at depths less than 30 m and for stations worked between 30 and 100 m depth. Trawl stations where the echo recordings were interpreted as pelagic fish (Type B) are symbolized by crosses. On all other stations echo recordings within 5 m from the bottom were interpreted to be derived from demersal fish (Type A). The stations with Type A recordings form a fairly good inter-relationship, the correlation coefficient being 0.92 and 0.91 for stations worked shallower than 30 m and in deeper waters respectively. The regression line for the interrelation, stations symbolized by a cross excluded, is shown in the figure. It is seen that the line for the shallower stations is notably steeper than that for the stations at depths between 30 and 100 m, their slope coefficient being 0.72 and 0.58 respectively. This indicates that the ratio between trawl catch per square nautical mile and acoustically assessed fish density varies with depth. This could be the effect of differential fish behaviour possibly caused by vessel-noice in shallow water, as discussed below.

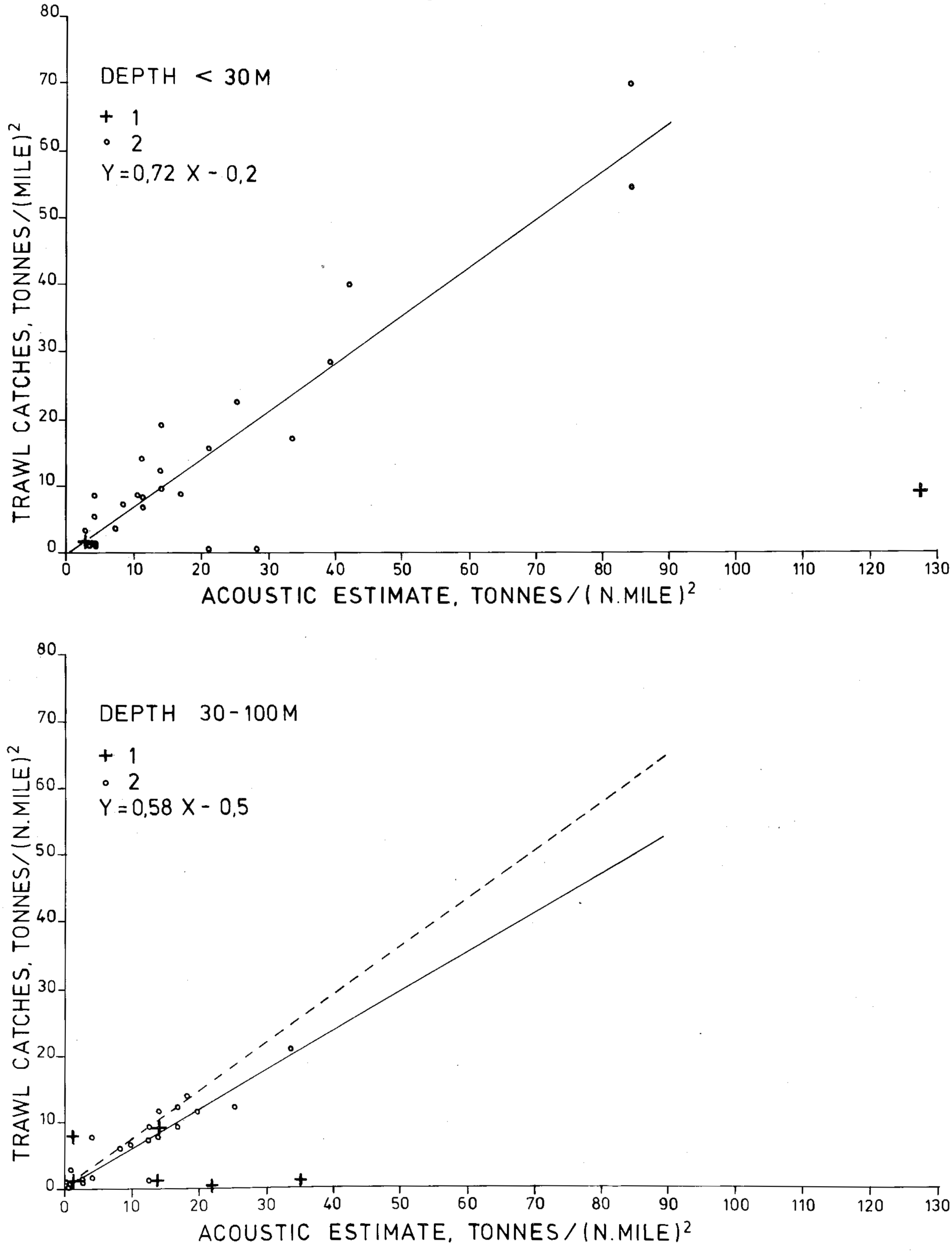


Fig. 17. Inter-relation between trawl catch per square nautical mile and acoustic assessment of echo recordings within 5 m from bottom during tow (Table 9). Regression line for top section is indicated by broken line in bottom section. 1) Echo recordings interpreted to be Type B. 2) Echo recordings interpreted to be Type A.

Table 9. Data on fish density on bottom trawl stations: Catch per square nautical mile calculated from catch and area swept by trawl net. Acoustic assessment of fish density (Integr. index) derived from echo recordings obtained within 5 m from bottom during tow. Interpretation of echo recordings by category.

TRAWL STATIONS AT DEPTHS LESS THAN 30 M.

Stn No	Depth m	Dist. towed nm	Catch kg	Integr. index	Catch tonnes/nm^2	Acoustic assessm. tonnes/nm^2	Interpret. of echo recordings
41	20	1.0	230	2.8	28.8	39.2	A
43	25	1.4	100	9.1	9.3	127.4	B
45	23	0.6	200	3.0	40.0	42.0	A
47	20	1.5	110	1.2	9.0	16.8	A
50	22	0.7	5	1.5	0.6	21.0	A
51	23	1.1	5	2.0	0.6	28.0	A
59	23	0.8	115	1.0	19.5	14.0	A
71	13	1.8	135	0.3	8.9	4.2	A
76	20	1.3	135	1.0	12.4	14.0	A
78	12	1.5	15	0.3	1.2	4.2	A
80	16	1.7	980	6.0	70.0	84.0	A
106	21	1.3	105	1.0	9.7	14.0	A
107	19	1.4	60	0.3	5.5	4.2	A
109	14	1.8	15	0.3	1.1	4.2	A
110	15	1.2	70	0.6	7.2	8.4	A
111	20	1.3	95	0.8	8.8	10.5	A
112	25	2.0	275	2.4	17.3	33.6	A
113	18	1.8	25	0.3	1.5	3.5	A
114	15	1.6	45	0.5	3.6	7.0	A
115	16	1.4	155	0.8	14.1	11.2	A
120	14	1.8	820	6.0	54.8	84.0	A
121	15	1.7	25	0.2	1.9	2.8	B
129	13	1.3	175	1.5	15.8	21.0	A
131	14	0.4	10	0.2	3.3	2.8	A
132	20	1.9	345	1.8	22.9	25.2	A
133	14	1.9	105	0.8	6.9	11.2	A
138	17	0.7	50	0.8	8.3	11.2	A

TRAWL STATIONS AT 30 - 100 M DEPTH.

Stn No	Depth m	Dist. towed nm	Catch kg	Integr. index	Catch tonnes/nm^2	Acoustic assessm. tonnes/nm^2	Interpret. of echo recordings
21	70	1.4	10	0.2	0.8	2.8	A
31	58	1.0	75	1.2	9.1	16.8	A
33	57	1.4	130	1.4	11.6	19.6	A
37	56	1.2	5	0.0	0.6	0.0	A
48	31	1.6	5	0.05	0.5	0.7	A
52	43	0.6	40	0.3	7.8	4.2	A
55	44	1.3	15	0.3	1.5	4.2	A
56	34	2.0	35	1.0	2.1	14.0	B
61	33	1.3	70	0.7	6.6	9.8	A
64	33	1.0	0	1.6	0.0	22.4	A-B
67	46	1.7	170	1.8	12.1	25.2	A
68	36	1.6	180	1.3	13.9	18.2	A
69	38	1.5	85	0.9	7.2	12.6	A
75	32	1.2	0	0	0	0	-
77	46	1.1	10	0.2	1.3	2.8	A
79	30	0.7	10	0.9	1.2	12.6	A
86	70	1.1	70	1.0	7.8	14.0	A
87	35	1.6	270	2.4	20.8	33.6	A
88	33	1.5	146	1.2	12.2	16.8	A
89	70	0.7	0	0	0	0	-
105	38	2.0	95	0.8	6.0	8.4	A
118	45	1.5	105	1.0	8.7	14.0	A-B
122	34	1.1	70	0.1	8.0	1.4	B
123	57	2.0	10	0.1	0.6	1.4	B
125	80	2.5	15	2.5	0.7	35.0	B
126	100	4.3	0	0	0	0	-
134	37	1.3	130	1.0	11.8	14.0	A
135	38	1.0	75	0.9	9.3	12.6	A

6. DISCUSSION OF METHODS

During the present survey the greater part of the fish biomass was observed near the bottom. The limitation of the echo sounder in detecting fish very close to the bottom is well known and thus part of the resources may have escaped detection and an under-estimate may have occurred.

