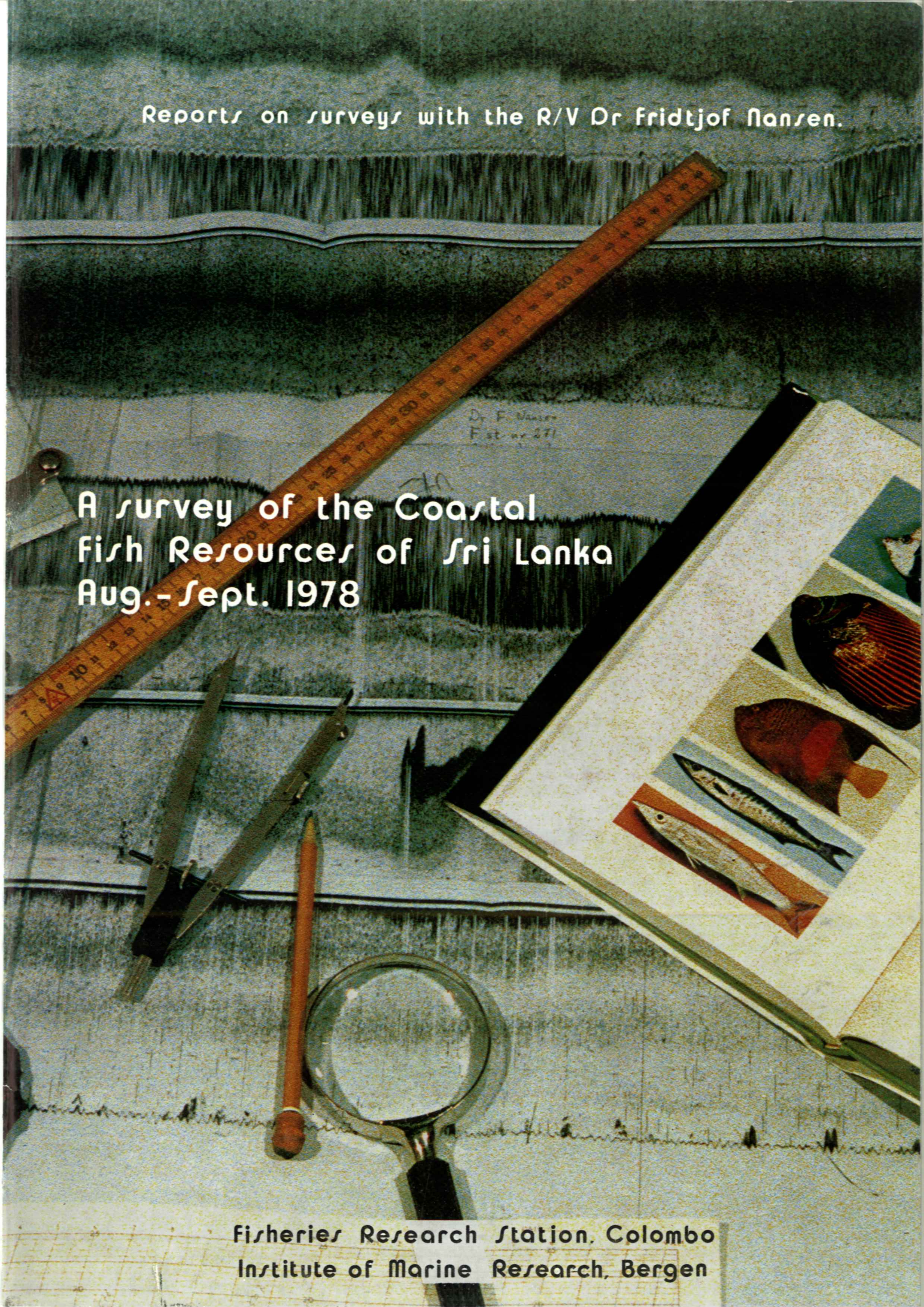
Reports on surveys with the R/V Dr Fridtjof Nansen.

A survey of the Coastal Fish Resources of Sri Lanka Aug.-Sept. 1978



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 the survey described in this report. 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

Report on a Survey of the Coastal Fish Resources of Sri Lanka August-September 1978.

Edited by

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A.S JOHN GRIEG

CONTENTS

1. INTRODUCTION

In an agreement under the general program for development cooperation between the governments of Norway and Sri Lanka, the services of the fishery research vessel "Dr. Fridtjof Nansen" were made available to Sri Lanka for a period of about 1½ months during August - September 1978. The vessel arrived in Colombo on August 12. A scheduled docking to replace a damaged sonar transducer had to be postponed. Although with this damage the vessel was not fully equipped for survey work, it was decided to make use of the spare time until docking by undertaking a survey of the NW coast of Sri Lanka. The particular task in this area was to map and study more closely the deep water trawling grounds for lobster and shrimp located in 1972 in the Gulf of Mannar. The period 16 - 22 August was used for this program.

During the subsequent part of the survey from 3 to 20 September the coastal shelf from Colombo southwards and around the island up to and including the Pedro Bank was covered. This part ended with a call on Trincomalee. During the final part of the survey, from Trincomalee 22 September with arrival in Colombo 27 September, certain parts of the shelf area on the SW and W coast were covered in more detail than had been possible previously.

The following scientific staff participated during all or part of the cruises:

Institute of Marine Research, Bergen	Fisheries Research Station, Colombo
G. Sætersdal	G.H.P de Bruin
G. Vestnes	M. Siddeek
Ø. Skåtun	K.P. Jinasena
S. Brattås	J.R. Samarasinghe
J.P. Maude	

The analysis and processing of the observations and data took place partly on board the vessel during the cruise and involved all the above staff. The final evaluations and the preparation of the report took place at the Institute of Marine Research, Bergen during November 1978 - February 1979. Dr. G.H.P. Bruin participated in this work during a visit to Bergen in December 1978. He also prepared a special review of previous survey activities which is appended to this report as Annex I. Mr J. Blindheim kindly analysed and reported on the oceanographical observations. Mr. Kariyawasam of the Fisheries Research Station prepared the drawings of the fish common in Sri Lankan waters, shown in Annex II.

2. VESSEL, EQUIPMENT, AND WORK SYSTEMS

2.1 Vessel and equipment

The R/V "Dr. Fridtjof Nansen" is a 150-foot combined stern trawler/purse seiner. A main engine of 1500 horsepower gives a maximum speed of 13 knots.

The bottom trawl was a 96-foot headline high opening shrimp-type which is adapted also to ordinary demersal fish trawling. The pelagic trawl was a 16 by 16 fathoms 1600 mesh square opening fine meshed mid-water gear. In addition bottom longlines and traps were used.

Nansen bottles were used for the hydrographic work in which temperature readings and samples for salinity and oxygen determinations were collected at standard depths. Salinity was analysed with an inductive salinometer and oxygen by the Winkler method.

The acoustic equipment consisted of two scientific sounders (120 and 38 kHz), two echo integrators, a searchlight sonar (18 kHz) and a netsonde (50 kHz).

2.2 Scientific work systems

The scientific observations and data are acquired, processed, analysed and interpreted through a set of work systems which may by classified as follows:

System:	Observing:
Acoustic system	Depth, bottom type, biomass (by categories)
Fishing system	Catch, amount and composition, biological data, fishability
Oceanographical observations	Temperature, salinity, oxygen, current
Plankton sampling system	Amount, composition
Surface observations system	Surface fish, whales, birds, fishing boats
Processing, interpretation, reporting system	

The origin and flow of data in these systems is described below:

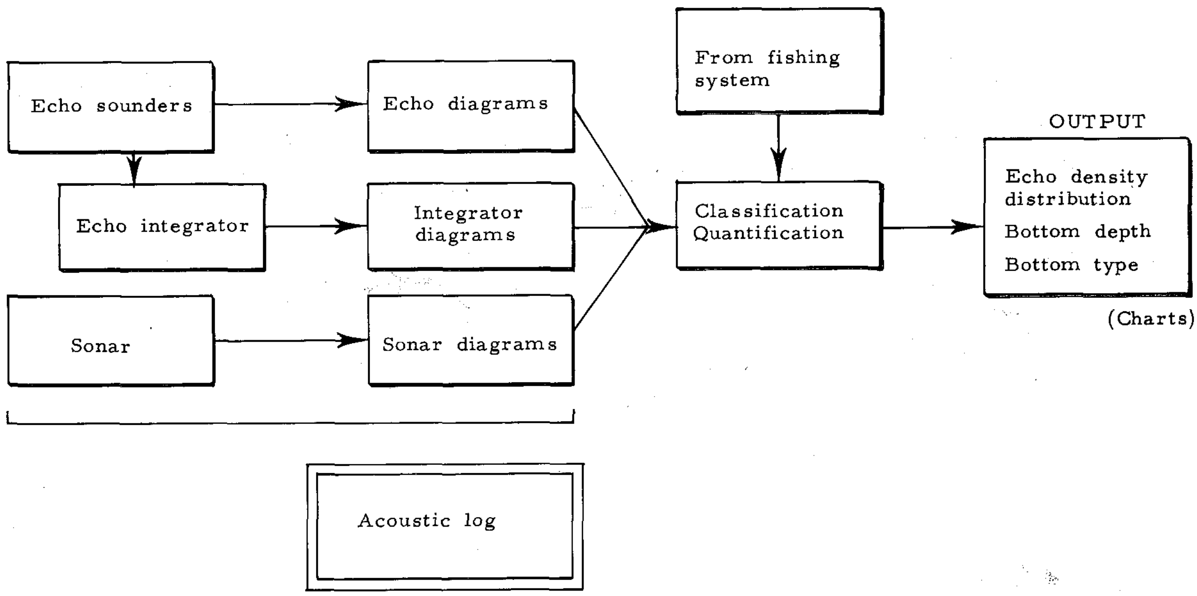


Fig. 1. Acoustic work system.

The acoustic system is of central importance in the combined acoustic/exploratory fishing survey work. All observations from the various sonar instruments are recorded as diagrams, while those parts of the observations which relate to fish or other types of biomass are at the same time quantified by the analog integrators. These processes are monitored through an "Acoustic log". The information then passes through a classification/quantification process. This usually takes the form of daily staff meetings where the sonar diagrams are studied and the biomass targets classified on the basis of their character and information provided from the "Fishing System". The output is usually presented in the form of "fish abundance charts" by species, groups of species or type of biomass, in units of relative or absolute abundance. In addition data on bottom depth and bottom type may be recorded.

The information flow through the "Fishing System" provides data on catches and catch rates by species or groups, which besides being used for identification of sonar targets will also provide some information on the "fishability" and behaviour of the species. Systematic sampling of catches may in addition provide important biological data on key species, and samples for processing tests or quality control may be preserved.

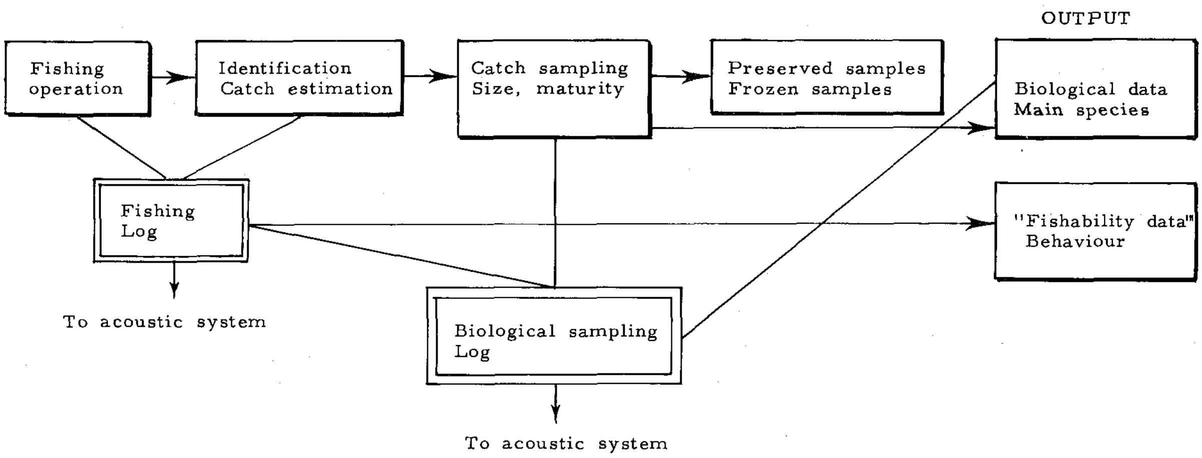


Fig. 2. The Fishing System.

The Oceanographical System provides information on the ocean environment usually presented in the form of section charts. These data may be supplemented by observations of surface currents from navigational logging.

Plankton sampling may provide information on the planktonic part of the biomass which can form important contributions to the total acoustically observed biomass, although being usually non-fishable. Visual surface observations may give indications of the distribution of surface schooling fish, whales, birds and fishing vessels.

The processed outputs from all of these systems are then evaluated and related and form the basis for the conclusions of the work.

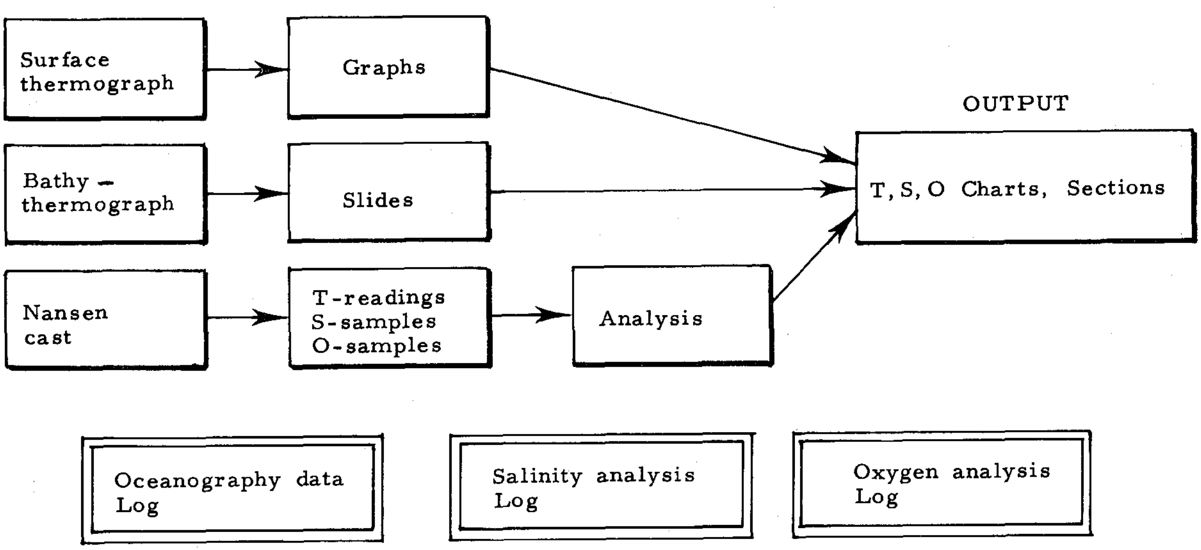


Fig. 3. Oceanographical observations system.

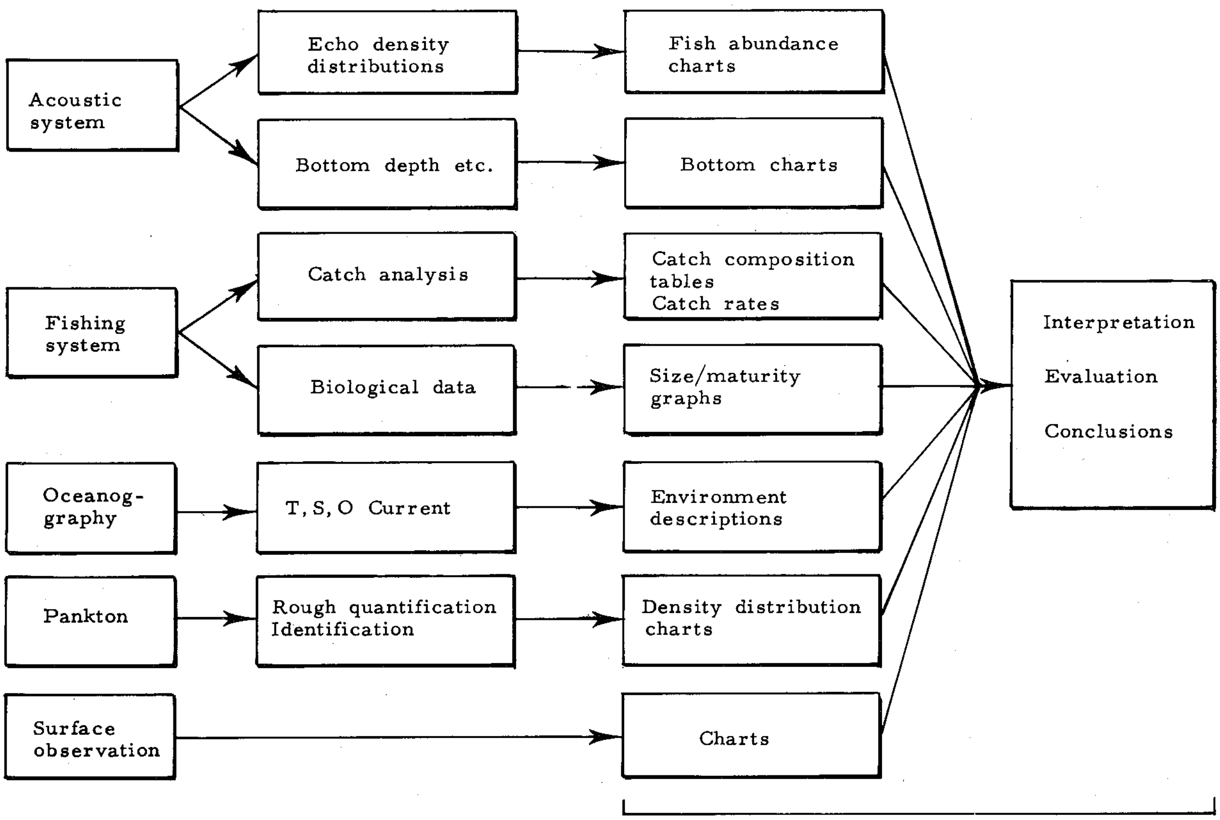


Fig. 4. The processing, interpretation and reporting system.

2.3 The operation of the acoustic instruments.

The transducer of the 38 kHz sounder was damaged when the ship grounded on the previous cruise. During the first part of the survey from 16 August to 7 September the two echo integrators were therefore used with the 120 kHz scientific sounder, integrating the depth slices 3-50, 50-100 m. The gain setting was 20 dB. The settings of the sounder were: Basic range 0-250, Transmitter 1/1 pulse length and band width 0.6 m.sec, 3 kHz - Reciever TVG and gain 20 log R, 0 dB. Recorder gain 6 or 7.

A new 38 kHz transducer was installed while docked in Colombo, and from September 7 the echo integrators were coupled to the 38 kHz scientific sound, integrating the depth slices 3-20, 20-40, 40-60 and 60-259, gain 30 dB. The settings of the sounder were as follows: Basic range 0-100/100-200. Transmitter 10/1 -Pulse length and band width 0.6 m.sec., 1 kHz - Receiver TVG and gain 20 Log R - 20 dB. Recorder gain 7.

Echo integrator values were recorded for each nautical mile sailed and average values for each 5 nautical miles were calculated and logged. A calibration of the integrator output from the 120 kHz and the 38 kHz sounders was made by steaming 90 nautical miles integrating from 50-100 m on the two instruments using the same settings as previously described. The "120 kHz integrator readings" from the first part of the survey were then converted to "38 kHz values".

The integrator readings e.g. in mm per nautical mile sailed relating to fish biomass can be expressed in absolute measures e.g. tonnes/$(nm)^2$ per mm/nm if the corresponding conversion factor is known. Conditions for establishing this factor experimentally by cage calibration or by use of single fish distributions were not available during the survey. The performance of the system was, however, checked repeatedly, and was found to have values according to the set norms. In the estimates of fish densities a basic value of the conversion factor C of 10.5 as used in previous surveys with the "Dr. Fridtjof Nansen" was applied. This value also corresponds reasonably well with calibrations done in other areas. The problems of conversion to absolute measures of fish density are further discussed below.

3. BOTTOM CONDITIONS

The echo diagrams from course tracks within the continental shelf area were analysed with respect to the character of the bottom. The following classification was used: (i) Even flat bottom, (as in Fig. 13, top); (ii) Uneven bottom (as in Fig. 15, bottom); (iii) Very rough bottom (as in Fig. 15, top and middle) and (iv) Steep slope (as in Fig. 19, profile A).

The findings are plotted in Fig. 5. One should note that the symbols indicate observations along a course line and may not represent the true bottom conditions of the wider areas covered by the symbols. Some allowance must also be made for navigational imprecision, although this was kept relatively small thanks to the satelite navigation system of the vessel.

The deep water trawling ground in the Gulf of Mannar is described under 5.3.2 below. Otherwise areas of smooth bottom were found in shallow waters on the north-west coast.

On the south-west coast from Negombo to Galle even flat bottom was rarely found outside the ten fathom line. Uneven and very rough bottom predominated, especially in a zone just inside the shelf edge.

The shelf off Hambantota was characterized by an intermediate zone of smooth bottom, with uneven or rough bottom both inshore and along the outer shelf edge.

Strips of even flat bottom are also found inshore along the more narrow shelf up to Batticaloa. Intermittent areas of smooth bottom can then be found up to Trincomalee, but the larger part of the shelf bottom off this coastline is uneven or rough.

North of Trincomalee there are rather wide parts of the shelf outside the ten fathom line with even flat bottom, particularly off the coastline between Boulder Point and Mullaittivu. The Pedro Bank itself offers a rather non-systematic variety of bottom conditions with a tendency for smoother bottom in the shallower parts.

In general only bottom classified as "even flat" was considered workable for bottom trawling. This type of echo recording is still no guarantee for the successful use of this gear, since smaller corals and rocks may still escape recordings, but most of the hauls made under these conditions were successfully completed. It is of course possible that parts of grounds classified as "uneven" may be suited for trawling, but to which extent this would be practicable can only be explored through a lengthy exploratory programme by which detailed local knowledge of the bottom type is acquired.

With the exception of a few restricted areas in the Gulf of Mannar, off the Pedro Bank and possibly south-east of Hambantota, the slope of the continental shelf seemed too steep for bottom trawling. Strong currents along the shelf edge also complicate the use of trawl gear in this zone.

These findings concerning bottom conditions in general support the previous information available. One could perhaps have expected to find more favourable bottom conditions for trawling on the Pedro Bank, since previous reports indicate this to be a "regular trawling ground". The explanation may be that the present survey, in contrast to previous work, was limited to the Sri Lankan part of the ground and thus did not cover the whole of the Pedro Bank.

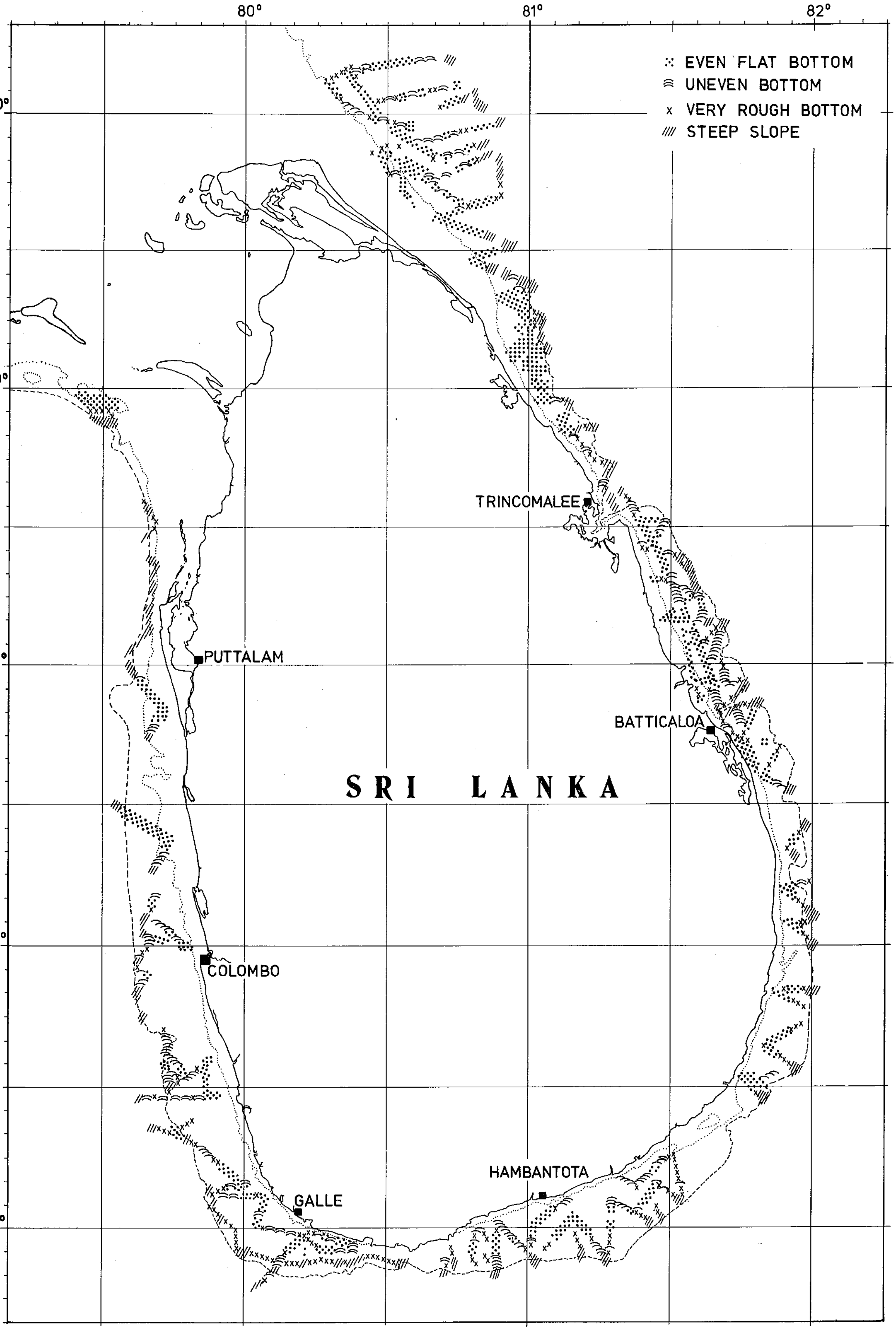


Fig. 5. Observations of the character of the bottom within the continental shelf.

4. HYDROGRAPHY

Temperature, salinity and dissolved oxygen were observed on nine sections across the shelf. The locations of the various sections are shown in Fig. 10. Observations were generally not made at depths greater than 500 m. The salinity samples were analysed onboard using a conductivity salinometer and the oxygen samples were analysed by the Winkler method.

4.1 Water masses

Fig. 6 shows T-S diagrams for Sections I, III, VI and IX. A watermass which was encountered in all sections is indicated in the diagrams by temperatures below 17°C and salinity between 34.9 and 35.1°/oo. This watermass, known as Indian Ocean Equatorial water (Darbyshire 1967), occupied the deeper strata in all sections and created a fairly uniform thermo-haline stratification all around the island at depths greater than approximately 150 m. The vertical distribution of temperature, salinity, density and dissolved oxygen which is illustrated in Figs. 7 and 8 is therefore confined to the upper 150 m.

Along the east coast the distribution of the watermasses was generally uniform from south to north. The salinity increased gradually with decreasing temperature between the low salinity surface water and the Indian Ocean Equatorial waters (Fig. 7), indicating only one watermass in the upper layers. This was Bay of Bengal water covering a large range of salinity and a small range of temperature. Fig. 7 shows that its temperature was close to 28°C and its salinity between 33 and 34°/oo, decreasing northwards. It may be mentioned that the salinity in this watermass undergoes considerable seasonal fluctuations with minimum after the north-east monsoon rains. (Ganapathy and Rao 1959, Thirupad, Varma and Reddy 1959, Mojunder 1967, Würtki 1971).

On the west coast the conditions in the upper layers were somewhat more complex and three different watermasses were observed. In Sections I and II the salinity in the mixed layer was about the same as in the deeper strata, between 34,9 and 35.0°/oo (Fig. 8). The temperature was quite low compared to the other sections, mostly below 25°C. This watermass was probably formed in this area, the Gulf of Mannar, during the south-west monsoon season. Observations made by the UNDP/FAO Pelagic Fishery Project, Cochin, India, revealed considerable seasonal fluctuations also here, with rapid temperature increase after the south-west monsoon to about 28°C by October (Anon 1973, 1976a).

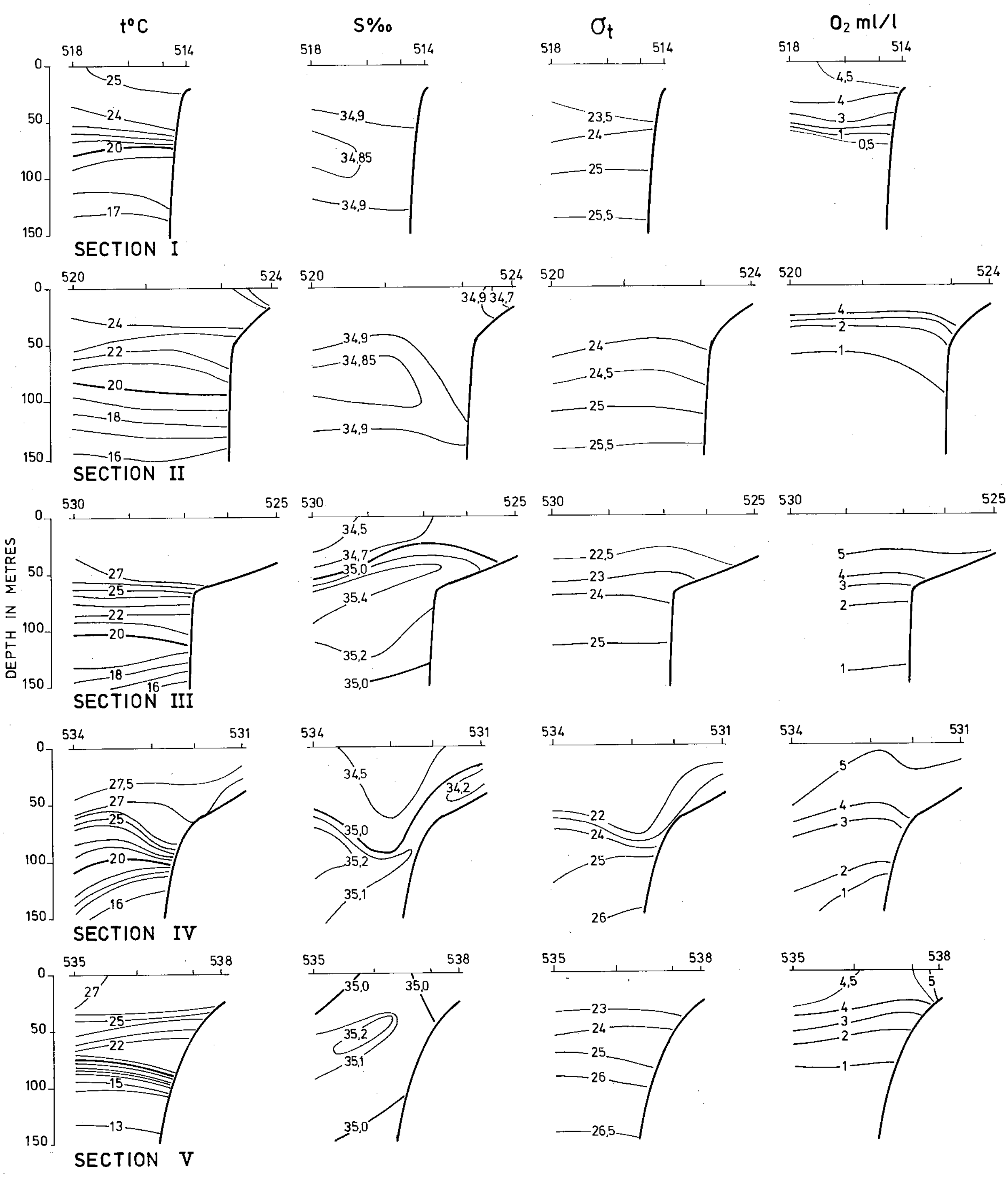


Fig. 8. Temperature, salinity, density (σ_t) and dissolved oxygen in the upper 150 m of Sections I-IV.

At depths mainly around 100 m in Sections III, IV and V there were waters of salinities above 35.1 $^{\circ}/oo$ and temperatures between 17 and 26 $^{\circ}C$ which is characteristic for Arabian Sea water (Darbyshire 1967) which has its origin in the northern Arabian sea.

4.2 Currents

The distribution of the watermasses in the upper layers indicated moderate current velocities in the Gulf of Mannar (Sections I and II). In the area of Section IV the current was probably fairly strong and running towards the east. Along the east coast the sections were suggestive of a southward component of the current (Fig. 7). This coast was, however, situated leeward to the eastbound oceanic flow and the current conditions were probably varying.

4.3 The thermocline

In the two northern sections on the west coast the mixed surface layer was 40 to 50 m deep, under which a relatively sharp thermocline was observed. In the sections further south the thermocline lay deeper, and in some cases it was less developed. On the east coast the main thermocline was well developed, and as a rule observed at 40 to 50 m depth. According to Samarasinghe (1975) this was shallower than at the end of the north-east monsoon season. In Section IX, and to a lesser extent in Section VIII (Fig. 7), the thermocline tilted upwards towards the shore, indicating possibility of upwelling in this area.

4.4 Dissolved oxygen

The distribution of dissolved oxygen (ml/l) in the sections is shown in Figs. 7 and 8. It can be seen that an oxycline normally coincided with the thermocline. The content of dissolved oxygen below the oxycline was low, in most cases below 1 ml/l. The mixed layer was well aerated, and most of the waters on the shelf contained between 3 and 5 ml/l. In sections VIII and IX, where there was a slight uplift of the oxycline over the shelf, the oxygen content was below 3 ml/l beyond about 30 m depth.