According to common diel behaviour pattern, many species are closer to the bottom by day than by night and the under-estimate should consequently be greatest during day hours. To look into this, replicate day - night surveying was done over 35 nautical miles on the Pedro Bank. The average ratio between night and day recordings, classified as Type A, was 1.3. This suggests a not insignificant under-estimate by day. Such an under-estimate is, however, difficult to quantify since the "dead zone" of the echo sounder varies with depth and the roughness of the bottom. Repeated surveying over only 35 nautical miles is also too limited to warrant any correction of the survey results. It supports, however, the assumption that some under-estimation may have occurred. Table 10 gives the number of nautical miles sailed by day and by night to survey the various sub-areas. It appears from the table that in areas II, III, IV and VI survey work was divided equally on day and night. In Area I there was some excess of night surveying while Area V was mostly surveyed by day. Underestimate due to the diel fish behaviour was therefore of most importance in Area V and least in Area I.

Extended parts of the survey area around Sri Lanka are shallow and here the sampling volume of the echo sounder becomes quite narrow. For instance at 20 m depth the diametre of the sound beam is hardly 2.5 m. This is illustrated in Fig. 18 where dimensions are correct in relation to 20 m echo depth. Dimensions of the trawl mouth are also included and the figure shows that at this depth the ratio between the diametre of the sound beam and the distance between trawl wings is about 1 to 6. It may therefore well happen that fish are caught without being recorded by the echo sounder.

In the upper water layers the vessel may also generate escape behaviour, at least for some species. Olsen (1979) has for instance shown that herring (Clupea harengus) responds to the passage of a vessel at least down to 50 m depth. This may partly be a "ploughing" effect with responding species moving

Table 10. Survey work split on day and night in the sub-areas, nautical miles surveyed and % of total.

Sub-area	Day N.miles	Day %	Night N.miles	Night %
I	185	44	240	56
II	535	49	565	51
III	280	48	305	52
IV	505	49	530	51
V	370	65	200	35
VI	460	49	480	51

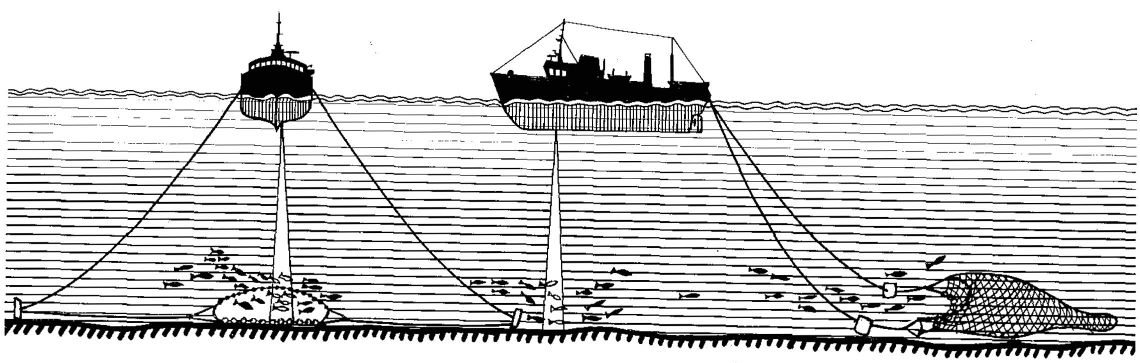


Fig. 18. Dimensions of the sound beam from the echo sounder at 20 m echo depth in relation to the distance between trawl doors and wind ends of the trawl net.

to the sides of the vessel, and partly the fish may move to the bottom. Both these types of response lead to avoidance of detection and consequently an under-estimate. The variation with depth of the ratio between trawl catches per unit area and acoustic estimate mentioned above (Fig. 17) supports this assumption. A part of the fish escaping the vessel may flee to the bottom and be caught more easily by the trawl, but avoid detection by the echo sounder. The response of the fish to the vessel is likely to decrease with increasing depth and may thus give rise to the depth variation of the ratio between trawl catch per unit area and acoustic estimate.

It is established that doors and bridles are active parts of the trawl gear because of their shepherding effects. In the present case, however, quantification is difficult since many trawl hauls were worked in very shallow water. The scaring effect of the vessel mentioned above will possibly also influence the trawl catches since fish may escape to the sides and reduce the herding effect of the doors and bridles. Because of this only the area swept by the trawl net was considered when working out catch per unit area.

The catch efficiency of the trawl may vary with species. The trawl stations marked with crosses in Fig. 17 indicate that avoidance may be quite significant for pelagic fish. An assessment based on these trawl hauls would result in a considerable under-estimate.

7. DISCUSSION OF SURVEY RESULTS

The main objective of the cruise was to repeat the survey conducted in August - September 1978 in another season.

The distributional pattern of the demersal resources (Type A) showed general similarities with the findings from Survey I. There were, however, some changes in the location of the most abundant concentrations. The highest echo intensities were observed in Area 1, the north-west coast north of Negombo. Even though this area was insufficiently covered during Survey I, it is likely that the demersal resources had now increased. On the south coast on the other hand, the assessment indicated a decrease. These observations suggest that a seasonal migration to the north-west coast may have occurred.

The assessment of demersal and semi-demersal resources (Type A) for the whole survey area amounted to 330 000 tonnes. This is very close to the assessment obtained from Survey I, but it is worth noting that Area I was excluded from that assessment. The present result therefore represents a decrease in relation to Survey I, but in consideration of the likely increased abundance in Area 1, the decrease is rather slight.

Following Report I a factor of 0.2 may be applied for the estimate of the sustained yield from the unfished standing demersal and semi-demersal biomass. On the basis of this the potential annual yield would be near 70 000 tonnes.

The two surveys give indication of some seasonal migrations, notably between the west and south coasts. This coastal stretch should therefore be considered as a whole with a potential annual yield of approximately 50 000 tonnes of demersal and semi-demersal fish.

On the east coast the demersal and semi-demersal biomass was at about the same level during the two surveys and the assessments suggest a potential of approximately 15 000 tonnes as annual yield. Out of this about 2000 tonnes may be taken on the Pedro Bank.

Pelagic resources were assessed at a total of approximately 70 000 tonnes for the whole survey area. Compared to the findings during Survey I this represents a drastic decrease. The reduction is demonstrated by extremely few recordings of small pelagic fish. The assessment of recordings classified as Type C hardly amounted to 5000 tonnes in total for the survey area. The most plausible reason for this low level is likely to be seasonal fluctuations and migrations to extreme shallow waters. As regards bigger pelagic species on the west and south coast this assumption is supported by reports on decreasing catches of pelagic fish from January to April (de Bruin 1979). On the east coast, however, de Bruin reports on high catches during June - September of small pelagic species. On the present cruise the Pedro Bank was surveyed in May and in June, in both cases with quite moderate recordings of pelagic fish.

The detection of dispersed small pelagic species could be obscurred by recordings of dense plankton consentrations. Such plankton recordings occurred, however, only in limited areas, notably near the shelf edge. Moreover, schools of pelagic fish would be distinguishable even in dense plankton layers. It thus seems highly unlikely that recordings of small pelagic fish were misinterpreted as plankton to an extent which can explain such a great difference. In conclusion the findings of the two cruises suggest that the abundance of the pelagic resources is variable.

Contrary to the trawl which has decisive shortcoming on rough bottom and in sampling of highly avoiding species, the acoustic survey method offers about the same level of precision throughout the survey area. From the discussion of the method it may be concluded that most of the sources of bias bring about an under-estimate. Am important exception is the density coefficient, the bias of which is difficult to determine. It might be argued that the fairly good agreement between the estimates based on respectively acoustic survey and trawl survey on the Pedro Bank simply depends on a suitable choice of coefficients for fish density and trawl efficiency. The coefficients are, however, established independently and the agreement suggests that they are within reasonable limits. In general it can therefore be concluded that the assessment presented is an under-estimate.

The various limitations and reservations mentioned in the report on Survey I also apply to these new findings. The extensive northern Palk Bay and Palk Strait areas are not covered, and extreme inshore shallow waters could only be covered incompletely. The important resources of large pelagic fish, tunas and tuna-like fish are probably only partly included in the biomass assessments.

Since bottom long lines are a passive type of gear, the results from the long line stations could not be applied in the assessment. This gear contributed nevertheless very usefully in the wide shelf areas where bottom trawl could not be used. The catches confirmed that the big demersal species accounted for at least part of the demersal recordings also in these areas.

Bottom long lines were operated at various times of the day. Most fishing experiments were made in daytime and lasted about two hours, but some experiments were also tried over night. No significant difference in fishing efficiency was observed in relation to time of day. The relatively small number of trials made during the cruise is, however, insufficient for definite conclusions about this. Predation on catch by bigger fish like sharks occurred, but was not a serious problem.

In several cases quite encouraging catches were taken on bottom long lines, up to 2.1 kg per hook. the catches vaired, however, with the type of bait used. Various types of baits were tried, but squid proved by far most successful.

Bottom long lines stand out as an interesting gear for commercial exploitation of the demersal resources. It is a comparatively inexpensive gear with only small demands on the fishing boat. With small modifications the existing mechanized fishing boats could probably divert to such fishery with profit.

8. LENGTH - AND WEIGHT DATA OF FISH

All principal species occurring in the catches were sampled for length and weight. These data will be processed in detail by the Fisheries Research Station of Colombo.

Annex Table 2 shows the size distributions by species for survey areas and Annex Table 3 shows the length - weight data for some species.

9. LIST OF REFERENCES

ANON. 1972. Atlas of surface currents, Indian Ocean. H.O. Publ. No. 566. U.S. Hydrographic Office 1970.

ANON 1979. Report on the FAO/IOP workshop on the fishery resources of the western Indian Ocean south of equator. IOFC/DEV/79/45.