The T - O_2 diagrams in Fig. 9 show how the oxygen content was related to temperature on the west and east coasts separately. It appears from the figure that particularly on the east coast there was a well defined interrelationship, and temperatures below 22°C were without exception associated with oxygen contents below 1 ml/l. Off the west coast the interrelation was not so well defined. In Sections I and II the conditions were similar to those on the east coast, but further south there were more scatter in the observations.

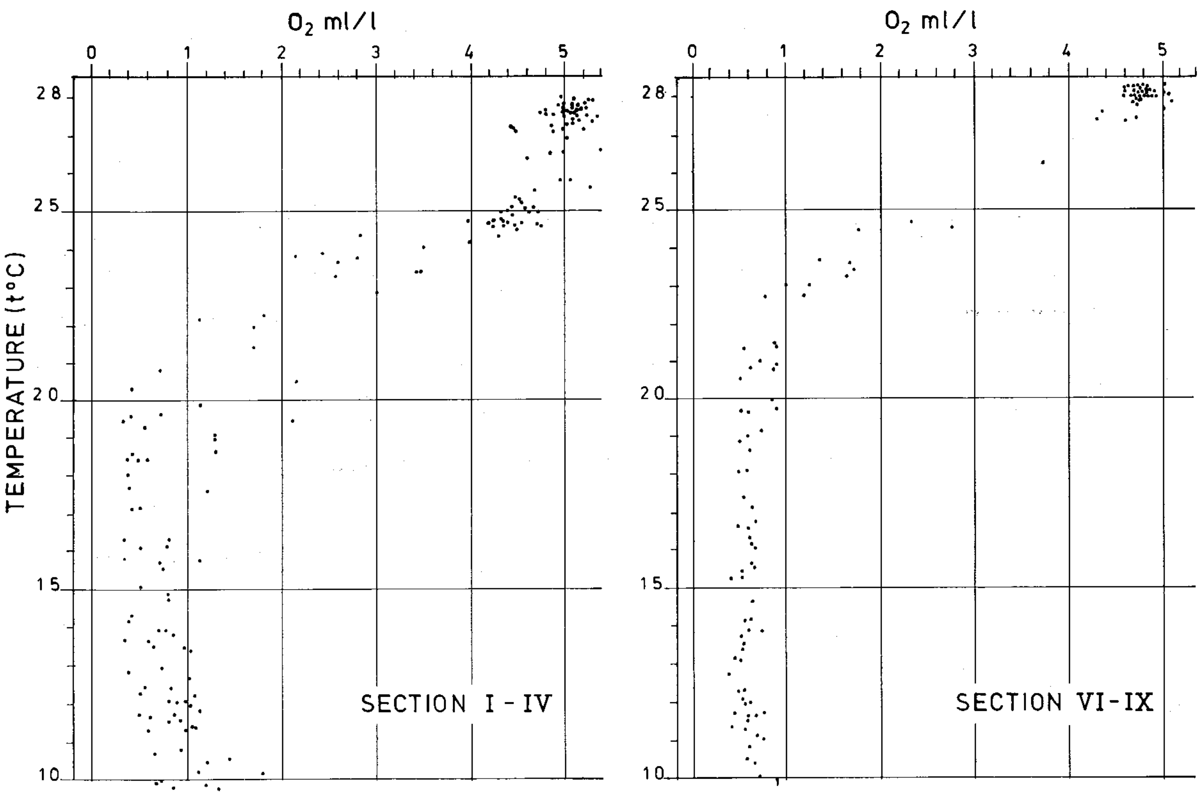


Fig. 9. Temperature-oxygen relationship on the west coast (left) and the east coast.

5. RESULTS OF THE FISH SURVEY WORK

5.1 Survey coverage; the echo recordings and their interpretation.

Assessment of the abundance of fish resources based on acoustic observations combined with experimental fishing is a method which especially lends itself to fish found in schools or other aggregations in mid-water. This is, however, a type of behaviour which characterizes a considerable number of the fish species found around Sri Lanka. But there are also notable exceptions, e.g. surface schooling tunas and tuna-like species and strictly bottom dwelling fish such as rays and flounders. Any fish found very close to the bottom (½ - 1 m) or in the very surface layer will escape echo sounder detection. For navigational reasons the work with this vessel is limited to waters deeper than about 10 m. The extreme inshore waters and the very large shallow area in the north, the Palk Bay and adjacent waters could thus not be covered. Towards the open sea, the survey was usually only extended a few miles beyond the continental shelf, except where oceanographical sections were worked usually 30-40 nm off the shelf. Important resources of tunas and tuna-like species exist in these off-shore waters, but they are not primary target species for a survey of this type, although they are to some extent recorded by the acoustic system.

Fig. 10 shows the complete cruise track covered by the acoustic system and the location of the various types of stations worked. Fishing with bottom trawl was considerably limited by large areas with unsuitable bottom conditions (see Section 3 above).

Because of differences in behaviour and size, different species or groups of fish species may give rise to different types of echo-recordings. Small-sized pelagic fish are for instance often found in well-defined schools, the recordings of which can be distinguished from those of the often looser aggregation in which semi-demersal larger fish are often found. Such a classification of the echo recordings is of considerable assistance in interpreting the acoustic observations, but a positive identification by fishing operations is still indispensable and also provides the only means of sampling fish in this type of combined survey.

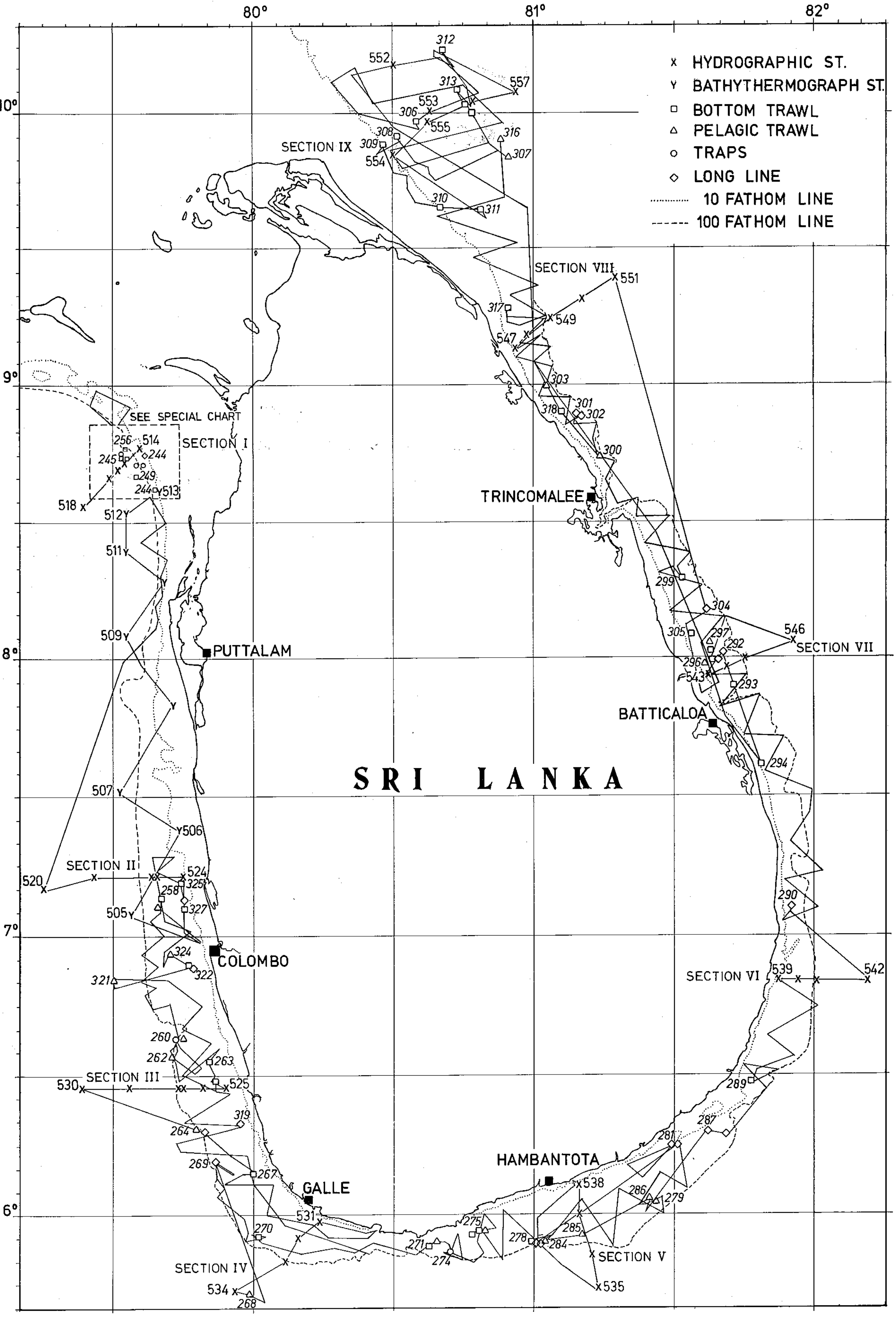
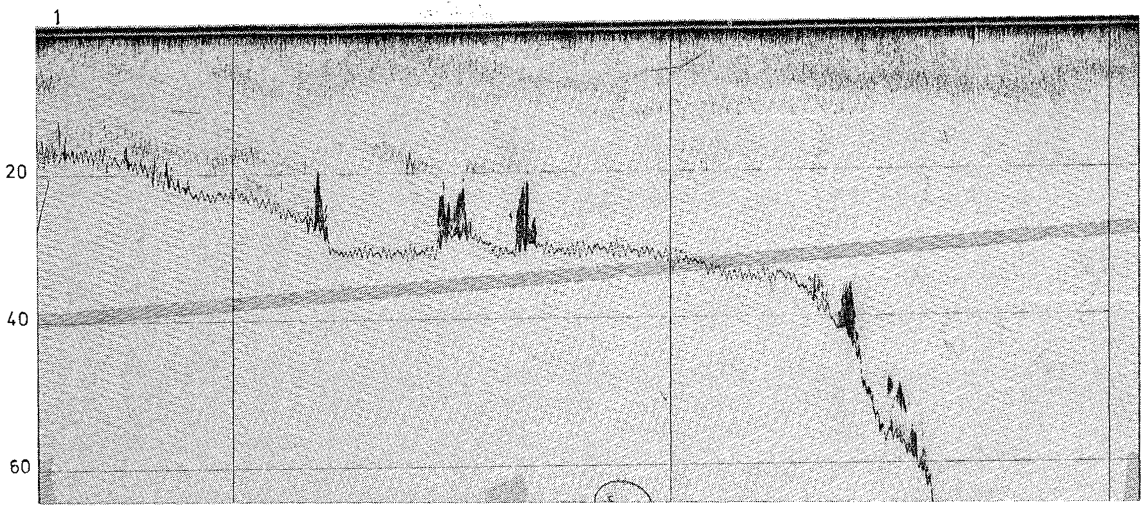
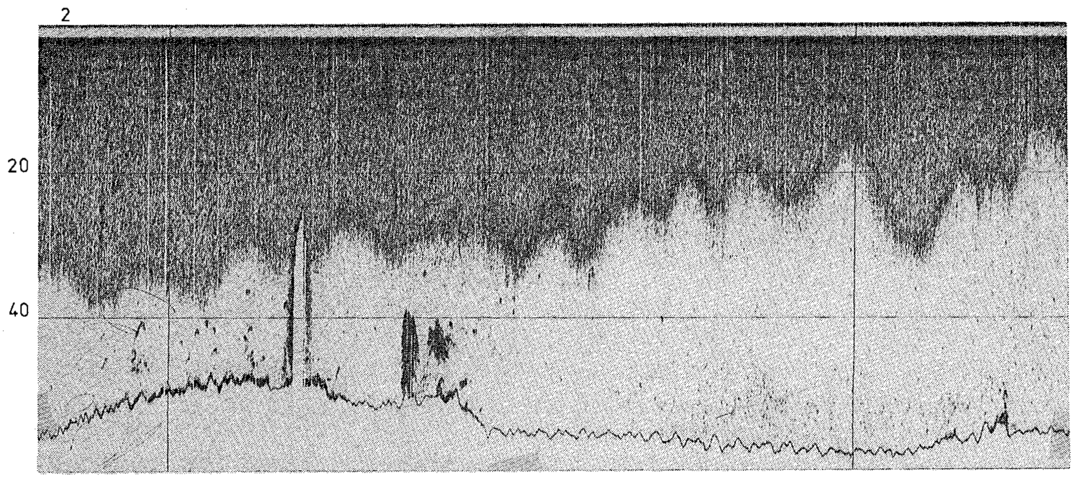


Fig. 10. Cruise tracks and stations worked.

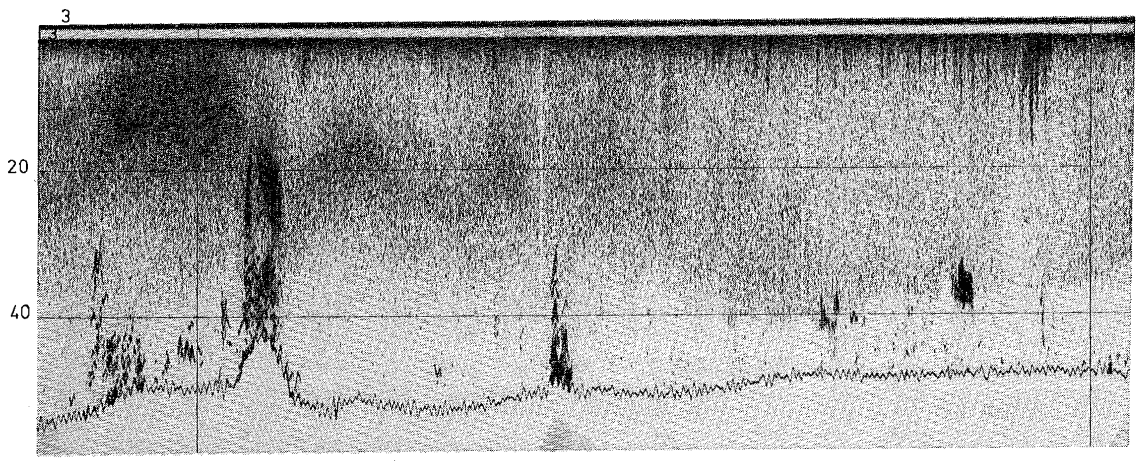


Echo diagram no.1. 0950 hrs. 24/9

Near fishing station 319, 38 kc.

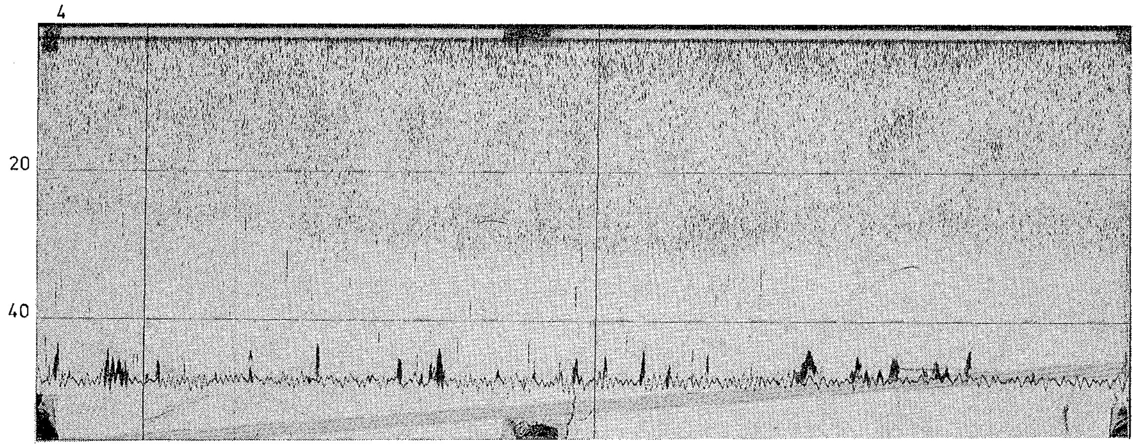


Echo diagram no.2. 2230 hrs. 8/9, 120 kc.

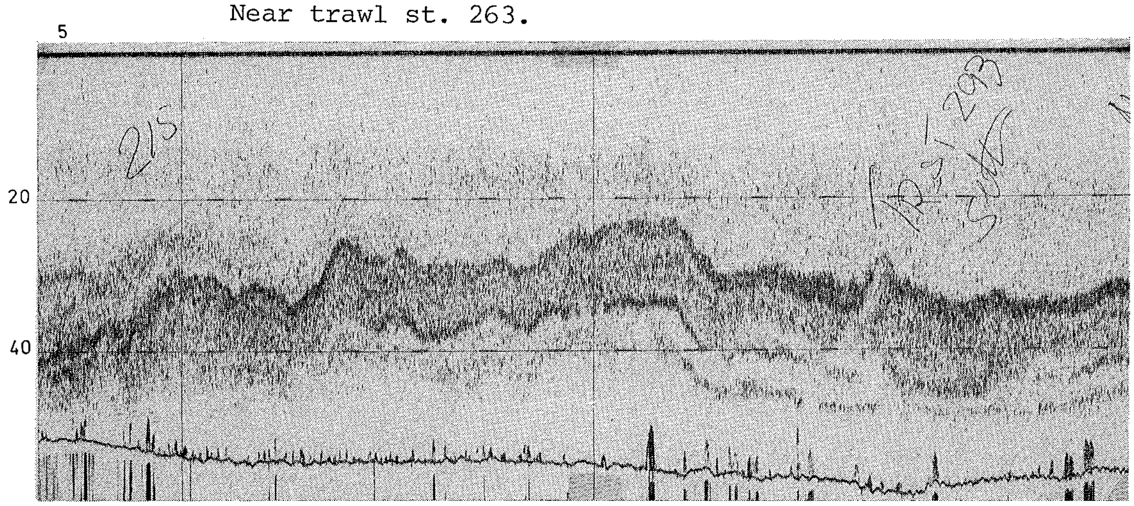


Echo diagram no.3. 0650 hrs. 11/9, 120 kc.

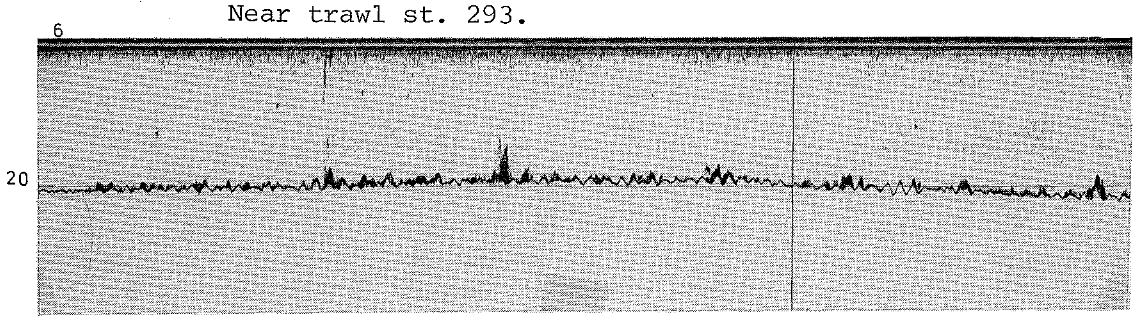
Fig. 11. Example of the "A" type of echo recordings from demersal or semi-demersal fish.



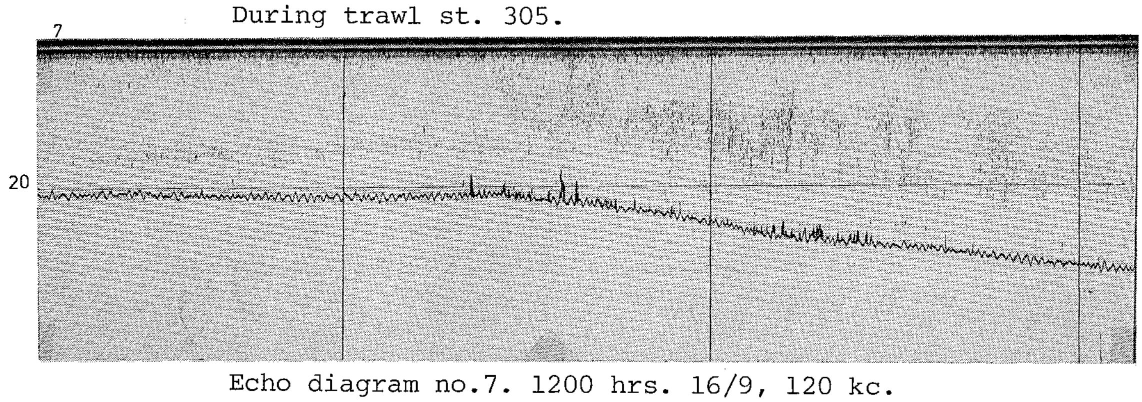
Echo diagram no.4. 1500 hrs. 3/9, 120 kc.
Near trawl st. 263.



Echo diagram no.5. 1000 hrs. 13/9, 38 kc.
Near trawl st. 293.

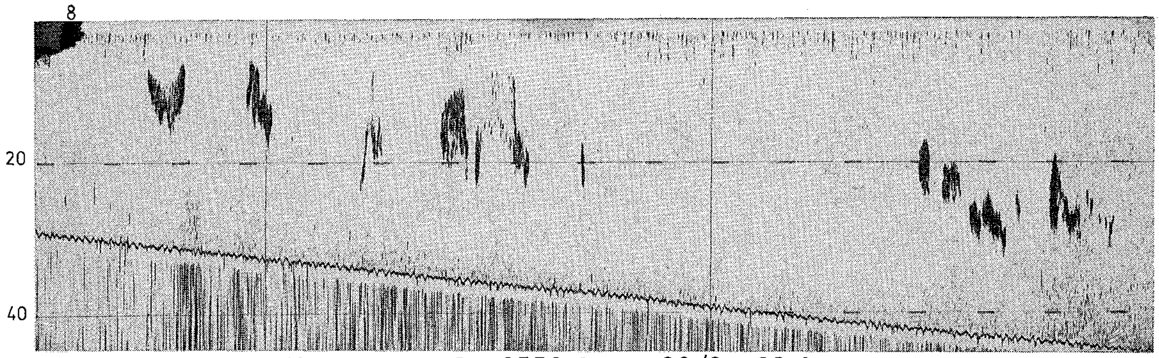


Echo diagram no.6. 1120 hrs. 16/9, 120 kc.
During trawl st. 305.

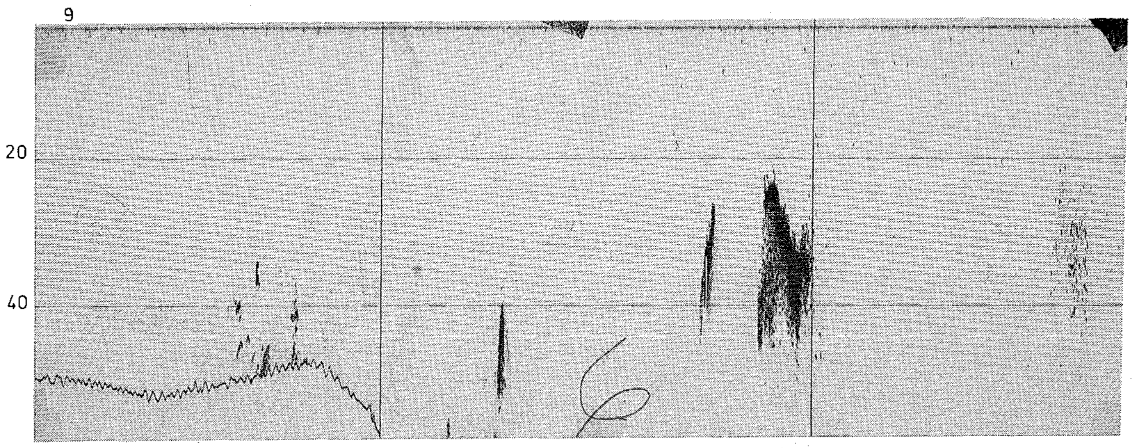


Echo diagram no.7. 1200 hrs. 16/9, 120 kc.
Near trawl st. 305.

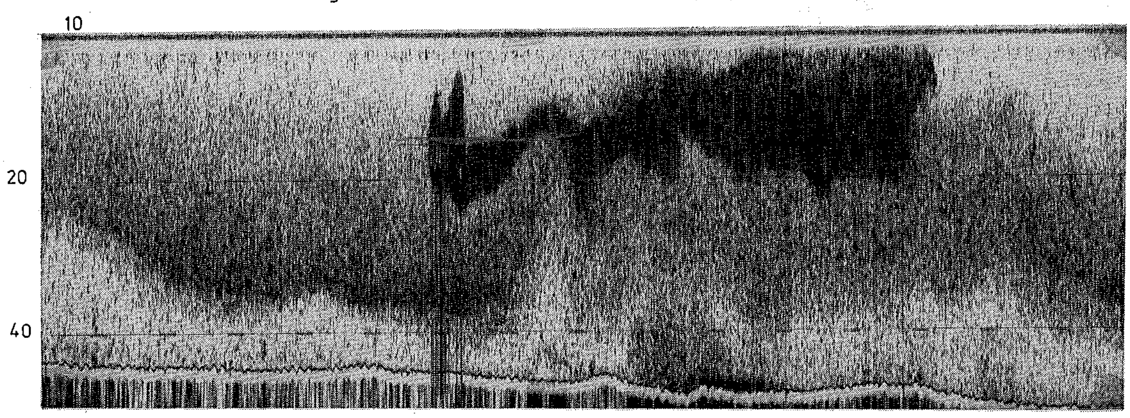
Fig. 12. "A" type of echo recording close to the bottom at or near trawl fishing stations.



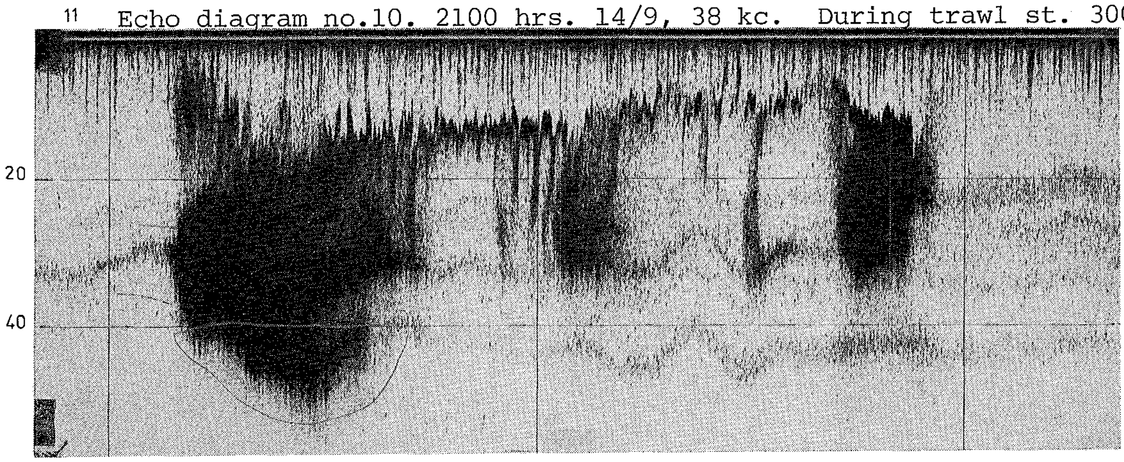
Echo diagram no.8. 0550 hrs. 20/9, 38 kc.



Echo diagram no.9. 1600 hrs. 12/9, 120 kc.

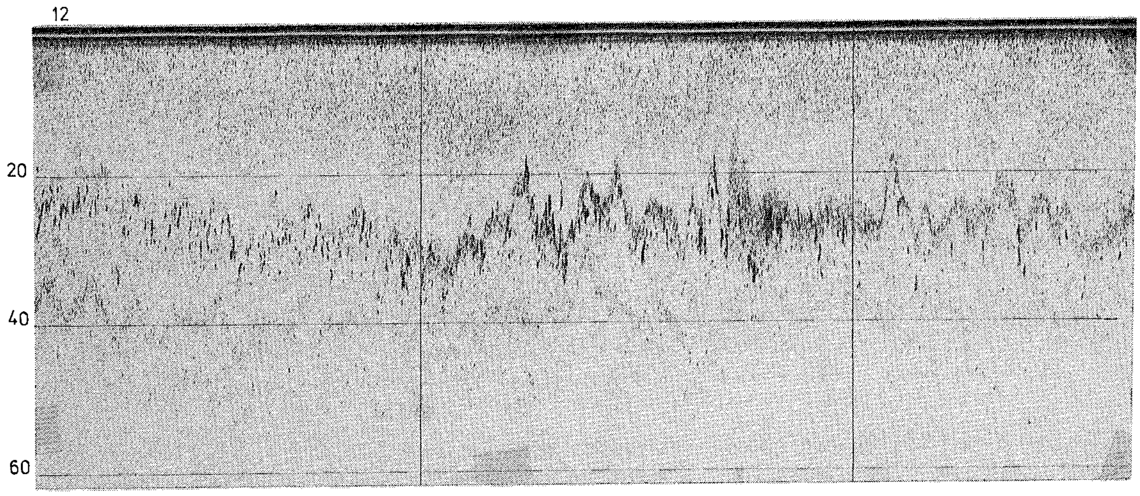


Echo diagram no.10. 2100 hrs. 14/9, 38 kc. During trawl st. 300.

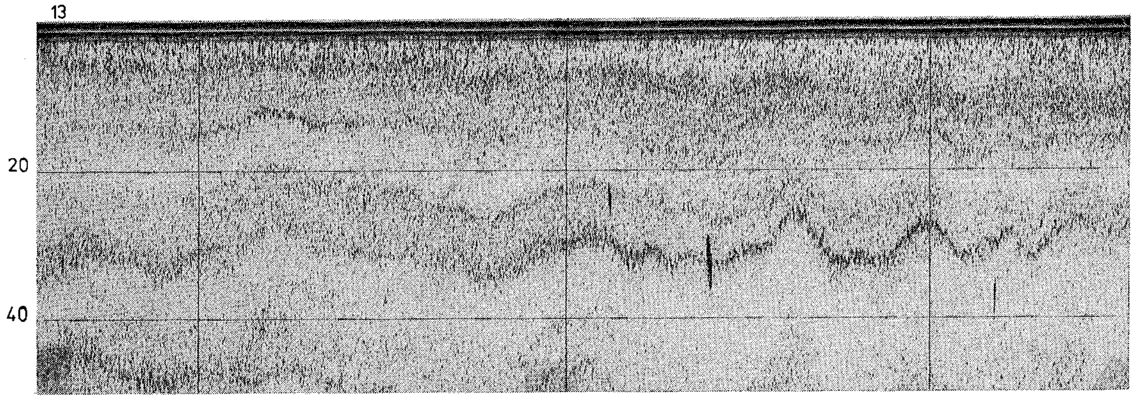


Echo diagram no.11. 0300 hrs. 18/9, 120 kc. Near trawl st. 307.

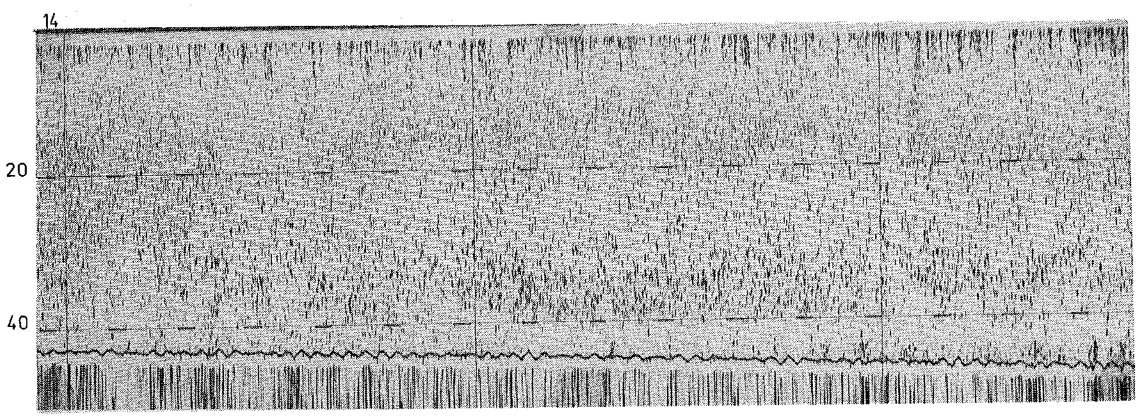
Fig. 13. Examples of the "C" type of recording (nos. 8, 9 and 10) of small pelagic fish. Recording no. 10 is from a school of meso-pelagic fish.



Echo diagram no.12. 2040 hrs. 17/9, 120 kc.

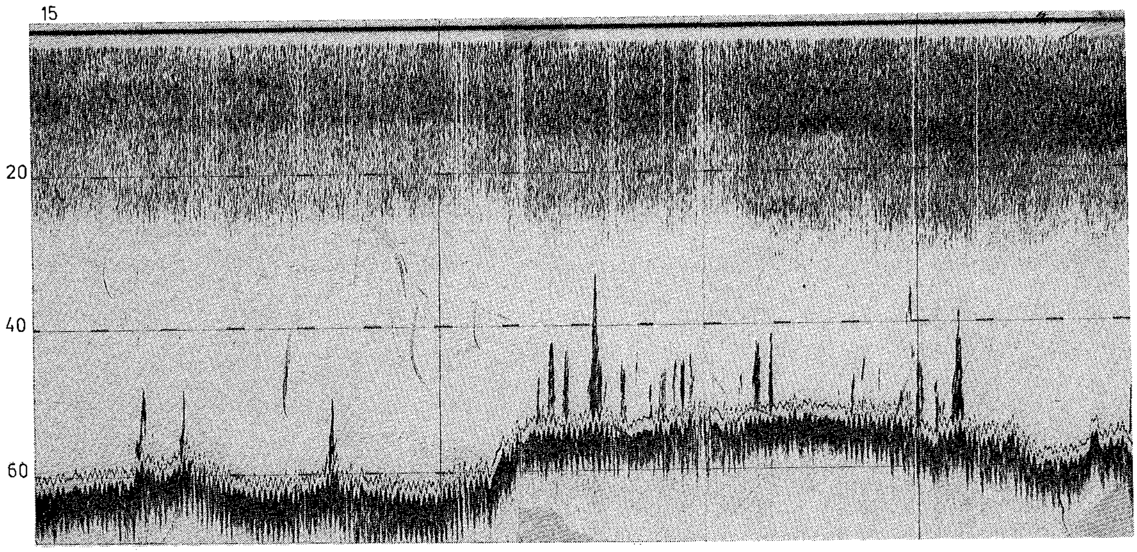


Echo diagram no.13. 0330 hrs. 16/9, 38 kc.