BIRKETT, L. 1978. Western Indian Ocean fishery resources survey. Report on the cruises of R/V Professor Meyatsev December 1975 - June 1976/ July 1977 - December 1977. Indian Ocean Programme, Technical report No. 21, FAO, Rome - August 1978.

BUDNICHENKO, U.A. *et al*. 1977. Results obtained from the "Aelita" exploratory surveys undertaken in the shelf and open waters continuous to the coast of the People's Republic of Mozambique (May 1976 through August 1977). Azcherniro, kerch 1977.

DARBYSHIRE, M. 1967. The surface waters off the coast of Kerala, south-west India. Deep Sea Res. 14: 295-320.

DE BRUIN, G.H.P. 1979. Review of previous resources surveys and existing fisheries. Annex in A survey of the coastal fish resources of Sri Lanka Aug. - Sept. 1978. (Sætersdal and de Bruin 1979).

DICKSON, W. 1974. A review of the efficiency of bottom trawls. Report by the Institute of Fishery Technology Research, Bergen.

FOOTE, K.G. 1979. Systematic species and frequency dependent differences among gadoid target strength functions. Contribution to meeting on hydro-acoustical methods for the estimation of marine fish populations, Cambridge, Massachusetts, 1979: 1-22 [Mimeo].

HARDEN JONES, F.R., MARGETTS, A.R., GEER WALKER, M., and ARNOLD, G.P. 1977. The efficiency of the granton otter trawl determined by sector-scanning sonar and acoustic transponding tags. Rapp. P.-v. Réun. Cons. int. Explor. Mer, 170: 45-51.

NAKKEN, O. and DOMMASNES, A. 1975. The application of an echo integration system in investigations on the stock strength of the Barents Sea capelin (Mallotus villosus, Müller) 1971-1974. Int. Coun. Explor. Sea Coun. Meet. 1975 (B:25): 1-9, [Mimeo].

NAKKEN, O. and OLSEN, K. 1977. Target strength measurements of fish. Repp. P.-v. Réun. Cons. int. Explor. Mer, 170: 52-69.

OLSEN, K. 1979. Observed avoidance behaviour in herring in relation to passage of an echo survey vessel. Int. Coun. Explor. Sea Coun. Meet. 1979 (B:18): 1-9, [Mimeo].

SAVILLE, A. (ed.) 1977. Survey methods of appraising fishery resources. FAO Fish. Tech. Pap., (171): 76 p.

SÆTERSDAL, G.S. and DE BRUIN, G.H.P. 1979. Report on a survey of the coastal fish resources of Sri Lanka August - September 1978. Fisheries Research Station, Colimbo, Institute of Marine Research, Bergen.

SÆTRE, R. and SILVA, R.P. 1979. The marine fish resources of Mozambique. Servico de Investigacoes Pesquiras, Maputo, Institute of Marine Research, Bergen - September 1979.

WRYTKI, K. 1971. Oceanographic atlas of the international Indian Ocean expedition. National Science Foundation, Washington D.C. 531 pp.

WRYTKI, K. 1973. Physical oceanography of the Indian Ocean, in Biology of the Indian Ocean, B. Zeitzshel (Ed.). Springer - Verlag Berlin, Heidelberg, New York 1973.

Appendix Table I. Record of fishing operations.

BTR = Bottom trawl. PTR = Pelagic trawl. LL = Long line.

Date	Time Start	St. no.	Gear type	Bottom depth (m)	Gear depth (m)	Position Lat. N	Position Long. E	Total catch (kg)	Catch per hour (kg)	Dominant species (or group) Total catch(kg)		Mean weight (kg)
26.4	0746	1	BTR	19	19	08°57'	79°32'	148	225	*Lethrinidae*	43.0	0.72
										Lutianidae	30.2	2.74
										Carangidae	10.9	10.90
										Plectorhynchus sp.	18.3	1.66
										Serranidae	21.9	2.19
26.4	1300	2	BTR	275	-	08°41'	79°34'	2272	2272	Puerulus sewelli(Lobster)	229	
										Deep water fish	1797	
26.4	2010	3	BTR	15		08°47'	79°40'	594	790	Lethrinidae	288	1.95
										Lutjanidae	39.3	1.46
										Plectorhynchus sp.	59.4	1.91
										Epinephelus undulosus	37.5	2.68
										Drepane punctata	92.1	1.17
										Gnathanodon speciosus	19.3	6.53
										Skates	43.5	1.21
										Otolithes sp.	14.2	1.29
27.4	1610	4	BTR	10		07°46'	79°42'	154	308	Lethrinidae	73.3	0.60
										Lutjanidae	14.4	2.88
										Plectorhynchus sp.	43.2	2.06
27.4	1905	5	PTR		45/57	07°48'	79°36'	19	37	semipelagic sp.	17.6	
										squid (small)	1.0	
28.4	0820	6	BTR	12		07°30'	79°43'	229	457	Epinephelus tauvina	35.0	17.50
										Lethrinidae	44.1	0.51
										Plectorhynchus pictus	54.9	1.96
										Skates	27.7	1.20
28.4	1128	7	BTR	15-20		07°25'	79°46'	150	300	Lethrinidae	13.3	0.28
										Lutjanidae	18.9	3.78
										Skates	11.7	1.17
										Pomacanthidae	15.4	1.28
										Parrotfish	26.6	1.48
										Gnathanodon speciosus	5.9	5.90
28.4	1450	8	BTR	24		07°18'	79°42'	93	185	Lethrinidae	19.4	0.13
										Lutjanidae	17.3	1.73
										Plectorhynchus pictus	23.4	2.60
										Skates	11.2	0.92
29.4	0007	9	PTR		45	07°08'	79°29'	16	32	*Semipelagic + squid + krill*		
29.4	0710	10	BTR	24		07°06'	79°42'	161	322	Skates	77.9	11.13
										Lutjanidae	21.6	5.40
										Epinephelus undulosus	27.3	3.41
										Plectorhynchus pictus	6.1	3.05
29.4	1249	11	BTR	37		06°56'	79°42	27	55	Lutjanidae	8.2	4.10
										Carangidae	5.3	1.77
										Lethrinus nebulosus	11.9	1.98
3.5	1030	12	BTR	44		06°51'	79°44'	32	65	Lutjanus sanguineus	8.2	4.10
										Lethrinus nebulosus	11.9	1.98
										Carangidae	10.4	1.73
3.5	1305	13	PTR	49	26/44	06°49'	79°42'	½	1	Squid + fish larvae		
3.5	1705	14	Gill net.		4/10	06°45'	79°32'	0	-			
4.5	0655	15	HL			06°33'	79°46'	0	-			
4.5	0900	16	HL	15		06°32'	79°55'	0				
4.5	1020	17	BTR	41		06°32'	79°52'	43	43	Lethrinus nebulosus	8.0	2.67
										Lutjanidae	10.9	5.45
										Epinephelus undulosus	10.0	5.00
										Plectorhynchus pictus	5.1	1.02
										Carangidae	8.6	4.30
5.5	0100	18	G.Net.		4-12	06°24'	79°40'	0	-			
6.5	0735	19	PTR		35	06°21'	79°44'	1	1	Plankton	1.0	
7.5	0001	20	BTR	63	63	06°05'	80°04'	-	-	Mudbottom, no good for trawling		
7.5	0701	21	BTR	70	70	?		9	18	Epinephelus undulosus	8.9	4.45
										Squid (small)	0.25	0.01
7.5	1104	22	HL			05°57'	79°58'	0				
7.5	1720	23	PTR	59	40-55	05°51'	80°09'	34	68	Naso tuberosus	30.0	1.67
										Sphyraena sp.	4.0	4.00
8.5	0520	24	LL	60	60	05°53'	80°01'	9	-	Cephalopholis sonnerati	2.5	0.83
										Pristipomoides typus	4.6	4.60
										Lethrinus nebulosus	2.2	2.20
8.5	1300	25	BTR	55	55	06°08'	79°53'	0	-			
8.5	1745	26	LL	58	58	06°10'	79°53'	169		Lethrinidae	82.8	3.31
										Ephinephelus sp	51.3	3.66
										Lutjanidae	32.6	4.08
8.5	2200	27	G.net.	57		06°11'	79°59'	0				
9.5	0510	28	LL	54	54	06°11'	79°53'	54		Lethrinidae	24.6	4.92
										Pristipomoides typus	9.3	4.65
										Caranx sp.	17.3	3.46

(Table I. contd.)