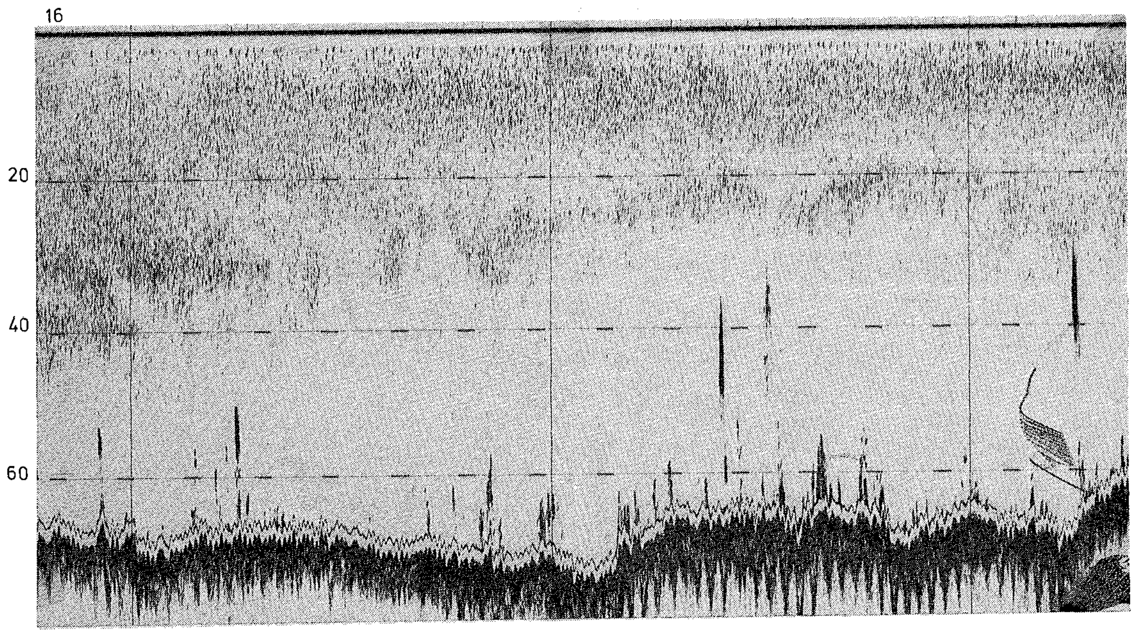


Echo diagram no.14. 0130 hrs. 17/9, 38 kc.

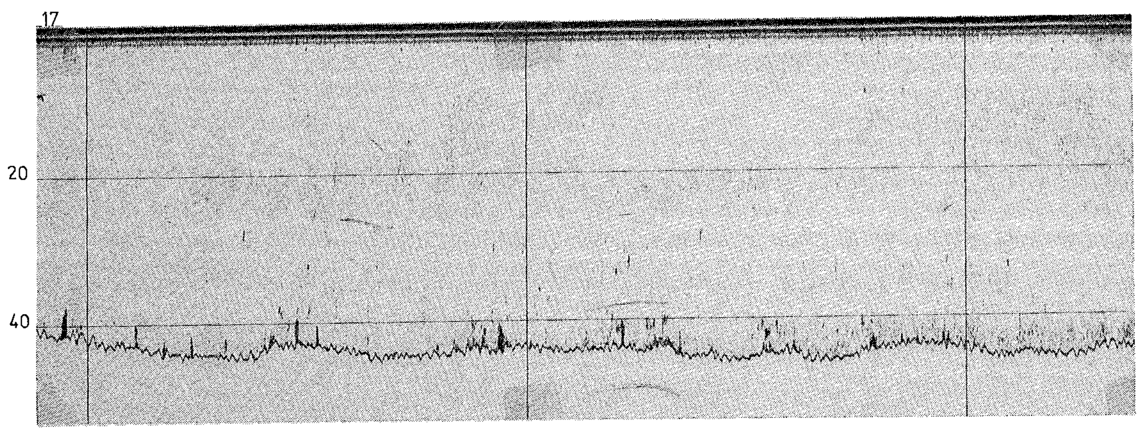
Fig. 14. Examples of the "B" type of echo-recordings of single fish or small schools of bigger fish closer to the surface.



Echo diagram no.15. 1300 hrs. 25/9, 120 kc.



Echo diagram no.16. 1030 hrs. 23/9, 38 kc.



Echo diagram no.17. 1830 hrs. 17/9, 120 kc.

Fig. 15. Comparison of typical echo recordings from the south-west coast (top, the Hambantota Bank (middle) and the Pedro Bank (bottom).

Based on previous experience and on identification by fishing, the fish recordings from the Sri Lankan waters were classified as follows:

A Schools and aggregations 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, and examples are shown in Figs. 11 and 12.

B Single fish traces or small schools of bigger fish closer to the surface waters, see Fig. 14. These recordings are thought to derive from tunas and tuna-like fish. 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. 13. These will most often derive from pelagic schooling fish usually of smaller size e.g. clupeiods, scads. This type was quite common particularly in inshore waters.

In addition, the types of echo recordings produced by plankton organisms and mesopelagic fish were identified while interpreting and processing the acoustic data. In this elaboration the contributions to the total integrator readings from plankton, meso-pelagic fish and the combined input from all types of other fish were estimated separately and charts of their distribution prepared.

Mesopelagic fish were found in offshore waters off the south-west coast and off the Pedro Bank in the north-east, but nowhere in significant abundance.

Charts of "echo-plankton" distribution were prepared, but a further analysis of these observations has not been made. A rough examination of the charts shows that the highest plankton integrator readings, up to 200-300 mm/nm were obtained from the south-west coast and off Batticaloa and Trincomalee. High values 50-80 mm/nm over wider areas were obtained in many parts of the coast from Colombo all around to Mullaittivu, but particularly along the edge of the shelf and off the shelf on the south-west coast. Observations vary considerably between day and night. A few attempts to identify the recordings and to calibrate the integrator readings with catches from plankton sampling were made. The organisms ranged, however, from small copepods to swimming crabs and large medusae, but time did not permit sufficient input into this task.

All further analysis of acoustic observations deals then with those contributions to the integrator readings assessed to be from fish, mesopelagic fish exempted.

5.2 Echo intensity distribution of fish and types of resources.

In order to demonstrate the geographical distribution of the integrator readings from fish targets, the observations were plotted along the cruise tracks and a distributional chart was prepared by interpolation. Fig. 16 shows a simplified version of the distributional chart in which all observations are referred to three arbitrarily chosen levels: very scattered (1-10 mm/nm) scattered (11-20 mm/nm) and dense (> 20 mm/nm).

A general feature of this distribution chart is that all of the denser "fish areas" are located inside the continental shelf or close to the slope. This is even more evident from a study of the more detailed original observations. A simple inspection further indicates that the regions of highest fish densities are from Negombo to Galle, the banks off Hambantota and from Trincomalee to Mullaittivu.

The qualitative examination of the acoustic observations through analysis of the echo-records showed considerable differences between the different parts of the coast. The level of precision in this analysis is not high enough to warrant a splitting of the relative contributions from the various echo-trace types to the integrator outputs. Instead the "types" described above were recorded on a sample basis over the entire survey area. These observations plotted in the echo-density chart are shown in Figs. 17. A visual impression of the types of echo-diagrams recorded in the various areas can be obtained by inspection of the samples shown in Figs. 11-15 with reference to their location as shown in Fig. 18. This figure also indicate the areas for which the further analysis of the data will be made. They are:

- I The north-west coast, north of Negombo and including the Sri Lankan part of the Gulf of Mannar.
- II The south-west coast from Negombo to Galle.
- III The Hambantota Banks
- IV The east coast from $6^{o}20'$ to $8^{o}20'$ including the shelf off Batticaloa.

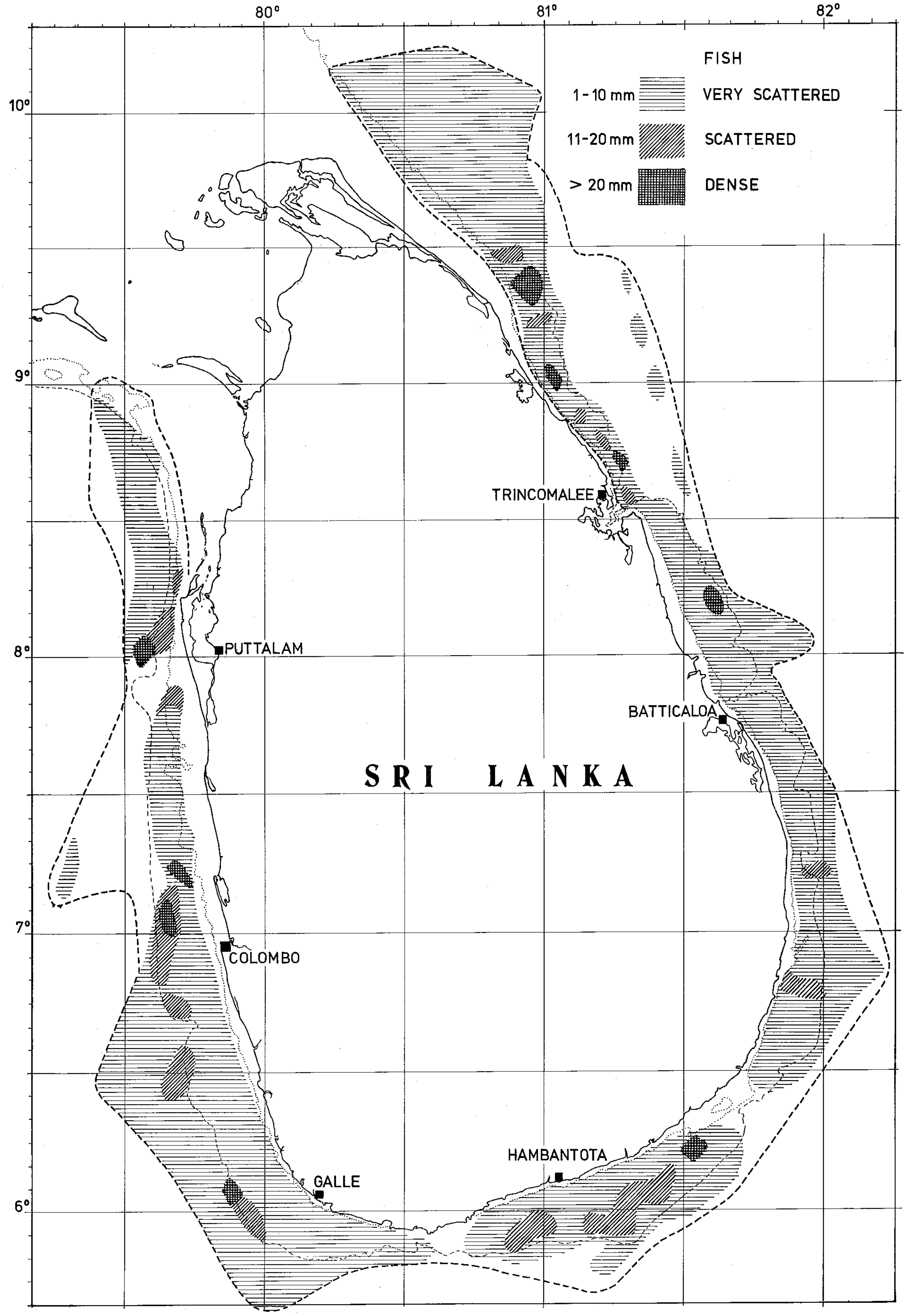


Fig. 16. Distribution of echo intensity of fish by levels of integrator deflection (mm per nautical mile).

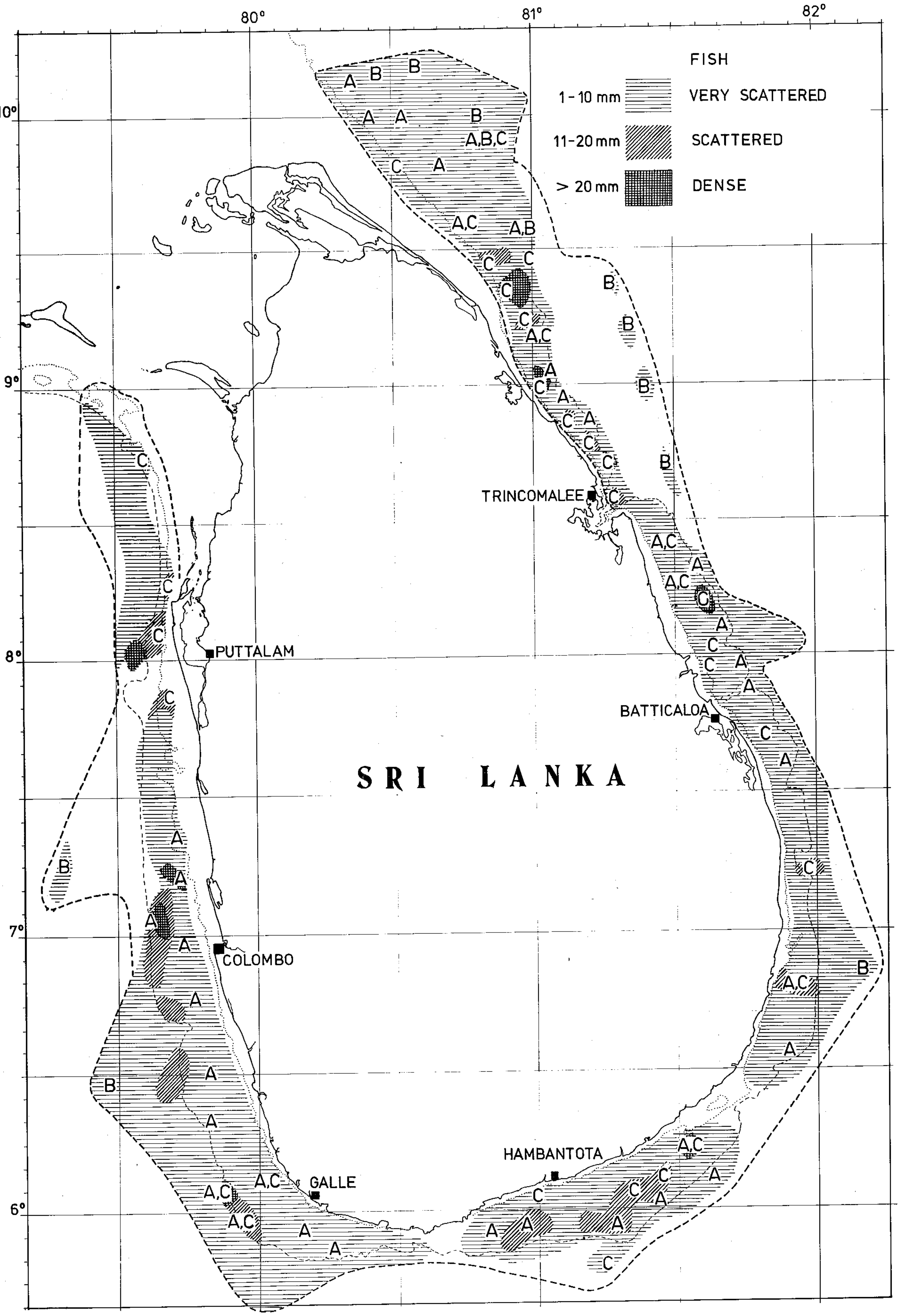


Fig. 17. Observations on the types of echo records plotted in the echo intensity chart. For legend see text.