Date	Time Start	St. no.	Gear type	Bottom depth (m)	Gear depth (m)	Position Lat. N	Position Long. E	Total catch (kg)	Catch per hour(kg)	Dominant species (or group)	Total catch(kg)	Mean weight (kg)
9.5	1440	29	BTR	45	45	06°26'	79°56'	443	1330	Caranx carangus	152	0.29
										Selar crumenophthalmus	24.0	0.86
										Otholithes sp.	164.4	?
9.5	1750	30	LL	66	66	06°17'	79°53'	3		Lutjanidae	3.0	3.00
										(Line broke after hauling a few hooks.)		
11.5	1155	31	BTR	58	58	05°56'	80°50'	73	229	Squid	28.9	0.04
										Lethrinus nebulosus	4.2	2.10
										Epinephelus undulosus	7.7	3.85
										Lutjanidae	12.1	4.03
										Plectorhynchus pictus	10.5	3.50
										Argyrops spinifer	2.1	1.05
										Sharks	5.3	2.65
11.5	1715	32	LL	65	65	05°55'	81°05'	89	40	Lethrinidae	48.9	3.06
										Serranidae	9.7	1.39
										Lutjanidae	19.0	3.80
										Plectorhynchus pictus	8.0	2.67
12.5	0755	33	BTR	57	57	05°58'	81°00'	128	255	Acanthurus sp. (surgeon)	39.1	0.85
										Serranidae	66.1	5.08
										Lutjanidae	12.2	3.05
										Plectorhynchus pictus	12.6	4.20
12.5	1225	34	LL	60	60	06°01'	81°16'	169		Lutjanidae	100.5	4.19
										Lethrinidae	36.6	4.58
										Serranidae	31.8	1.77
12.5	1700	35	LL	59	59	05°58'	81°16.5'	No catch				
13.5	0550	36	LL	25	25	06°08'	81°21'	49		Serranidae	20.8	1.75
										Lutjanidae	27.0	3.86
										Lethrinidae	3.5	1.75
13.5	1135	37	BTR	56	?	06°05'	81°23'	6	12	Aprion virescens	5.0	5.0
										3 small lobsters	1.0	0.3
13.5	1300	38	PTR	54	0	06°05'	81°24'	0	-			
13.5	1715	39	LL	65	-	06°03'	81°27,5'	212		Carangidae	17.6	5.87
										Lutjanidae	61.4	4.72
										Lethrinidae	106.3	3.94
										Serranidae	12.7	2.54
										White tip shark	11.2	3.73
14.5	0445	40	LL	65	65	06°14'	81°39.5'	27		Lutjanidae	16.6	5.53
										Lethrinidae	9.9	3.30
14.5	1225	41	BTR	20	20	06°32'	81°45'	230	461	Leiognathidae(pony-fish)	71.6	
										Sardines	68.9	
										Rastrelliger kanagurta	36.0	0.23
										Sphyraenidae	9.9	0.07
										Gerridae(silver biddies)	10.8	0.12
										Scombroidea	14.9	0.13
										Catfish	18.0	1.00
14.5	2050	42	PTR	27	?	06°39'	81°48'	1		0-groups of various sp.		
15.5	0055	43	BTR	25	25	06°42'	81°50'	100	201	Leiognathus	52.5	0.07
										Rastrelliger kanagurta	9.0	0.14
										Sciaenidae	4.0	0.04
										Sardines (mixed)	5.5	0.02
15.5	0640	44	LL	65-71		06°45'	82°00'	37		Lutjanus sanguineus	14.6	4.87
										Caranx sp.	10.2	5.10
										Shark (scoliodon)	3.9	1.95
15.5	2247	45	BTR	21-24	21-24	07°06'	81°55'	200	800	Lutjanidae	61.7	3.25
										Plectorhynchus pictus	19.4	243
										Epinephelus undulosus	12.0	3.00
										Lethrinidae	48.7	1.19
										Surgeon fish (Acanthuridae)	50.9	1.30
16.5	0505	46	LL	68-75		07°00'	82°00'	34		Lutjanidae	14.9	3.73
										Lethrinidae	9.3	3.10
										Caranx sp.	5.8	5.80
16.5	1035	47	BTR	21	21	07°20'	81°53'	198	394	Large cat shark	90.0	90.00
										Lutjanus rivulatus	24.1	6.03
										Plectorhynchidae	23.4	3.34
										Epinephelus sp.	13.7	6.85
										Drepane punctata	36.5	1.52
17.5	0455	48	BTR	31	31	07°25'	81°55'	7	14	Sardinella sirm	1.0	0.14
										Balistes sp.	6.0	2.00
										Squid	0.25	0.01
17.5	0945	49	LL	49	49	07°35'	81°54'	14		Lethrinidae	4.6	1.53
										Elagatis bipinnulatus (Carangidae)	1.9	1.90
										Lutjanus sanguineus	4.9	4.90

(Table I. contd.)

Date	Time Start	St. no.	Gear type	Bottom depth (m)	Gear depth (m)	Position Lat. N	Position Long. E	Total catch (kg)	Catch per hour (kg)	Dominant species (or group) Total catch (kg)		Mean weight (kg)
18.5	1040	50	BTR	23	23	07°35'	81°48'	3	12	Plectorhynchus pictus	2.8	2.80
18.5	1510	51	BTR	23	23	07°00'	81°55'	5	15	Epinephelus tauvina	3.0	3.00
18.5	1820	52	BTR	43	43	07°13'	81°58'	40	160	Scomberomorus commerson	2.0	2.00
										Lethrinus nebulosus	7.3	3.65
										Plectorhynchus pictus	6.0	3.00
										Epinephelus undulosus	5.3	5.30
										Lutjanidae	13.0	4.33
18.5	2005	53	PTR	>300	60-75	07°17'	81°59'	0.5	1	Squid - lobster prawn	0.5	
20.5	0900	54	PTR	58	?	07°54'	81°45'	0	-			
20.5	1100	55	BTR	44	44	07°57'	81°36'	80	160	Lethrinus nebulosus	10.0	1.67
										Epinephelus sp.	11.4	5.70
										Div. small fish		
20.5	1317	56	BTR	34	34	08°03'	81°34'	32	69	Scomberomorus commerson	2.0	2.00
										Scomberoides sp. (caran.)	3.3	3.30
										Rastrelliger sp. (small)	19.6	
21.5	0040	57	BTR	41	41	08°05'	81°35'	20	40	Thenus orientalis	0.75	0.15
										Shrimp	0.10	
										Sphyraena	2.0	2.00
										Lutjanus argentimaculatus	3.7	3.70
										Saurida	3.8	0.17
										Caranx sp.	1.1	0.18
21.5	0345	58	BTR	51	51	08°06'	81°37'	78	158	Plectorhynchus pictus	15.3	2.55
										Acanthuridae	11.9	1.70
										Caranx sp.	3.3	3.30
										Lethrinidae	32.4	1.30
										Lutjanidae	7.0	3.50
21.5	0705	59	BTR	23	23	08°08'	81°32'	117	467	Carangidae (large)	60.6	5.05
										- " - (small)	13.6	0.33
										Sphyraena sp.	6.8	0.68
										Otholites sp.	3.6	0.36
										Psettodes erumei	4.0	1.00
										Gerres filamentosus (Silver biddies)	8.0	0.17
21.5	0850	60	BTR	14	14	08°08'	81°32'	60	240	Holothurians	60.0	
21.5	1040	61	BTR	30-36	30-36	08°11'	81°37'	73	145	Lethrinidae	14.0	2.00
										Epinephelus sp.	4.3	4.30
										Lutjanidae	15.7	3.14
										Plectorhynchus pictus	11.5	1.92
										Carangidae	26.1	0.47
21.5	1310	62	LL	37	37	08°10'	81°33'	4	-	Caranx sp.	3.9	3.90
21.5	0730	63	LL	47	47	08°19'	81°32'	34		Lethrinus miniatus	19.6	2.80
										Lutjanus bohar	9.6	4.80
21.5	1005	64	BTR	29-37	29-37	08°22'	81°27'	05	1	Small prawns and small black fish		
22.5	1730	65	Gill-nets	67-549	-	08°32'	81°27'	0				
23.5	0600	66	LL	75	75	08°25'	81°30'	35		Lethrinidae	27.5	2.50
										Lutjanidae	5.6	1.87
										Epinephelus megachir	1.9	0.48
23.5	1245	67	BTR	40-52	40-52	08°31'	81°23'	170	340	Skates	100	33.00
										Carangidae	16.4	1.49
										Lutjanidae	15.3	3.83
										Acanthuridae	12.5	1.04
										Lethrinidae	12.4	3.10
										Balistidae	6.5	1.30
23.5	1810	68	BTR	37	37	08°44'	81°13'	181	362	Lutjanidae	19.6	3.27
										Epinephelus tauvina	31.1	10.37
										Lethrinus nebulosus	7.0	3.50
										Plectorhynchus pictus	40.0	1.90
										Carangidae	24.0	0.89
24.5	0723	69	BTR	36-41	36-41	08°55'	81°06'	86	172	Lutjanus rivulatus	10.0	5.00
										Epinephelus sp.	4.2	2.10
										Lethrinus nebulosus	6.6	2.20
										Acanthuridae	6.0	1.25
										Caranx sp.	9.3	3.10
										Carangoides sp.	5.0	0.17
										Plectorhynchus pictus	28.4	2.58
24.5	1255	70	BTR	21	21	09°03'	80°59'	2	4	Scomberomorus commerson	2.0	2.00
24.5	1430	71	BTR	13	13	09°07'	80°58'	133	266	Scomberomorus commerson	14.1	2.82
										Epinephelus species	64.1	8.01
										Pectorhynchus pictus	22.4	2.80
										Selaroides leptolepis	21.2	0.02
25.5	0740	72	LL	72	72	09°20'	80°59'	17		Lethrinus nebulosus	16.2	2.70
25.5	1030	73	PTR	75	55	09°20'	81°00'	0.1		Small red prawns		
25.5	1240	74	BTR	15	15	09°17'	80°53'	28	238	Carangidae	109	0.85
										Otholitus sp.	[illegible]5.4	0.60
										Arius thalassinus	5.6	1.40
										Leiognathus sp.	3.1	0.12
										Chirocentrus dorab (Wolf herring)	1.2	0.40
25.5	1955	75	BTR	29-36	29-36	09°37'	80°44'					

(Table I. contd.)

Date	Time Start	St. no.	Gear type	Bottom depth (m)	Gear depth (m)	Position Lat. N	Position Long. E	Total catch (kg)	Catch per hour (kg)	Dominant species (or group) Total catch (kg)		Mean weight (kg)
25.5	2340	76	BTR	20	20	09°40'	80°40'	136	273	Lutjanidae	57.0	0.86
										Plectorhynchus pictus	22.5	2.50
										Epinephelus species	20.4	4.08
										Caranx sp.	17.8	0.71
										Thenus orientalis	3.0	0.25
										Squid	1.4	0.35
26.5	0305	77	BTR	43-48	43-48	09°43'	80°46'	12	36	Lutjanus sanguineus	3.5	3.50
										Naso tuberosus	4.0	1.33
										Scoliodon	1.9	1.90
26.5	0850	78	BTR	11-13	11-13	09°44'	80°31'	14	28	Carangidae	8.3	0.92
										Priacanthus sp.	3.6	0.33
26.5	1315	79	BTR	30	30	09°42'	80°42'	7	28	Lethrinus nebulosus	4.5	1.50
										Plectorhynchus pictus	2.6	2.60
26.5	1525	80	BTR	16	16	09°49'	80°30'	976	1953	Lutjanidae	129.5	2.87
										Lethrinus nebulosus	121.6	2.03
										Epinephelus species	245.9	4.73
										Pomadasyidae	149.6	2.20
										Carangidae	22.8	1.43
										Sphyraena sp.	21.5	1.02
										Acanthurus sp.	104.0	2.17
										Drepane punctata	61.5	1.10
27.5	0720	81	BTR	84-94	84-94	10°03'	80°32'	5	10	Small skates, Sphyreana	5.	
27.5	1220	82	?LL	24	?	10°06'	80°21'	0				
27.5	2130	83	BTR	212-289	212-289	10°20'	80°40'	150	150	Deep water fish	150.	
										12 deep sea lobster		
28.5	0520	84	BTR	340/365		10°11'	80°43'	28	56	Deep water fish	20.0	
										Shrimps	6.0	
										Crabs	1.5	
28.5	0845	85	BTR	239/269		09°59'	80°47'	4	8	Small prawns	0.5	0.01
										Octopus	0.5	0.13
										Deep water fish	2.5	0.06
28.5	1130	86	BTR	63-79	63-79	10°07'	80°27'	70	140	Carangidae	1.3	0.26
										Lutjanidae	26.5	3.31
										Epinephelus species	17.6	2.93
										Lethrinus nebulosus	10.4	2.08
										Argyrops spinifer (Silver breams)	3.1	0.52
										Balistes sp.	5.9	0.84
										Small squids	1.2	
28.5	1510	87	BTR	32-40	32-40	10°05'	80°27'	270	540	Lutjanidae	49.6	1.71
										Lethrinidae	75.6	1.76
										Epinephelus sp.	32.2	4.03
										Plectorhynchus pictus	21.9	3.65
										Acanthuridae	47.5	1.76
										Carangidae	28.3	1.35
28.5	1707	88	BTR	27-39	27-39	09°57'	80°28'	147	294	Acanthuridae	35.2	1.17
										Lethrinidae	25.9	2.88
										Lutjanidae		
										Epinephelus sp.	22.0	2.44
										Plectorhynchus pictus	13.3	2.22
										Argyrops spinifer	5.5	0.55
										Carangidae	8.9	0.26
										Sphyraene jello	5.6	0.16
28.5	2145	89	BTR	60-72	60-72	09°43'	80°48'	0				
29.5	0700	90	LL	48-52	48-52	08°35'	81°18'	0		70 hooks of 100 lost		
30.5	0652	91	LL	45	45	06°57'	82°01'	20		Aprion virescens (snapper)	6.8	6.80
										Shark	13.3	1.90
30.5	1545	92	LL	65		06°17'	81°42'	10	5	Shark	10.2	1.7
31.5	0930	93	HL	52-60	52-60	06°05'	79°58'	-				
4.6	1615	94	BTR	25		06°50'	79°49'	0.6	1.2	Scomberomorus sp.	0.6	0.6
5.6	0525	95	LL	65		05°56'	80°54'	0	0	Soft bottom		
5.6	0850	96	BTR	67	66	05°54'	80°56'	21	42	Sparidae	3.8	3.80
										Lutjanidae	14.8	2.96
										Small squid	2.0	
5.6	1200	97	BTR	51	51	06°03'	81°08'	16	199	Sharks	8.0	2.67
										Plectorhynchus pictus	7.9	2.63
5.6	1320	98	BTR	52	52	06°02'	81°09'	52	(104)	Lutjanidae	38.8	4.31
										Serranidae	9.3	3.10
										Lethrinidae	3.2	1.07
										Carangidae	0.5	1.25
5.6	1600	99	LL	37	37	06°03'	81°07'	8	(4)	Lutjanidae	6.3	6.30
5.6	2100	100	PTR		40	05°57'	81°01'	21	31	Small squid	18.0	
										Red bait	2.0	0.0056
5.6	2235	101	PTR		40	05°59'	81°06'	13	13	Small squid	5.0	
										Red bait	1.5	0.0056

(Table I. contd.)

Date	Time Start	St. no.	Gear type	Bottom depth (m)	Gear depth (m)	Position Lat. N	Position Long. E	Total catch (kg)	Catch per hour(kg)	Dominant species (or group)	Total catch(kg)	Mean weight (kg)
6.6	0705	102	LL	59-57		05°54'	81°05'	13		Serranidae	11.4	3.80
										Gymnocranius griseus (Large-eye bream)	1.1	1.10
6.6	1100	103	LL	19		06°04'	80°59'	29		Carangidae	11.7	11.70
										Lethrinidae	5.3	1.77
										Serranidae	2.0	0.67
										Skate	10.0	10.00
6.6	1715	104	LL	75		05°58'	81°19'	1		Lutjanidae	1.1	1.10
7.6	1350	105	BTR	35-42	35-42	08°53'	81°08'	96	143	Lutjanidae	22.1	3.69
										Lethrinus nebulosus	5.4	0.9
										Pomadasyidae	40.8	2.26
										Serranidae	12.9	2.15
										Carangidae	7.5	2.50
7.6	1655	106	BTR	21	21	09°06'	80°59'	107	256	Scomberomorus commerson	4.3	2.15
										Plectorhynchus pictus	19.0	3.17
										Lutjanidae	30.6	3.83
										Gnathanodon speciosus	11.4	3.80
										Lethrinus nebulosus	10.2	3.40
										Epinephelus sp.	27.5	9.17
7.6	1838	107	BTR	20	20	09°16'	80°54'	60	120	Wolf herring	1.0	1.00
										Scomberomorus sp.	0.9	0.90
										Leiognathus sp.	58	0.01
7.6	2020	108	Dredge	130	130					Some benthos		
8.6	0640	109	BTR	14		09°25'	80°50.5'	17	34	Ribbon fish (Trichiurus)	1.2	0.60
										Wolf herring (Chirocentrus dorab)	1.8	0.36
										Otholites sp.	7.6	0.63
8.6	0826	110	BTR	15		09°32'	80°46'	87	174	Lethrinus sp.	10.1	2.53
										Epinephelus sp.	21.0	5.25
										Lutianidae	11.5	2.88
										Carangidae	8.4	0.47
										Gerres filementosus (Silver biddy)	2.6	0.26
										Leiognathus (Ponyfish)	5.1	0.02
										Ray	15.0	3.00
										Rachycentron canadus	3.6	3.60
8.6	1020	111	BTR	20		09°43'	80°40'	97	194	Lethrinus nebulosus	61.2	1.36
										Lutjanus sanguineus	8.8	2.93
										Epinephelus sp.	10.5	10.50
										Plectorhynchus pictus	6.6	3.3
										Scomberomorus commerson	5.1	2.55
										Sphyraena	0.9	0.45
										Thenus orientalis (Lobster)	3.8	0.27
8.6	1227	112	BTR	27	22	09°51'	80°34'	276	424	Acanthuridae	97.6	1.37
										Carangidae	34.0	0.76
										Serranidae	26.5	3.31
										Lethrinidae	17.7	1.97
										Plectorhynchus pictus	23.4	2.60
										Siganus sp. (Rabbitfish)	40.6	1.85
										Blue parrot fish	15.4	2.57
8.6	1500	113	BTR	18 z	-	09°54'	80°28'	23	45	Sphyraena sp.	6.1	0.67
										Shark	3.2	1.07
										Carangidae	7.6	0.84
										Stromateus niger	5.1	0.64
8.6	1700	114	BTR	15	15	10°01'	80°21'	47	94	Serranidae	12.3	3.08
										Plectorhynchus pictus	19.7	3.28
										Carangidae	8.2	1.64
										Lethrinus nebulosus	4.2	2.1
										Chirocentrus dorab	0.7	0.70
8.6	1915	115	BTR	17		10°07'	80°15'	155	310	Plectorhynchus pictus	44.1	2.76
										Serranidae	44.8	1.95
										Lethrinus nebuloses	14.1	2.35
										Lutjanidae	34.3	2.29
										Carangidae	14.7	0.82
										Chirocentrus dorab	0.9	0.90
8.6	2035	116	LL	37	37	10°08'	80°21'	24	-	Serranidae	9.6	1.92
										Lethrinus nebuloses	9.9	1.98
										Lutjanus sanguineus	2.8	2.80
										Shark	1.8	1.80
9.6	0745	117	PTR	38	20	10°05'	80°23'	5 l.		Fish larvae + Salps	5 l.	
9.6	0855	118	BTR	46	46	10°10'	80°20'	105	210	Serranidae	19.2	1.75
										Lethrinidae	8.3	1.66
										Lutjanidae	21.7	3.61
										Argyrops spinifer	10.7	0.51
										Plectorhynchus pictus	8.7	4.10
										Skates	25.0	4.17
9.6	1300	120	BTR	14	14	09°49'	80°31'	822	1644	Acanthurus strigosus	188.7	2.52
										Lethrinus nebulosus	147.0	1.88
										Lutjanidae	70.3	2.34
										Serranidae	48.0	4.80
										Pomadasyidae (sweetlips)	25.8	2.87
										Parrotfish	28.2	4.70

(Table I. contd.)