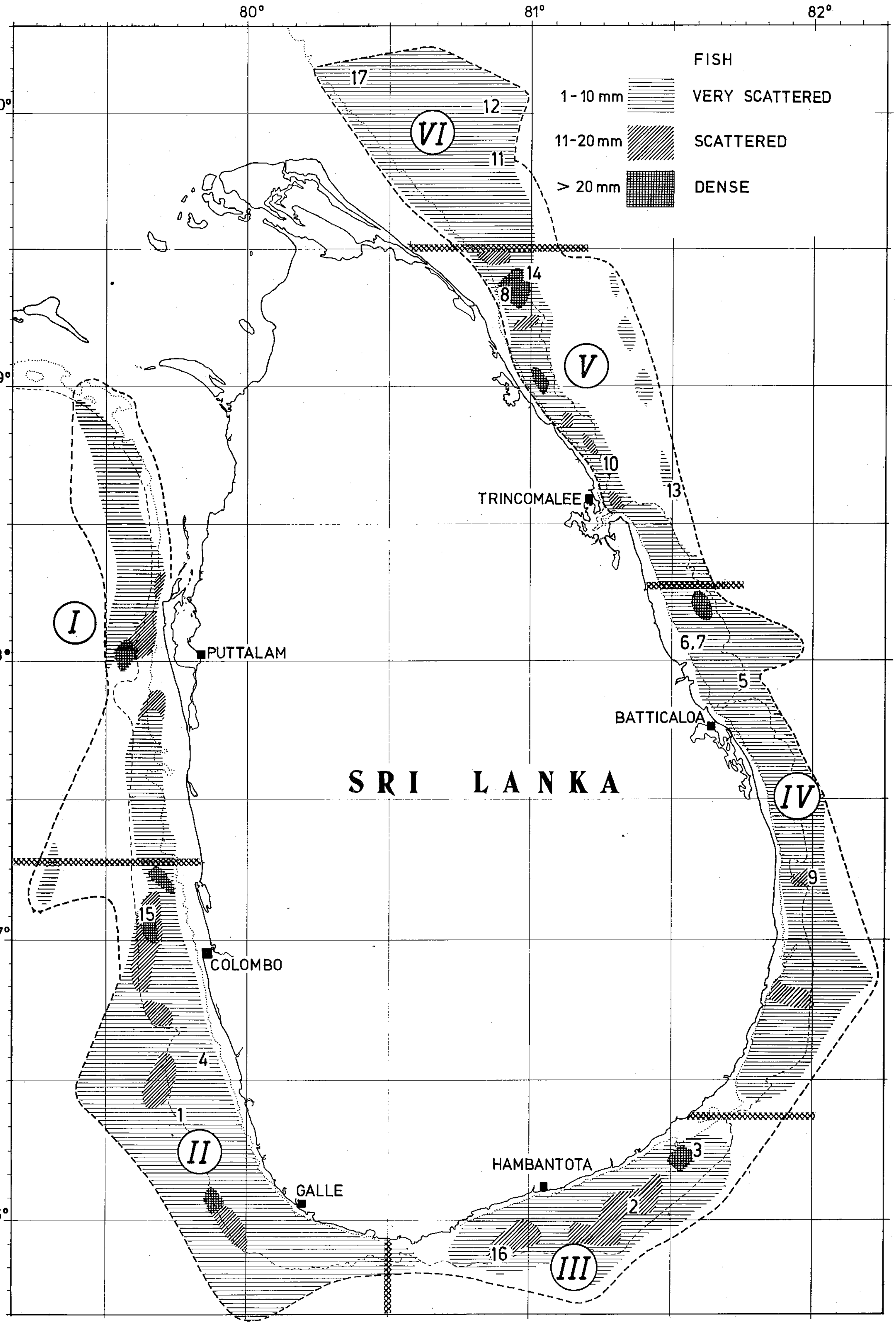


Fig. 18. Locations from which the samples of echo diagrams shown in Figs. 11 to 15 derive, and limits of the areas for further analysis of the data on fish distribution.

V The north-east coast from 8°20' to 9°30' past Trincomalee up to Mullaittivu, and

VI The Pedro Bank from 9°30' to somewhere near the Indian part of this broader shelf area.

5.3 Survey results in the various areas.

5.3.1 Estimation of fish biomass

As mentioned under 2.3 above, the integrator readings expressed in mm per nautical mile sailed can be converted to absolute measures of fish biomass by use of a conversion factor C determined by the system used and its performance. When converting echo-abundance observations to measures of weight of fish biomass the size of the fish targets in question must also be considered, because the echo target strength of fish is not a linear function of its weight, but more closely related to the square of the fish length. The conversion factor C can therefore be assumed to be approximately proportional to fish length. The basic value of C of 10.5 referred to above relates to fish of about 17 cm total length. Length measurements are available of samples of the various types of fish caught during the survey, and all measurements are summarized in Table 1. From this it can be concluded that the mean size of all

Table 1 . Summary of length-measurements by species or species groups. TL - total length, FL - fork length.

cm	Snappers TL	Groupers TL	Sweet lip TL	Breams FL	Trevallys FL	Baracuda FL	Surgeon fish FL	Seerfish FL	Ribbonfish TL	Scads FL	"Sardine" FL	Indian mackerel FL	Halfbeak FL
5-9										2	1	23	
10-14				11	1					93	18		
15-19				19	5					50		1	9
20-24	4			7	15	1	1			1		12	60
25-29	7			10	14	1	2						
30-34	5			2		15	5						
35-39	4					5	18		1				
40-44	9	1		1	9	1	10		10				
45-49	6			10	6		3		26				
50-54	3		1	22	45		3		18				
55-59	7	4	6	21	34				8				
60-64	9	9	6	15	17								
65-69	10	12		8	4								
70-74	3	2		1	4			10					
75-79	1			1				14					
80-84	2			1	1			8					
85-89								2					
N	70	28	13	108	157	23	42	34	63	146	19	36	69

species classified as demersal or semi-demersal (type A records) is about 45 cm while that of the other main category "type C", small pelagic fish is about 14 cm. Thus C = 10 may be applied to the small pelagic "type C" recordings, while approximately 2.5 times that value should be used in converting the integrator readings from "type A" fish. Since the distribution of these types of fish varied considerably between the areas, ratios were applied based on a rough assessment of Fig. 17 as follows:

Area	I	1	Area	IV	1,5
	II	2		V	1
	III	1,5		VI	1,5

The total echo abundance for each area was calculated by a planimetric integration of the distributional charts, and the area indices converted to fish biomass by weight. Table 2 shows the results. Estimates of the bank areas inside the 100 fathom line are also shown in the table.

Table 2. Indices of integrated echo-abundance, estimates of standing biomass and areas of banks inside the 100 fathom line.

Area		Index of echo abundance	Estimated biomass 1.000 tons	Area of coastal banks inside 100 fathoms nm^2
I.	NW Coast	(3.500)	(40)	1500
II.	SW Coast, Negombo-Galle	10.800	220	1350
III.	Hambantota Banks	6.900	100	940
IV.	E Coast 6°20'-8°20'	7.600	120	1300
V.	Trincomalee-Mullaittivu	4.700	50	560[x)]
VI.	Pedro Bank to abt. 10°15'	2.200	30	1020[x)]
Remaining northern shelf area, Palk Bay, Palk Strait etc. to mid-line				2800

[x)] Outside about 10 fathoms depth.

The reliability and likely bias of these estimates must be considered. They represent only rough estimates of the biomass in the areas and water layers covered at the time of the survey. There were several opportunities of repeated coverage with high consistency of results which shows that the relative distributions are well represented. The estimates of measures of absolute biomass are, however, highly dependent on the conversion factor used in the various areas, and these are only roughly assessed.

The results of the fishing experiments supports the differences in the size of the fish found between areas, and in a very general way also the different levels of abundance. The biomass measures shown in Table 2 may tend to be underestimates because a) fish found in the very surface layer and in a layer close to the bottom will escape acoustic detection, and b) the survey did not cover the extreme inshore waters with less than about 10 m of depth. In addition one should note that the survey did not cover Palk Bay, that surface pelagic off shore resources were poorly covered, and that the results can only be referred to the relatively brief season covered. These limitations are further discussed below.

5.3.2 Area I, the North-west coast.

The work in this area took place from 17 - 21 August, and the principal task was a more detailed survey and mapping of the deep water trawling ground

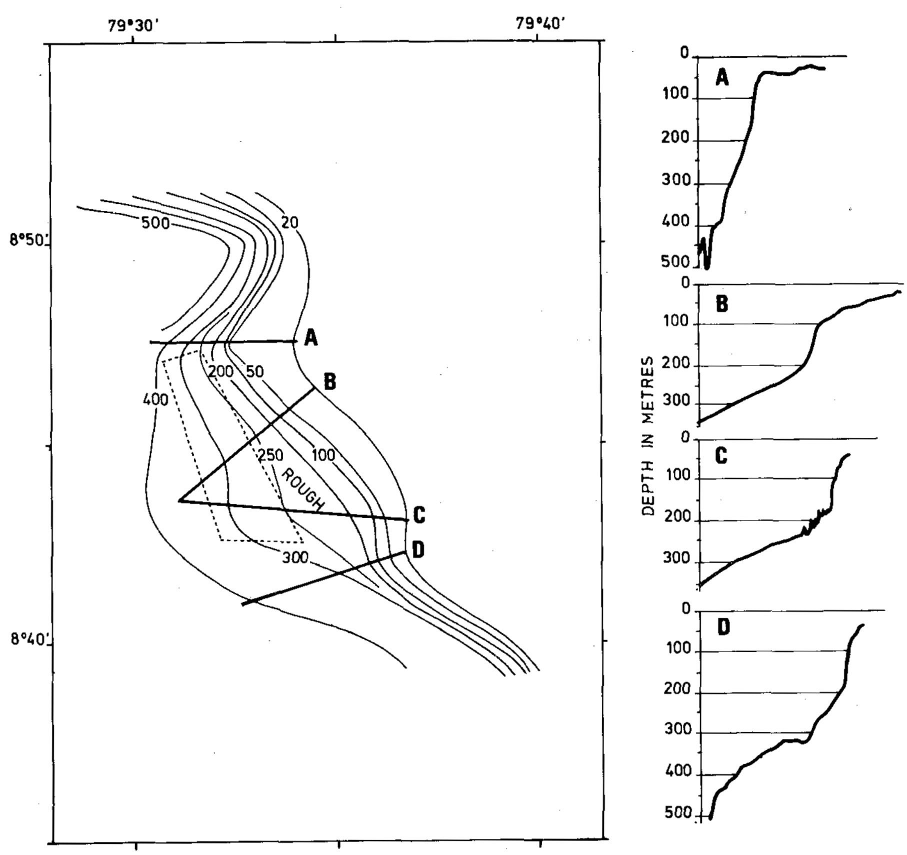


Fig. 19. Bathymetric chart based on an echo survey of the deep sea trawling ground off Kudremalai Point in the Gulf of Mannar. Right: some depth profiles.

already located by the "Optimist" in 1972 (See Annex I on previous surveys). The course track followed is shown in Fig. 10 except for the work inside the boxed area. Upon starting test fishing the need for a detailed bottom chart of the ground was evident. A systematic coverage with echo sounding resulted in the chart shown in Fig. 19. The sections A, B, C and D demonstrate the character of the corresponding profiles. The survey thus identified a plateau between about 250 and 400 m depth with only a moderate inclination and with even nearly flat bottom. The extent of the plateau is, however, only about 6 by 2 nautical miles.

A summary of the fishing operations from this ground is presented in Table 3, while the details of each haul are shown in Appendix Table I. The ratio by weight of lobster, deep sea prawn and fish was 1:3:8. Catch rates for lobster ranged up to 140 kg per hour's tow, for prawns up to nearly 600 kg and for fish up to about 1,3 tonnes. The average rates for the seven hauls listed in Table 3 are about 55, 170 and 520 kg per hour respectively for lobster, prawn

Table 3. Summary of fishing stations in Area I.

Gulf of Mannar, deep sea trawling ground.
(Station Nos. 244-256, 17 - 21 August 1978)

		Ratio
Lobster (Puerulus sewelli)	320 kg	8%
Shrimp (Identified off Cochin as:)	1080 kg	27%
(Aristaeus semidentatus)		
(Parapandalus spinipes)		
(Heterocarpus gibbosus)		
(Heterocarpus Wood-Masoni)		
(to be identified)		
Deep Water Fish	2500 kg	64%
Indian Lizard Fish .... Ratio: 33%		
Acropoma japonicum 25%		
Epinnula orientalis, Bathyclupea hoskynni, Chlorophthalmus agassizi 25%		
Other varieties 17%		

Bottom trawl; catch per hous tow:

Station no.	Fish	Prawn	Lobster	Crabs	Octopus
245	650	240	50	40	20
249	1200	60	40		
252	1270	580	140		
253	40	10	12		
254	160	80	16		
255	8	4	1	2	
256	300	230	130		

and fish. These rates are higher than those reported from a much greater number of trawl hauls by the OPTIMIST, see Annex I.

With better knowledge of the ground and the current, the average catch rates could probably be increased substantially. The successful use of this small ground would, however, require good navigational equipment. But the fishable area is small and the total yield that could be obtained from it on a sustained basis would not be very high. The commercial value of these deep water prawns also remains to be assessed since they are of small size. Samples were left in Colombo with the Institute for Fisheries Technology. The fish belong to a deep-water community and they are not commercially known. Several of the species are, however, reported to be good food fish.

A hydrographic section was worked across this deep-water trawling ground. The relevant observations show that the fauna at the fishing depth of about 300 m are adjusted to a level of oxygen content of about 0,5 ml/l.

The effort spent in surveying other resources on the north-west coast was very limited, both because of defect equipment and lack of time before the scheduled docking of the vessel in Colombo. The estimated biomass in the area of

Table 4. Summary of fishing stations in Area II, SW Coast, Negombo to Galle.

Bottom trawl (catch in kgs per hours tow)

Station no.	Total catch	Snappers breams groupers etc.	Trevallys mackerels etc.	Small pelagic silver bellies	Sharks rays	Other commercial	Other non-commercial
258	310	170				110	30
263	220		220				
267	23		16			7	
270	76	63				13	
325	3000	1650	60	460	150	440	300
327	30				9	121	

Long line

Station no.	No. hooks	Total catch kgs	Snappers breams groupers etc.	Other commercial
266	200	50	48	2
269		13	13	

about 40 000 tonnes should be considered with all reservations. No fishing operations were undertaken outside the deep-water ground, but the echo records were mostly identified as small pelagic fish.

5.3.3 Area II, The SW Coast from Negombo to Galle.

The shelf along this part of the coast is fairly wide and was as shown in Fig. 10 well covered in the survey. Relatively high values of echo intensity were observed, especially off Negombo and along the edge of the shelf southwards. A major proportion of the echo records of fish in this area were classified as "type A", demersal or semi-demersal fish (see Fig. 17). The echo-diagrams shown as no. 1 in Fig. 11 and no. 15 in Fig. 15 exemplify the usual recording on these banks.

Conditions for bottom trawling were poor in most of the areas of highest fish abundance. The catches from the fishing operations made are summarized in Table 4, and they confirm the impression from the echo diagrams that the majority of the fish resources in the area consists of mainly larger-sized demersal or semi-demersal species. Some of the catches included large-sized squid and sperm whales presumably feeding on the squid were frequently observed along the shelf edge. The estimated total biomass of 220 000 tonnes (Table 2) is the highest of any of the areas, and also represents the highest abundance per $(nm)^2$ of shelf area.

5.3.4 Area III, The Hambantota Bank.

This is a well defined bank area, also with a relatively broad shelf, limited by the Little Basses Reef to the east and the narrow shelf off Dondra Head to the west.

Zones of relatively high echo intensity were also found in this area with predominance of "A type" of recordings on the outer parts of the bank (Fig. 17). Echo diagrams nos. 2 and 3 in Fig. 11 and no. 16 in Fig. 15 demonstrate these observations. "Type C" recordings also occurred in several locations, especially on the inner parts of the bank.

Nor in this area did trawlable bottom coincide with high abundance of demersal fish. The results of the fishing stations in the area, Table 5, reflect, however, the presence of both demersal and pelagic fish. Notable are the relatively good catches on long line. The estimated total biomass of fish of about 100 000 tonnes (Table 2) does not represent as high abundance per unit shelf area as on the south-west coast, but it is significantly higher than the following areas.

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

Bottom trawl (catch in kgs per hours tow)

Station no.	Total catch	Snappers breams groupers etc.	Trevallys	Small pelagic	Sharks rays	Other commercial	Other non-commercial
271	44	7		5	10	10	12
275	140	105	3	3		23	6
277	42	15	2	1		24	

Pelagic trawl (catch in kgs per hours tow)

Station no.	Total catch	Trevallys mackerels etc.	Small pelagic	Other commercial
272	50	12	15	13
276	140		140	
279	110			60
284	113	111		
286	120			105

Long line

Station no.	No. hooks	Total catch kgs	Snappers breams groupers	Trevallys	Sharks rays
280	100	14		6	8
281	100	25		15	10
282	200	50	50		
283	200	92	84	7	1
287	200	10	3		7
288	200	0			

5.3.5 Area IV, East Coast and Batticaloa Banks.

The shelf along this considerable stretch of coastline is rather narrow. Only a few areas of higher echo intensity were located, the recordings being a mixture of types "A" and "C", with type "B" in the open waters off the shelf. Echo diagrams nos. 5, 6 and 7 in Fig. 12 and no. 9 in Fig. 13 derive from this area.

Most of the bottom trawl hauls, Table 6, were carried out on fairly good bottom north of Batticaloa. The pelagic trawl was not used successfully in identifying school targets. The total biomass present at the time of the survey was estimated at about 120 000 tonnes, most of which was considered to be pelagic fish.