Date	Time Start	St. no.	Gear type	Bottom depth (m)	Gear depth (m)	Position Lat. N	Position Long. E	Total catch (kg)	Catch per hour(kg)	Dominant species (or group)	Total catch(kg)	Mean weight (kg)
9.6	1615	121	BTR	15	15	09°04'	80°39'	26	52	Carangidae	23.0	1.64
9.6	1820	122	BTR	32-36	32-36	09°32'	80°49'	112	224	Scomberomorus commerson	10.8	2.70
										Carangidae	10.6	0.46
										Gerres sp. (Silver-biddies)	3.0	-
										Skates	40.0	20.-
										Sharks	34.5	1.44
9.6	2015	123	BTR	58	58	09°49'	80°45'	10	20	Small bottom fish		
9.6	2125	124	LL	63	63	09°50'	80°44'	4	-	Sharks	2.7	1.35
										Epinephelus sp.	0.6	0.6
10.6	0710	125	BTR	80	80	09°55'	80°40'	13	27	Squid	4.3	
										Swimming crabs	5.0	
										Decapterus russelli (Carang.)	2.1	0.03
10.6	0953	126	BTR	101	101	10°07'	80°32'	12	15	Nemipterus sp. (Thread fin bream)	10.1	0.016
										Squid	0.5	0.05
10.6	1215	127	BTR	253	253	10°12'	80°42'	15	29	Acetes sp. (Shrimp)	10.0	
10.6	1450	128	BTR	160	160	10°06'	80°41'	1	2	Nemipterus sp.	1.0	0.035
10.6	1916	129	BTR	14	14	09°47'	80°30'	324	512	Skates	150.0	18.75
										Plectorhynchus pictus	27.3	2.28
										Lethrinus nebulosus	18.0	2.00
										Serranidae	20.7	2.59
										Lutjanus argentimaculatus	9.0	1.80
										Sphyraena sp.	7.0	0.78
										Caranx sp. (big)	21.6	1.27
										Carangoides sp. (small)	22.6	0.35
10.6	2100	130	LL	16	16	09°48'	80°31'	24	-	Epinephelus sp.	12.2	4.07
										Lethrinus rivulates	10.9	1.82
										Plectorhynchus pictus	1.9	1.90
11.6	0930	131	BTR	14	14	09°40'	80°35'	10		Drepane punctata	5.3	2.65
										Oteolithes argentus	1.5	1.50
11.6	1040	132	BTR	20	20	09°47'	80°34'	343	686	Lethrinidae	60.6	1.95
										Plectorhynchus pictus	41.5	2.77
										Lutjanidae	30.4	3.38
										Epinephelus undulosus	15.2	3.04
										Scomberomorus commerson	4.6	4.60
11.6	1255	133	BTR	14	14	09°55'	80°24'	129	258	Skates	25	1.67
										Lethrinus nebulosus	28.6	2.38
										Plectorhynchus pictus	16.0	4.00
										Epinephelus sp.	14.2	2.37
										Carangidae	34.1	2.13
11.6	1440	134	BTR	37	37	09°53'	80°33'	130	260	Carangidae	94.0	0.20
										Rastrelliger kanagurta	8.2	0.16
										Lutjanus sanguineus	14.7	2.45
11.6	1645	135	BTR	38	38	09°48'	80°39'	74	148	Carangidae	11.7	0.32
										Lethrinus nebulosus	9.1	0.83
										Epinephelus undulosus	9.6	3.20
										Lutjanidae	22.3	3.71
										Acanthuridae	6.3	0.90
15.6	0430	136	LL	43		08°46'	79°33'	63	-	Lutjanidae	33.9	3.39
										Lethrinus sp.	22.1	2.01

(Table I. contd.)

Date	Time Start	St. no.	Gear type	Bottom depth (m)	Gear depth (m)	Position Lat. N	Position Long. E	Total catch (kg)	Catch per hour (kg)	Dominant species (or group)	Total catch (kg)	Mean weight (kg)
15.6	0855	137	BTR	272	272	08°45'	79°31'	1500	2250	Deep water fish (mostly Chlorophthalmus bicornis)	1355	-
										Deep sea Lobster	68	0.09
										Shrimp	77	-
15.6	1135	138	BTR	18	18	08°52'	79°32'	82	247	Epinephelus sp.	34.7	6.94
										Lethrinus sp.	8.3	2.08
										Skates	31.8	1.67
15.6	1352	139	BTR	15	15	08°44'	79°41'	87	174	Scomberomorus sp.	22.4	3.20
										Lutjanidae	51.5	5.72
										Skates (ray)	10.0	0.67
15.6	1630	140	BTR	11	11	08°38'	79°41'	1000	2000	Lethrinus nebulosus	520.7	2.28
										Lutjanidae	150.2	3.95
										Plectorhynchus pictus	59.	2.47
										Scomberomorus commerson	15.7	3.30
										Carangidae	50.9	5.35
										Drepane punctata	206.3	1.73
15.6	2025	141	BTR	17	17	08°29'	79°42'	83	496	Lethrinus sp.	44.2	0.98
										Plectorhynchus pictus	7.0	3.50
										Drepane punctata	17.1	1.90
16.6	0510	142	LL	17	17	07°52'	79°39'	1	-	Shark	0.8	0.80
16.6	0810	143	BTR	9	9	07°49'	79°40'	26	104	Ray	20.	20.0
										Pilot fish	6.0	1.20
16.6	0931	144	BTR	11	11	07°43'	79°43'	125	375	Lutjanus argentimaculatus	10.2	1.46
										Lethrinus sp.	22.7	1.34
										Carangoides sp.	12.4	0.59
										Butterfly fish	10.5	1.17
										Skates	25.0	
16.6	1305	145	BTR	14	14	07°28'	79°43'	11	22	Scomberomorus sp.	3.9	1.95
										Carangoides sp.	2.2	2.20
										Wolf herring	1.3	0.43
16.6	1432	146	BTR	19	19	07°21'	79°41'	65	130	Lethrinus sp.	26.5	2.04
										Epinephelus sp.	9.6	3.20
16.6	1640	147	BTR	14	14	07°11'	79°47'	584	1168	Lethrinus sp.	83.0	1.54
										Scomberomorus sp.	7.0	1.17
										Scianidae	62.8	7.85
										Pomadasyidae (sweetlips)	58.4	3.24
										(misc. mostly leiognathus)	360.	

Appendix Table II. Size distribution (%) of selected species by areas, fork length.

		6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0
	n	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5	25.5
Rose-finned pigface bream (<u>Lethrinus rhodopterus</u>)																					
AREA I, NW coast	295					5	7	16	20	12	11	9	11	4	3	2	1				
Yellowstripe trevally (<u>Selaroides leptolepis</u>)																					
AREA IV, East coast	21					5	48	29	14					5							
AREA V, Trincomalee	100	1	6	3	37	33	12	5	2	1											
Indian mackerel (<u>Rastrilliger kanagurta</u>)																					
AREA IV, East coast	35												3	3	57	34			3		
AREA VI, Pedro Bank	52													12	10	6	27	38	8		
Russels scad (<u>Decapterus Russelli</u>)																					
AREA VI, Pedro Bank	75					4	1	21	48	17	7	1									
Squid																					
AREA III, Hambantota Banks	136	1	1	4	11	14	13	14	6	7	10	6	8	3	1	1					
Red bait (Depterygonotus leucogrammicus, Bleeker)																					
AREA III, Hambantota Banks	54	19	54	22	6																
<u>Atule mate</u> (Carangidae)																					
AREA V, Trincomalee	45													2	11	42	36	4		2	2
Silver sillago (<u>Sillago sihama</u>)	108							5	40	46	9										

Appendix table II. Continued.

	N	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	80	90
Starry Pigface Bream (<u>Lethrinus nebulosus</u>)																		
Area I, NW coast	370	13	15	1	4	5	7	8	11	25	10	2						
Area II, SW coast	35							6	14	34	26	20						
Area III, Hambantola Banks	34					3	3	3	9	9	24	32	15	3				
Area IV, East coast	19		5	5		11	5	16	5	5	11	32	5					
Area V, Trincomalee	58	2		2	9	16	12	9		5	28	19						
Area VI, Pedro Bank						5	14	17	22	25	14	2						
Longface emperor (<u>Lethrinus miniatus</u>)																		
Area I, NW coast	56						5	18	9	16	9	9	9	14	11			
Area II, SW coast	12									(8		17	8	8	58)			
Area III, Hambantota Banks	25					4				8	8	4	4	20	48	4	4	
Area IV, East coast	11		(18		9		9			36	18			9)				
Area V, Trincomalee	33					6	3	6	6	27	24	15	6	6				
Area VI, Pedro Bank	19							21		32	37	11						
Sweetlip (<u>Plectorhynchus Pictus</u>)																		
Area I, NW coast	112							3	26	33	19	14	5					
Area II, SW coast	6																	
Area III, Hambantota Banks	9																	
Area IV, East coast	16								19	6	25	38	6	6				
Area V, Trincomalee	72						1	1	11	10	24	35	14	4				
Area VI, Pedro Bank	106						1	2	8	16	18	34	16	5	1			
Grouper (<u>Epinephelus undulosus</u>)																		
Area I, NW coast	36				3		3	3	8	8	22	42	11					
Area II, SW coast	12										17	50	25	8				
Area III, Hambantota Banks	38					5			5		8	32	47	3				
Area IV, East coast	3																	
Area V, Trincomalee	7																	
Area VI, Pedro Bank	70						3		1	3	26	39	29					
Moon fish (<u>Drepane punctata</u>)																		
Area I, NW coast	118					1	29	62	24	2								
Area II, SW coast	0																	
Area III, Hambantota Banks	0																	
Area IV, East coast	25					8	44	44	4									
Area V, Trincomalee	0																	
Area VI, Pedro Bank	23					4	30	43	9									
Surgeon Fish (<u>Acanthurus strigosus</u>)																		
Area I, NW coast	1																	
Area II, SW coast	0																	
Area III, Hambantota Banks	25		4			12	52	28	4									
Area IV, East coast	7																	
Area V, Trincomalee	18		6	22	44	22	6											
Area VI, Pedro Bank	100		1	2	25	32	29	11										

Appendix table II. Continued.

	N	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	80	90
Mangrove Red Snapper (<u>Lutjanus argentimaculatus</u>)																		
Area I, NW coast	14							14	50	21	7			7				
Area II, SW coast	0																	
Area III, Hambantota Banks	2																	
Area IV, East coast	1																	
Area V, Trincomalee	10								10	30	20		40					
Area VI, Pedro Bank	57							4	25	51	12		4	2				
Snapper (<u>Lutjanus rivulatus</u>)																		
Area I, NW coast	17									12	29	41	18					
Area II, SW coast	1																	
Area III, Hambantota Banks	39									5	21	31	26	15	3			
Area IV, East coast	9																	
Area V, Trincomalee	29								10	7	24	21	17					
Area VI, Pedro Bank	33									18	30	15	21	15				
Snapper (<u>Lutjanus sangvineus</u>)																		
Area I, NW coast	24						8	25	17	13		21	13	4				
Area II, SW coast	3																	
Area III, Hambantota Banks	7																	
Area IV, East coast	3																	
Area V, Trincomalee	7																	
Area VI, Pedro Bank	31						3	6	16	29	16	23	3		3			
(<u>Naso tuberosus</u>)																		
Area I, NW coast	0																	
Area II, SW coast	18								11	61	28							
Area III, Hambantota Banks	0																	
Area IV, East coast	3																	
Area V, Trincomalee	2																	
Area VI, Pedro Bank	23						13	4	17	35	26	4						

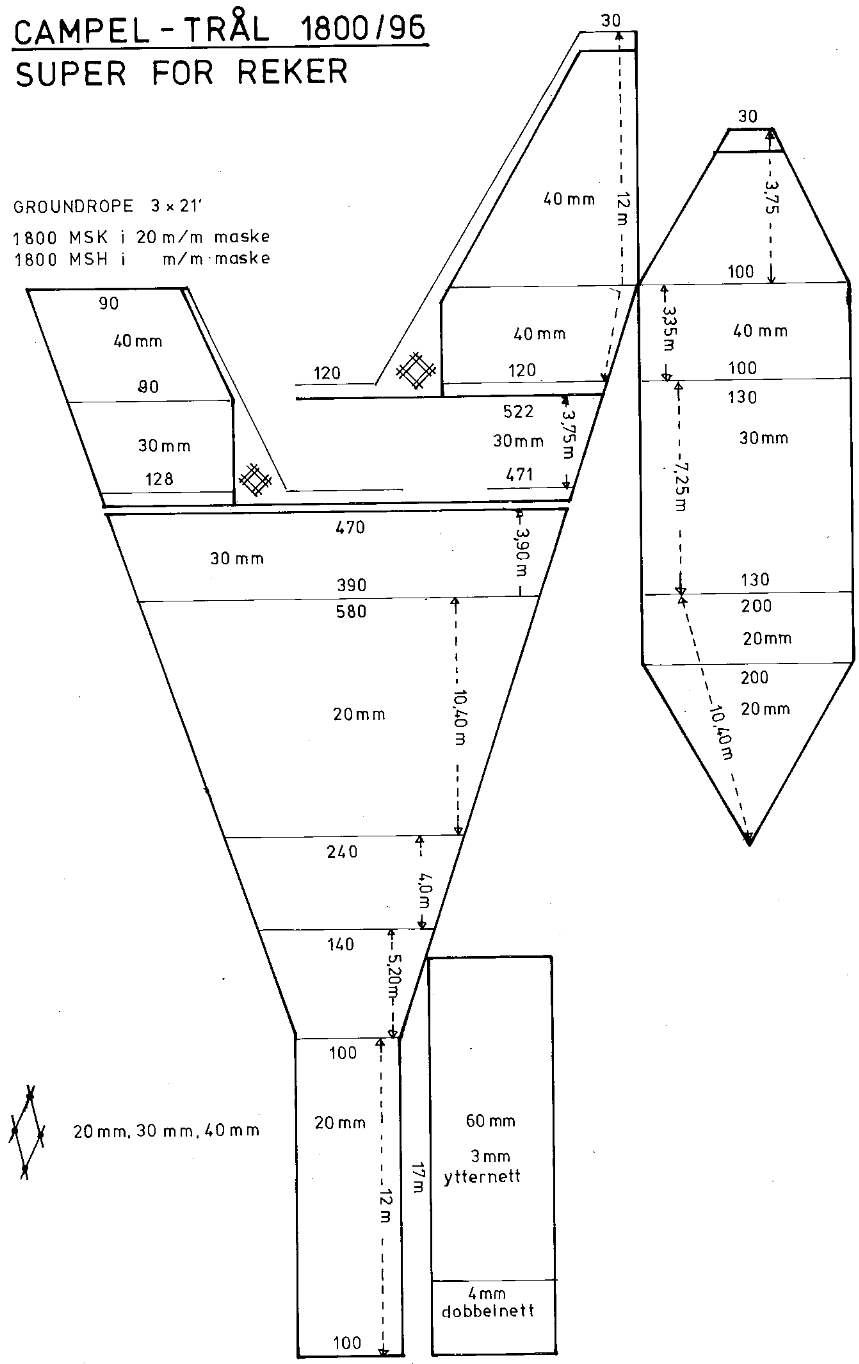
Appendix Table III. Length-weight relationships. *Mean* length (cm) and weight (kg) of samples. Fork-length = FL.

Lethrinus *nebulosus* (Pigface Bream)			Lutjanus rivulatus (Snapper)			Epinephelus undulosus (Grouper)			Plectorhynchus pictus (Sweet lip)			Drepane punctata (Moon fish)			Acanthurus strigosus (Surgeon fish)			Gnathanodon speciosus (Golden toothless trevally)		
N	FL	W	N	FL	W	N	FL	W	N	FL	W	N	FL	W	N	FL	W	N	FL	W
1	50.0	2.4	5	56.0	4.16	6	39.5	1.25	9	48.2	1.60	2	39.0	1.70	18	39.0	1.25	1	69.0	5.9
103	41.59	1.51	2	54.0	5.35	14	54.4	2.68	25	48.8	1.98	76	37.3	1.21	6	44.3	1.87	1	61.0	4.9
9	39.26	1.63	2	57.5	4.6	5	57.6	3.60	28	48.8	1.96	24	35.5	1.52	2	48.5	1.45	1	65.0	5.8
9	44.7	2.03	1	64.0	5.3	2	57.0	4.45	3	54.3	3.43	3	37.3	1.85	25	49.2	2.52	2	61.0	4.5
8	27.9	1.04	1	60.0	5.2	8	57.3	2.75	9	54.8	2.60	2	44.0	2.65	2	48.5	2.35	3	57.7	3.8
6	45.5	1.98	23	57.6	4.22	2	58.0	2.80	3	56.7	2.67	25	38.6	1.73	1	47.0	2.2	2	60.0	3.65
17	51.3	2.68	3	59.3	4.37	10	61.8	4.21	3	67.3	4.20	9	40.0	1.90	4	38.7	1.18			
1	59.0	3.80	1	60.0	4.3	8	60.5	3.05	8	52.7	2.43	1	43.0	2.3	1	38.0	1.2			
4	54.3	2.40	2	65.0	5.8	7	57.0	2.51	6	54.7	3.23	1	39.0	1.6						
2	42.5	1.75	15	54.5	3.74	1	63.0	3.7	1	58.0	2.8									
21	57.7	3.58				4	59.5	3.0												
2	49.5	2.20																		

APPENDIX I.

Design of the net of the bottom trawl.

This was a shrimp trawl type which is adapted also to demersal fish trawling. The ground rope was equipped with 0.5 m rubber bobbins. When operated with 40 m bridles the distance between the wing ends was about 15 m and with a net sonde the vertical opening was measured at about 5 m.



APPENDIX II

Acoustic instruments and conversion factors for fish density.

The vessel was equipped with two echo sounders, one operating at 38 kHz and one at 120 kHz. During the recent refit of the vessel, the 38 kHz echo sounder was refitted with a new ceramic transducer and a transistorized external transmitter.