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

Bottom trawl (catch in kgs per hours tow)

Station no.	Total catch	Snappers breams groupers etc.	Trevallys mackerels etc.	Small pelagic silver bellies	Sharks rays	Other commercial	Other non-commercial
289	70	69					
293	100	92				8	
294	63	52		11			
295	260	151	22	29	3	44	11
298	355	14	243	64	6	28	
299	95	52	4	1	1	37	
305	140	113		7		20	

Pelagic trawl

Station no.	Total catch	
296	5	Swimming crabs and small squid
297	8	Fish larvae and small squid

Long line

Station no.	No. hooks	Total catch kgs	Snappers breams groupers etc.	Trevallys mackerels etc.	Sharks
290	200	28	10	18	
291	200	2	2		
292	200	44	44		

5.3.6 Area V, Trincomalee to Mullaittivu.

The narrow shelf past Trincomalee widens somewhat further north where trawlable bottom is available in shallow waters. Concentrations of relatively high echo intensity were present locally over most of the shelf. They were all associated with type "C" records of schooling pelagic fish. These were at least to some extent identified as small scad, mackerel and clupeids and larval stages of these fish, Table 7. Some offshore areas of type "B" records were also located. The total biomass of about 50 000 tonnes estimated for this area, corresponds to the abundance of Area IV on a per-unit basis.

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

Bottom trawl (catch in kgs per hours tow)

Station no.	Total catch	Snappers breams groupers etc.	Trevallys mackerels etc.	Small pelagic silver bellies	Sharks rays	Other commercial	Other non-commercial
317	1030	720	75	86	50	100	

Pelagic trawl (catch in kgs per hours tow)

Station no.	Total catch	
300	700	Fish larvae, barracudas, scads, mackerels
303	80	Small scads, mackerels, various pelagic

Long line

Station no.	No. hooks	Total catch kgs	Snappers breams groupers etc.	Sharks
301	200	82	78	4
302	200	2	2	

5.3.7 Area VI, The Pedro Banks to about $10^{\circ}15'$.

The Pedro Bank represents an extension of the shelf with an area of about 1000 $(nm)^2$ between 10 and 100 fathoms south of about $10^{\circ}15'$ L.N. This area and part of the deep offshore waters was well covered with a survey grid, but low values of echo intensity prevailed over all parts of the bank, as shown in

Fig. 16. Echo diagram no. 17 in Fig. 15 shows a typical recording, and the low level of echo abundance of fish on the bank compared with, for example, the conditions found on the south-west Coast and Hambantota Bank is immediately evident from a visual comparison with the echo diagrams 15 and 16 shown in the same figure.

Hauls with the bottom trawl on various parts of the bank confirmed the paucity of fish available at the time, see Table 8. A few hauls were also made in deep water along the slope, but catches were poor. In some areas just off the shelf mesopelagic fish was recorded in local abundance (see Echo diagram no. 11, Fig. 13). The total biomass was assessed at about 30 000 tonnes, of which a considerable part was small pelagic or surface pelagic fish.

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

Bottom trawl, shallow and medium depth (catch in kgs per hours tow)

Station no.	Total catch	Snappers breams groupers etc.	Trevallys mackerels etc.	Small pelagic silver bellies	Other commercial	Other non-commercial
306	1		1			
308	110	15	93		2	
309	15				15	
310	8	4	3		1	
311	1		1			

Pelagic trawl

Station no.	Total catch	
307	1000	Lantern fish (975) and swimming crabs
316	110	Lantern fish and swimming crabs

Bottom trawl, deep water

Station no.	Total catch	Deep sea lobster	Deep sea prawn	Deep sea fish	Other
312	0				
313	50		5	45	
314	90	3	3	74	10
315	30	1	3	24	2

6. SUMMARY OF FINDINGS, DISCUSSIONS, CONCLUSIONS

6.1 Summary of survey findings.

The overall objective of the survey was to describe and assess the demersal, semi-demersal and pelagic resources available on the Sri Lankan coast principally over the shelf banks. Because of the extreme shallow waters of the Palk Bay and -Strait this area could not be included.

Observations on the type of bottom was processed and presented in a bottom-type chart. This confirms previous findings that areas of good trawling ground are limited, mostly to the shallow inshore parts of the shelf, and the shallow northern area.

Hydrographic observations enabled a description of the watermasses along and on the continental shelf, the depth of the thermocline and the oxycline. The content of dissolved oxygen below the oxycline was low, in most cases around 1 ml/l. In this environment significant quantities of commercial types of fish will not be found. On the north-west, north-east and east coast the depth of the oxycline was only about 50 m, while it was found at about 100 m or more off the west, south-west and south coast. The observed variations in fish distribution may be related to this difference.

A detailed investigation of the deep-water trawling ground in the Gulf of Mannar was undertaken as a special first task of the work. The trawlable area was located and mapped, but found to be of rather limited extent, only about 2 by 6 nautical miles. Catches comprised deep sea lobster, deep sea prawn and deep-water fish in the approximate ratios 1:3:8. Catch rates for lobster ranged up to 140 kg per hour's tow, for prawn up to about 600 kg and for fish up to about 1.3 tonnes. The average catch rates of seven hauls: 55, 170 and 520 kg per hour respectively for the three types of resources are higher than those reported in earlier surveys, but a substantial sustained yield cannot be expected from this small fishing ground.

The main survey effort provided a chart of the distribution of the observed echo intensity of fish in the coastal areas covered. Through a classification of the echo records and from results of fishing experiments different types of resources were identified. The two most important were demersal and semi-demersal larger fish such as snappers, groupers, breams and trevallys on the one hand and smaller pelagic schooling fish such as scads, sardines, silver bellies, etc. on the other. The relative distribution of these resources are shown in Figs. 16 and 17.

On the basis of certain assumptions concerning the conversion of observations of echo abundance to measures of standing biomass, preliminary estimates of quantities of biomass were made for various areas of the coast. These findings can briefly be shown as follows:

Area	Biomass 1000 tonnes	Bank area inside 100 fathoms nm^2	Types of resource
Negombo-Galle	220	1350	Mostly demersal and semi-demersal
Hambantota	100	940	Demersal with some small pelagic
East Coast	120	1300	Pelagic and demersal
Trincomalee to Mullaittivu	50	500	Mostly small pelagic
Pedro Bank	30	1020	Demersal and pelagic

The average density of fish biomass in the whole area covered was about 100 tons per $(nm)^2$. The sustained yield forms only a minor part of the standing biomass. For long-lived larger fish the harvestable fraction is smaller than for smaller short-lived species. Assuming these proportions to be 0.2 and 0.5 respectively, the annual potential yields from the five survey areas would amount to approximately 70 000 tonnes of demersal fish and 100 000 tonnes of pelagic species. The main part of the demersal and semi-demersal fish are available on the south-west and southern part of the coast. A rough assessment indicates that only about a third of the biomass on the Pedro Bank would be available for bottom trawling, indicating a potential annual yield on this bank of about 2000 tonnes for this type of fishery.

6.2 Results of fishing operations.

The fishing operations primarily served to identify the echo targets and provide samples of fish, but some limited conclusions may also be drawn concerning the possible commercial usefulness of the operated gears. Bottom trawling was fairly successful in a few localities, but in general the distribution of demersal or semi-demersal fish did not coincide with the rather limited areas of good trawl bottom. Catches with the pelagic trawl were poor, but the rather few hauls made do not provide a basis for evaluating the possible usefulness of this type of gear in Sri Lankan waters. The same reservations must be taken with regard to the results of the trap fishing. Fishing with bottom longlines did, however, produce envouraging catch rates in several localities, notably on the Hambantota Banks. It seems reasonable to expect that with a better knowledge of the local fishing grounds and the most suitable bait, hauling time etc., this gear could be put to good commercial use. The problem of losses of hooks and of captured fish from high abundance of sharks was evident, but this could be reduced by reducing the fishing time of the lines. Exploitation of the shark resources with special shark lines would after some time also help to alleviate this problem.

6.3 Discussion of the findings.

The main finding of the survey is represented by the assessed biomass of approximately 0.5 million tonnes and its distribution along the stretch of coast covered by the survey from Negombo to the Pedro Bank, an area of around 5 thousand nm^2 of shelf. The sustained yield from this biomass is assessed at about 170 000 tonnes of which 70 000 tonnes are estimated to be valuable demersal and semi-demersal food fish. The mean yield density corresponds to 100 kg/ha for all the resources and 40 kg/ha for demersal resources respectively, both of which represent high values compared with many other areas. It seems likely, however, that a shelf area such as that of Sri Lanka exposed to the strong and changing ocean currents related to the monsoon systems should have a relatively high biological productivity. The resources also extend offshore beyond the shelf, and the reference to productivity per unit shelf area is thus of limited relevance.

Various limitations and reservations should be kept in mind when evaluating these findings. They represent only a part of the fish resources of Sri Lanka's shelf because of the incomplete coverage of the north-west coast and the exclusion of the northern Palk Bay and Palk Strait areas. This latter represents about 2800 nm^2 of shelf area. Also the extreme inshore shallow waters were incompletely covered, this being particularly the case in the north-west area where the estimated biomass was only 40 000 tonnes on a 1500 nm^2 shelf coast. Results of fishing experiments have indicated relatively high abundance of certain types of resources at least in some parts of these northern shallow waters (see Annex I).

In order to enable a rough assessment of the potential also in these northern uncovered areas one may make the simple assumption that the density of biomass found in that part of the north-west area which was actually covered by the survey, viz. 50 tonnes per nm^2, extends over the whole northern grounds. This represents half the mean density of biomass found in the surveyed area from Negombo to Pedro Bank. These waters would then hold some 170 000 tonnes of fish biomass. The major part of the well over 200 000 tonnes biomass from the north-west and north coasts will be small short-lived species eg. silver bellies, and the potential yields may be assessed at 70 000 tonnes of small sized fish and 10 000 tonnes of larger food fish. With these rough assessments added, the total potential yield for the Sri Lanka shelf is indicated to be 250 000 tonnes of which about 80 000 tonnes is valuable food fish. This assessment includes the major part of the present catch of about 100 000 tonnes.

This total potential of a quarter million tonnes per year may well turn out to be a conservative estimate. It does not specifically identify the important resources of large pelagic fish, tunas and tuna-like fish which are probably only partly included in the biomass assessment. The current annual catch of tunas, bill fishes and sharks at and beyond the shelf edge amounts to about 20 000 tonnes. A decline of catch rates indicate that these stocks may already be affected by exploitation.

The trawl fishery potential of the Pedro Bank of only 2000 tonnes is somewhat lower than previous estimates, which range from 3000 tonnes upwards. (Anon (1975)). From evaluations of previous fishing experiments and commercial results on the bank it seems probable that the available stock on this ground may fluctuate seasonably.

In general it should be stressed that the results reported represent the state of the resources of the time of the survey. In nearby and comparable areas such as the Pakistani coast and the south-west coast of India large-scale seasonal fluctuations of the biomass of short-lived species such as sardines and mackerel have been demonstrated (Anon (1978) and Anon (1976b)). It is likely that such seasonal changes also occur in Sri Lankan waters, and in addition there are possible changes in available biomass caused by migrations which in particular may affect larger fast-moving surface pelagic fish such as tunas and tuna-like species.

6.4 Brief conclusions.

The survey describes the distribution of the biomass of commercial fish along the coast from Negombo to Pedro Bank, the total standing weight of which is assessed at approximately 0,5 million tonnes. On the basis of some simple assumptions concerning the mean density of biomass in the northern shallow waters (Palk Bay and -Strait) not covered by the survey, the total biomass of Sri Lanka's coastal shelf and imediately adjacent waters is assessed at close to 3/4 million tonnes. The sustained annual potential yield from these resources is indicated to be about 250 000 tonnes, of which about 80 000 tonnes represent large demersal or semi-demersal fish. This estimate may well prove to be on the conservative side, but it should be used as preliminary advice that the present level of catches of about 100 000 tonnes can at least be doubled.

An important finding is the demonstration of good resources of demersal and semi-demersal fish on the south-west coast from Negombo to Galle and on the Hambantota banks.

Demersal resources were rather sparse on the Pedro Bank at the time of survey.

In general the diversity of types of resources, their distribution and the nature of the shelf grounds suggest conditions for a diversified fishery based on small fishing units.

Since it is likely that considerable seasonal changes occur in the abundance of the fish resources and in their distribution, a repetition of this type of survey at other seasons is highly recommended. Investigations of the resource potentials of the shallow northern areas are also essential for providing the basis of resource information needed for development planning.

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Table I. Record of fishing operations.
BTR: bottom trawl, PTR: pelagic trawl, T: traps, LL: longline.

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)
17.8	1510	244	BTR			trawl was taken in.	08°44'	79°32'	-	-		
17.8	1510	245	BTR	300	300		08°44'	79°32'	1000	923	Shrimp (240) Indian Lizard fish (216) Acropoma japonicum (162) Crabs (40) DS lobster (50) Octopus (20)	
17/18.8	2042	246	T	290 300	290 300		08°45'	79°31.7'	20	-	Deep sea fish and crabs (20)	
17/18.8	2055	247	T	242 249	242 249		08°45'	79°32.4'	20	-	Deep sea fish and crabs (20)	
18.8	1020	248	LL	-		bad bait	08°45'	79°37.7'	0	-		
18.8	0847	249	BTR	310	310		08°41'	79°36'	224	1493	Fish (208), Shrimp (9.6), Lobster (9.6)	
18.8	2102	250	T	40 49	40 19		08°43'	79°36'	-	-	Small fish (5 pieces) Skate (2 pieces)	
18.8	2120	251	T	19 20	19 20		08°43'	79°36'	0	-		
20.8	1133	252	BTR	274	274		08°44'	79°32'	2000	1905	Fish (1268) Shrimp (584) Lobster (144)	
20.8	1943	253	BTR	288 310	288 310		08°47'	79°31'	49	52	Shrimp and fish (36.6) Lobster (12.4)	

(Table 1. continued)

Date	Time Start GMT	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)
21.8	0717	254	BTR	293	293	08°44.4'	79°32'	189	252	Fish (120), Shrimp (58), Lobster (11)	
21.8	0957	255	BTR	275-289	275-289	08°44'	79°32'	12	14	Fish (7.6), Shrimp (3.6), Lobster (0.6)	
21.8	1150	256	BTR	275	275	08°48'	79°32'	500	667	Fish (225), Shrimp (175), Lobster (100)	
3.9	1417	257	PTR	32	25	07°06'	79°39.5'	0	-		
3.9	1639	258	BTR	36	36	07°08'	79°40.2'	129	310	Lutjanidae (70) Squid (35) Common fish (12) Non common fish (12)	3.04 1.21 1.71 -
3.9	1740	259	PTR	41	25	06°38'	79°45'	0	-		
3.9	1940	260	T	56-62	56-62	06°38'	79°49.6'	40	-	Rachycentron canadus (9) Epineptelus taurina (31)	1.50 31.00
3.9	1952	261	T	58-61	58-61	06°37.5'	79°43.4'	4	-	Rachycentron canadus (4)	1.00
4.9	1015	262	PTR	56	20-40	06°35.3'	79°42.8'	0	-		
4.9	1415	263	BTR	45-46	45-46	06°33'	79°50.5'	220	213	Caransc speciosus (200) Carangoids malabaricus (15)	3.81 2.14
4/5.9	0450	264	LL	65	65	06°18'	79°49.8'	0	-		
4/5.9	0505	265	LL	66	66	06°18'	79°49.8'	0	-		
4/5.9	0440	266	LL	52	52	06°20.4'	79°49'	50	-	Lethrinidae (40.4) Serranidae (2.9) Rachycentron canadus (4.5)	3.11 0.73 2.25
5.9	0951	267	BTR	63-66	63-66	06°09.7'	80°00'	23	23	Carangidae (16) Balistidae (2.5) Synodontidae saurida (1.0)	1.60 1.25 0.02
5.9	2330	268	PTR			05°42'	80°01'	20	40	Mesopelagic fish Swimming crabs (20)	

(Table 1. cont.)