After the modification the echo sounders were calibrated in Bergen. Source level and voltage response of the 38 kHz echo sounder were measured at 133.4 dB and 12.5 dB respectively. Corresponding values for the 120 kHz echo sounders were 120.1 dB and - 1.4 dB respectively. The echo sounders were again calibrated in Trincomalee harbour on 12 June and no change in performance was observed.

The 38 kHz echo sounder was used for the acoustic assessment and two analog echo integrators were therefore connected to this instrument. During the survey the echo integrators were integrating in the depth slices 5-20, 20-40, 40-60 and 60-100 or 200 m as appropriate according to depth. The gain setting was 30 dB.

Settings of the 38 kHz echo sounder were: Basic range 0-100/100-200 m. Transmitter 10/1, external. Pulse length and band width 0.6 m sec. - 1 kHz. Receiver TVG and gain 20 log R - 20 dB. Recordergain 7. Beam angle $8x8^{o}$.

The 120 kHz echo sounder was operated with the following settings: Basic range 0-100 m. Pulse length and band width 0.6 m. sec. - 3 kHz. TVG and gain 20 log R 0 dB. Recorder gain 6. Beam angle $8x8^{o}$.

Before the vessel left Bergen it was also intercalibrated with the R/V "Johan Hjort". The relation between the integrator outputs (M) of the two vessels was found to be

$$M_{\text{Dr. Fr. Nansen}} = 1.1\ M_{\text{Johan Hjort}}$$

Both vessels used 38 kHz echo sounders with ceramic transducers.

The modification of the 38 kHz echo sounder resulted in an alteration of its performance. Because of this the density coefficient which is applied for the conversion of relative echo integrator values (mm/nautical mile) to fish biomass has changed in value since Survey I. A density coefficient for the present survey therefore had to be established. Besides its dependence on the performance of the echo sounder, this coefficient also depends on the sound back scattering properties of the fish species being surveyed. Empirical experiments have shown that the back scattering properties may be different for different species (Nakken and Olsen 1977), presumably depending on the shape and anatomy of the fish. Dealing with only one species, it has been established that the density coefficient, C, is a function of fish length (Nakken and Dommasnes, 1975).

$$C = C_I \ C_S \ L^{-m}$$

Here L represents the body length of the fish while C_S and m are species dependent factors. C_I depends on the performance of the echo sounder. Further studies suggest that m takes values close to 2, varying somewhat with species (Foote 1979).

As illustrated in Fig. 19 the dorsal aspect of fishes with deep and compressed bodies, as for example many species of caranx and breams, is considerably smaller in relation to body weight than the dorsal aspect of more heavy-bodied species like groupers. Species with deep compressed bodies are therefore likely to give weaker echoes than heavy-bodied fish with equal body weight.

In order to arrive at an overall density coefficient, mean values for length and weight of fish have to be applied together with the data from the intercalibration with the R/V "Johan Hjort". The general density coefficient for "Johan Hjort" can be written.

$$C = 8.4 \ 10^6 \ L^{-m}$$

Based on the intercalibration a basic density coefficient for the 38 kHz echo sounder is then (number of individuals).

$$C = 9.3 \ 10^6 \ L^{-m}$$

In Report I a mean length of 45 cm was used for demersal and semi-demersal fish (Type A). The composition of catches as given in Table 1 indicates that this mean length is valid in sub-areas II - VI also for the present cruise. In Area I there was a greater part of young fish and smaller species, particularly breams, and the mean length was about 35 cm. To give some allowance for the high percentage of species with compressed bodies and assumably weak echoes, the factor m is given a relatively low value of 1.9. The density coefficient for Type A then becomes

$$C = 9.3 \quad 10^{6} \quad 45^{-1.9}$$

With a mean weight of Type A species of 2.1 kg this will give a factor of 14 tonnes/mm nm^2. For Area I the factor will be 11 tonnes/mm nm^2.

Combined for Type B and C means of length and weight of 40 cm and 1.0 kg lead to a density coefficient of 8 tonnes/mm nm^2.

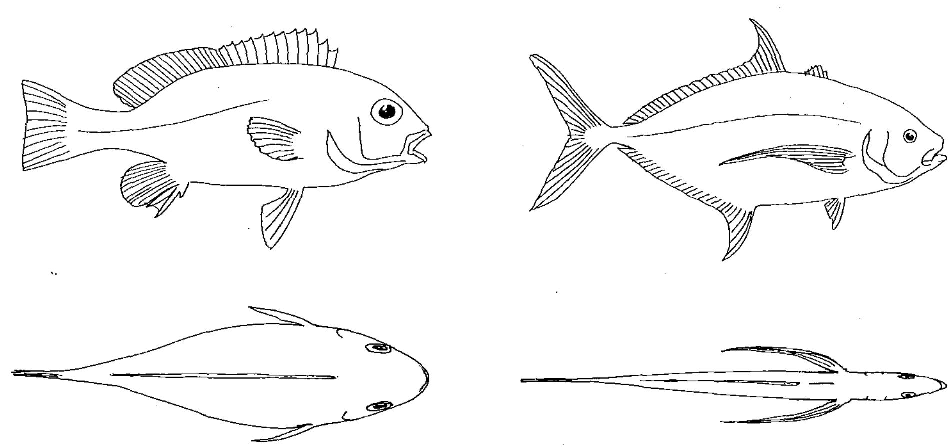
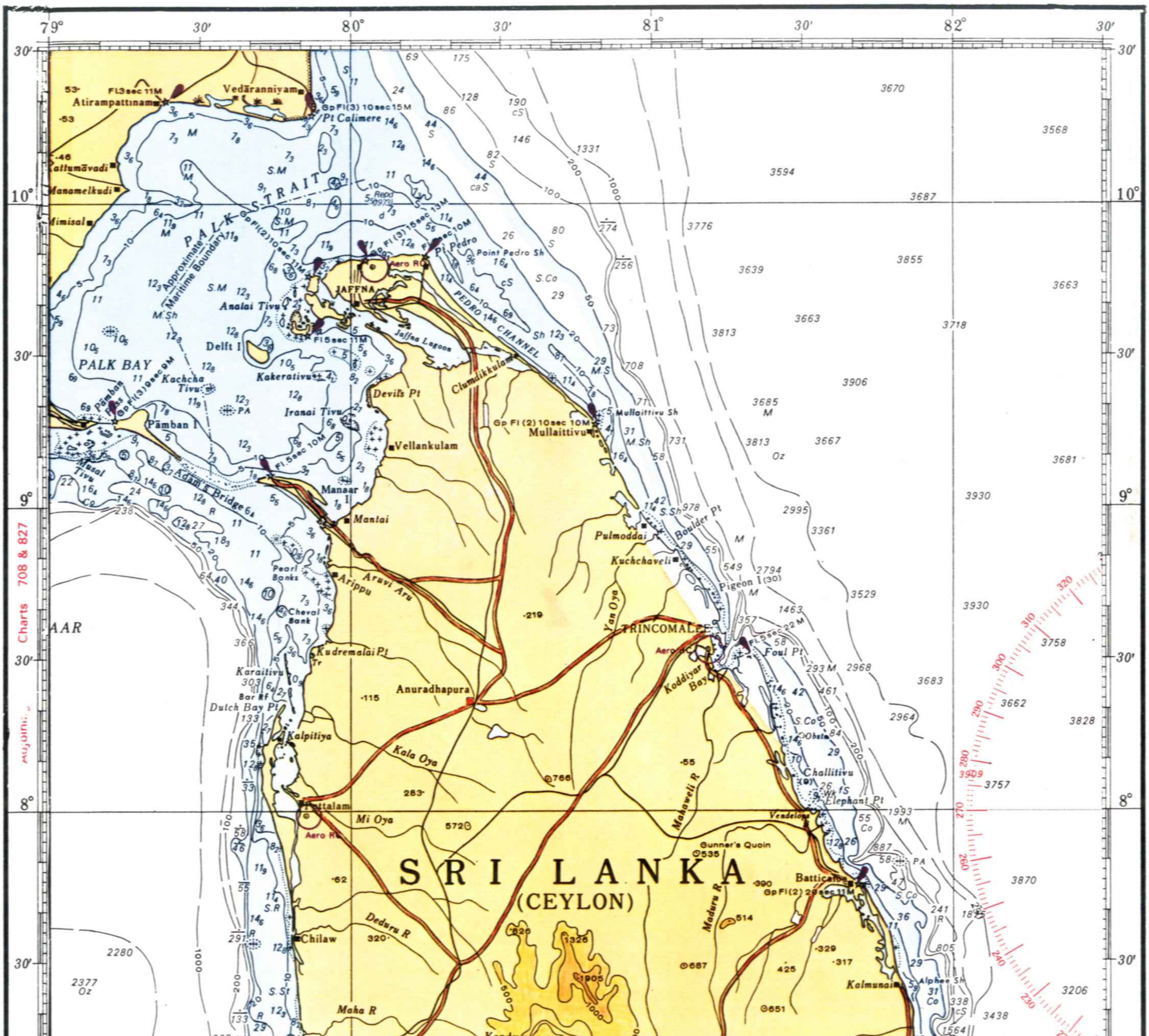


Fig. 19. Dorsal aspect of a heavy-bodied fish (grouper) in relation to the dorsal aspect of a fish with deep and compressed body (caranx).



Published at Taunton 3rd June 1977 under the Superintendence of Rear-Admiral D. W. Haslam, O.B.E., Hydrographer of the Navy.

A.S JOHN GRIEG