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)
5/6.9	0515	269	LL	56	56	$06^{\circ}11.6'$	$79^{\circ}52'$	13	-	Lethrinidae (13.2)	2.20
6.9	1206	270	BTR	83	74-79	$05^{\circ}55'$	$80^{\circ}01'$	23	77	Lethrinidae (18.5)	3.08
6.9	1832	271	BTR	44-46	44-46	$05^{\circ}53.5'$	$80^{\circ}37'$	22	29	Squids (2.8)	-
										Lethrinidae (1.4)	0.16
6.9	2005	272	PTR	44	11	$05^{\circ}54'$	$80^{\circ}41'$	26	52	Leiognathidae (6.8)	-
										Sphyraenidae (6.0)	0.29
										Small squids (6.2)	-
										Clupeidae (1.7)	-
6/7.9	2151	273	T	60-71	60-71	$05^{\circ}52'$	$80^{\circ}42'$	6	-	Lethrinidae (5.6)	2.70
6/7.9	2201	274	T	61-62	61-62	$05^{\circ}52'$	$80^{\circ}42.1'$	0	-		
7.9	1105	275	BTR	54-55	54-55	$06^{\circ}56.5'$	$80^{\circ}48.6'$	144	137	Serranidae epineph (83.0)	3.32
										Lutjanus malabaricus (17.0)	5.66
										Lethrinidae (7.9)	0.56
										Carangidae (2.9)	0.11
										Plectophynchidae (15.7)	1.74
										Synodontidae (2.5)	0.10
7.9	1305	276	PTR	39	0	$05^{\circ}56.5'$	$80^{\circ}49'$	70	135	Hemirlamptus georgii (66)	-
										Decapterus russellii (3.2)	-
7.9	1500	277	BTR	57-59	57-59	$05^{\circ}56'$	$80^{\circ}48'$	42	41	Squid (22)	-
										Serranidae epineph (12)	3.00
										Lutjanidae (2.4)	1.20
										Carangidae (2.0)	1.00
										Rachycentridae (2.0)	1.00
8.9	1159	278	BTR	70	67	$05^{\circ}54.4'$	$80^{\circ}59.4'$	broken	-		
8.9	2017	279	PTR	58	25	$06^{\circ}03'$	$81^{\circ}26'$	110	110	Squid (60)	-
										Swimming crabs (44)	-
										Decapterus russellii (2.4)	-
9.9	0540	280	LL	16	16	$06^{\circ}15'$	$81^{\circ}30.5'$	14	-	Carcharias acutus (7.5)	1.87
										Carangidae (6.7)	3.35

						Mean weight (kg)
					...acutus (10)	1.66
					...5.4)	5.13
					...nebulosus (11.8)	3.93
					...utjanidae (22.4)	1.60
					...ectorhynchidae (13.6)	4.53
				92	Lethrinidae (44.9)	3.74
					Lutjanidae (27.0)	4.50
					Plectorhynchidae (9.0)	4.50
					Carangidae (6.5)	6.50
				113	Scomberomorus commersonii (111.0)	3.47
		...5'			1 squid	-
	[illegible]	81 25.5'	122	122	Acanthuridae (98.0)	0.92
					Squids (6.5)	-
					Carangidae (5.0)	5.00
	...18'	81°37.4'		-	Carcharias acutus (6.0)	1.20
					Tachysurus subrostratus (2.8)	2.80
	06°17'	81°41.5'	0	-		
	06°29'	81°47'	44	71	Lutjanidae (22.6)	4.52
					Serranidae (17.3)	4.32
					Lethrinidae (2.0)	1.00
					Carangidae (1.6)	0.02
25	05°06'	81°55.5'	28	-	Carangidae (17.6)	4.40
					Lutjanus rivulatus (5.0)	5.00

(Table 1. cont.)

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)
13.9	0519	291	LL	51	51	07°59.5'	81°39.5'	2	-	Lethrinus nebulosus (2.3)	2.30
13.9	0539	292	LL	61	61	08°00.6'	81°40.5'	44	-	Lutjanidae pristi-pomoides sp (39.5)	1.23
										Lethrinus nebulosus (3.8)	3.80
13.9	1008	293	BTR	55-56	55-56	07°55.3'	81°42.7'	154	103	Lutjanidae (70.3)	3.35
										Serranidae epineptelus sp. (7.2)	3.60
										Lethrinidae (29.0)	3.22
										Plectorhynchidae (31.0)	2.58
13.9	1317	294	BTR	25	25	07°37.2'	81°49'	47	63	Lutjanus rivulatus (17.5)	5.83
										Plectorhynchidae (12.7)	3.18
										Serranidae epineptelus (6.7)	6.70
										Lethrinidae taurina (2.5)	2.50
										Emmelichthyidae (Redbait) - numerous	-
13.9	1820	295	BTR	39	39	08°01.4'	81°38.8'	260	260	Plectorhynchus pictus (37)	3.36
										Acanthuridae (29)	2.42
										Lutjanidae (28.8)	0.78
										Serranidae epineptelus (25.8)	12.90
										Lethrinidae (38)	0.93
										Otolithus sp. (10.5)	1.05
										Scomberomorus (6.0)	3.00
										Tachysuridae commersonii (6.0)	3.00
										Sparidae (5.0)	0.83
										Carangidae (5.0)	0.45

(Table 1. cont

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)
13.9	2015	296	PTR	38	10-15	07°58.7'	81°36.4'	5	10	Swimming crabs and squid (5)	-
14.9	0525	297	PTR	50	20-30	08°02.9'	81°37.22'	4	8	Squid and fish larvae (4)	
14.9	0645	298	BTR	39	39	08°01.7'	81°36.7'	355	355	Carangidae (273.9)	0.93
										Plectorhynchidae (22.3)	3.18
										Lethrinus nebulosus (6.0)	3.00
										Carcharinidae (6.0)	3.00
										Sparidae argyssfis spinifer (3.5)	0.70
										Emmelichthyidae (predominant in the meshes)	-
14.9	1333	299	BTR	38-46	38-46	08°17'	81°32'	95	95	Serranidae epineptelus (18)	3.60
										Plectorhynchidae plectorhynchus pictus (10.2)	2.40
										Balistidae (10.6)	1.06
										Lutjanidae (6.8)	1.13
										Lethrinidae (17.2)	0.36
										Mullidae (12)	-
										Squids and cuttle fish (13.5)	-
										Carangidae (3.7)	0.92
										Emmelichthyidae (predominant)	
14.9	2035	300	PTR	47	15	08°44.4'	81°14.9'	83	711	Fish larvae (60)	-
										Sphyraenidae (15)	0.47
										Carangidae (3)	0.17
										Rastrelliger kanagurta (2.5)	0.18
15.9	0527	301	LL	40-43	40-43	08°52.7'	81°09.5'	82	-	Lethrinidae (37.6)	2.69
										Lutjanidae (36.2)	4.02
										Carcharinidae (4.0)	2.00
15.9	0543	302	LL	51-65	51-65	08°53.2'	81°10'	2	-	Lutjanidae (1.5)	1.50
15.9	1115	303	PTR	39-41		08°59.7'	81°02.4'	79	71	Carangidae (40.1) (Small scads included)	-

(Table 1. cont.)

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)
16.9	0526	304	LL	53	53	08°15.8'	81°55.6'	1	-	Carcharias acutus (0.7)	0.70
16.9	1030	305	BTR	20-23	20-23	08°03.2'	81°34'	82	140	Lutjanidae (25)	2.50
										Serranidae epineptelus (22.9)	2.86
										Plectorhynchidae (11.0)	3.67
										Balistidae (8.0)	2.00
										Lethrinidae (6.8)	0.25
										Acanthuridae (4.3)	1.43
17.9	1440	306	BTR	54-56	54-56	09°58'	80°35'	1	1.7	Decapterus russellii (0.6)	0.15
18.9	0340	307	PTR		20-30	09°50'	80°55'	1000	1000	Myctophidae (975)	-
18.9	0851	308	BTR	32-33	32-33	09°53.5'	80°31.2'	65	130	Carangidae (46.6)	0.31
										Lutjanus sebae (10.2)	3.40
										Pentapochidae (5.0)	0.45
18.9	1150	309	BTR	18	18	09°52.5'	80°28'	7	16	Balistidae (5.2)	0.74
18.9	1507	310	BTR	27	27	09°41'	80°39'	7	8	Carangidae carangoides (2.9) gymnostethoides	1.45
										Serranidae epineptaurinor (2.2)	2.20
18.9	1716	311	BTR	45	45	09°33.7'	80°53'	1	2	Scomberomorus comersonii (1.0)	1.00
19.9	0735	312	BTR	229-269	229-269	10°13.8'	80°40.9'	0	-	- (trawl net torn)	
19.9	1222	313	BTR	248-261	248-261	10°05.2'	80°44.8'	28	51	Chlorophtholmus bicornis (24.0)	0.02
										Deep sea prawn (2.2)	0.01
										Octopus (0.1)	

(Table 1. cont.)

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)
19.9	1415	314	BTR	305-312	305-312	10°02'	80°46'	47	90	Chlorophthalmus bicornis (23.4)	0.02
										Centroloptus species (11.7)	0.05
										Chlorophthalmus agarsizi (3.9)	0.03
										Deep sea prawn (1.5)	0.01
										Deep sea lobsters (1.4)	0.08
19.9	1558	315	BTR	346-376	346-376	10°00'	80°47.3'	12	33	Deep sea fish (Cubiceps) ? (3.6)	0.05
										Octopus (2.2)	0.04
										Chlorophthalmus bicornis (1.7)	0.02
										Deep sea prawn (1.0)	-
										Deep sea lobsters (0.3)	0.06
19.9	2000	316	PTR	1100	40	09°54.6'	80°53'	75	112	Swimming crabs (40)	-
										Myctophidae (35)	-
20.9	1110	317	BTR	19	19	09°16.9'	80°54'	516	1032	Leiognathidae (280.0)	-
										Trichiurus laumela (51.0)	0.09
										Sciaenidae (35.7)	0.07
										Sphyraena picuda (30.6)	0.11
										Parastromateus niger (22.1)	0.52
										Chirocentrus dorab (17.0)	0.28
										Thrissocles setirostris (12.0)	0.03
										Penaeus and Metapenaeus sp. (prawn) (2.3)	-
20.9	1555	318	PTR	39	15	08°54'	81°00'	1004	2008	Jellyfish (1000)	-

(Table 1. cont.)

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)
24.9	0525	319	LL	39-44	39-44	06°19.5'	79°57.2'	14	-	Lethrinidae (8.9)	2.96
										Serranidae epineptelus (3.7)	1.23
										Balistidae (1.3)	1.30
24.9	1245	320	BTR	43-44	43-44	06°29'	79°52'	63	126	Balistidae abalistes (1.5)	1.50
										Rays (60.0)	30.00
										Squid (0.20)	0.006
24.9	1855	321	PTR	44	20	06°50.7'	79°38'	9	18	Lutjanidae (6.0)	6.00
										Squid (small) (1.7)	-
25.9	0515	322	LL	35	35	06°53'	79°47'	3	-	Eulamia spallangani (2.5)	2.50
25.9	0625	323	BTR	38	38	06°54'	79°44'	8	16	Cuttlefish (2.4)	1.20
										Decapterus russellii (1.0)	0.04
										Small squid (0.9)	0.02
25.9	0920	324	PTR	43	12	06°56'	79°42.9'	0	0	-	
25.9	1625	325	BTR	18-20	18-20	07°12'	79°44'	3000	3000	Lethrinus nebulosus (1400)	2.33
										Lutjanidae (122)	1.30
										Carcharias acutus (80)	1.60
										Carangidae (520) (small)	-
										Plectorhynchidae (54)	1.80
										Serranidae epineptelus (29)	1.81
26.9	0525	326	LL	19	19	07°08.8'	79°45'	24	-	Carcharinidae (12)	2.00
										Pentapodidae (12)	4.00
26.9	0615	327	BTR	19	19	07°06'	79°45'	10	30	Sphyraenidae (2.6)	0.22
										Leiognathidae (0.7)	0.007
										Squid (0.5)	0.06

Table II a. Size distribution (%) of selected species by areas.
FL - fork length, TL - total length.

Length in 5 cm groups.

	n	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Golden toothless trevally (*Gnathanodon speciosus*) F. L																		
AREA 2 SW-Coast	46						2	33	28	24	6	9						
AREA 4 SE-Coast	67						13	7	43	28	8							
Barred spanish mackerel (*Scomberomorus commersonii*) F. L																		
AREA 3 Hambantota Banks	35											28	40	23	6			
Surgeon fish (*Acanthurus strigosus*) F. L.																		
AREA 3 Hambantota Banks	42		2	5	12	43	24	7	7									
Pink snapper (*Pristipomoides species*) F. L.																		
AREA 4 East Coast	32	12	3	9	12	28	19	2	2	1								
Large headed ribbon fish (*Trichiurus haumela*) T. L.																		
AREA 5 Trincomalee	63					1	17	46	27	8								

Table II b . Size distribution (%) of selected species by areas.
FL - fork length, TL - total length.

Length in $\frac{1}{2}$ cm groups.

	n	6.0 6.5	7.0 7.5	8.0 8.5	9.0 9.5	10.0 10.5	11.0 11.5	12.0 12.5	13.0 13.5	14.0 14.5	15.0 15.5	16.0 16.5	17.0 17.5	18.0 18.5	19.0 19.5	20.0 20.5	21.0 21.5	22.0 22.5	23.0 23.5
Russell's scad (Decapterus Russelli) F.L. AREA 2 SW-Coast	27							8	37	29	18	4							
AREA 3 Hambantota Banks	57						2	12	33	7	7	17	19	2					
Golden scad F.L. (Selar kalla) AREA 4 SE-Coast	44					5	33	29	16										
Deep-sea fish T.L. (Cloropththalmus bicornis) AREA 6 Pedro Bank	73				3	15	26	42	12			1							
Indian mackerel F.L. (Rastrelliger kanagurta) AREA 5 Trincomalee	36	5	19	38										3		16	6	6	5
Half beak F.L. (Hemiramphus Georgii) AREA 3 Hambantota Banks	69													7	6	20	49	11	7

Table III. Length-weight relationships. Mean length (cm) and weight (kg) of samples.
TL - total length, FL - fork length.

Snappers			Groupers			Long-nosed pig - face bream			Starry pig-face bream			Large-eyed bream			Trevally			Sweetlip		
n	$\overline{TL}$	$\bar{W}$	n	$\overline{TL}$	$\bar{W}$	n	FL	$\bar{W}$	n	$\overline{FL}$	$\bar{W}$	n	$\overline{FL}$	$\bar{W}$	n	FL	$\bar{W}$	n	TL	$\bar{W}$
9	28, 5	0, 32	25	62, 9	3, 32	3	61, 3	3, 63	10	55, 1	2, 95	11	24, 5	0, 45	46	57, 3	n=16 3, 81	9	58, 2	2, 59
1	64	5, 0					51, 5	1, 35	4	55, 0	2, 63				2	70, 5	6, 00	4	61, 0	3, 18
32	40, 6 x)	1, 23					66	4, 09	7	59, 1	3, 82				(1	84	6, 5)			
7	64	6, 43					48	1, 0	1	61, 0	3, 8				(5	61, 4	4, 42)			
7	62, 1	3, 43					57, 1	2, 86	8	57, 5	3, 5				(4	61, 3	4, 4)			
3	61, 7	5, 83							6	47	2, 83				67	51, 9	2, 75			
6	61 x)	4, 67																		
2	68, 5	7, 3																		

x) FL

ANNEX I.

REVIEW OF PREVIOUS RESOURCES SURVEYS AND EXISTING FISHERIES

By

G.H.P. De Bruin[x]

1. Indigenous Fisheries

The coastline of Sri Lanka is 850 miles long, and wherever fishing off this coastline has been possible there have developed throughout the centuries traditional methods of catching fish. The most common gear used by the local fishermen is the shore seine or "ma-dela". It is operated from a 20-30 ft long, wide, flat-bottomed boat known as the "ma-del paru". The nets are manually operated - which consists of pushing the boat with the net out to sea, shooting the net and then hauling the net on to the shore.

Shore seining or beach seining can be successfully carried out only in calm weather and is hence a very seasonal operation governed by the monsoons. Active fishing takes place during the north-east monsoon on the north-west, south-west and south coasts while in the south-west monsoon it takes place on the east and north-east coasts. The operation of the shore seine is limited to a radius of 1 to 1½ miles from the shore and where the bottom of the sea has no sharp rocks or other obstacles. The species of fish caught are small varieties such as herring, Indian mackerel, sardines, silver biddies or the juveniles of larger species such as horse mackerel, queen fish, trevally, Spanish mackerel, mackerel tuna, frigate mackerel, sharks and skates.

According to Canagaratnam (1965) the beach seine was the most important single contributor to the coastal fishery. About 3 000

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units are available throughout the country, but no more than a fraction of these are used on any particular day. The landings of beach seines increased from about 19 000 metric tonnes in 1959 to about 32 000 metric tonnes in 1961 and again decreased to about 24 000 metric tonnes in 1963.

Although the total landings from beach seines appear to be high, it is not a very efficient form of fishing, considering the large number of people employed in a single operation and that the catch per man-hour is only about 8 lb. The only argument in favour of continuing with this form of fishing is that it is totally labour-intensive and all the gear and boats used in the operation are locally made from local materials.

Apart from the beach seines the other traditional craft are the log rafts called "teppams" or "katumarams", the dugout canoes or "vallams" and the outrigger canoes or "orus". These craft carry out drift net fishing (nets made of cotton or hemp in the past and nylon polyamide at present), bottom set net fishing for demersal fish, prawns and lobsters, trolling for pelagic fish, and bottom longlining for demersal skates and sharks in the Palk Bay region. Apart from this, the large "orus" carry out pole and line fishing for skipjack and juvenile yellowfin tuna in the deeper waters. Most of these craft operate in a zone not more than 5 miles from the shore, with the exception of the pole and line fishermen who go out as far as 20 miles from the shore.

In 1959 the number of traditional craft was around 13 000 - 14 000 and brought in about 29 000 metric tonnes of fish. In 1963, 17 000 traditional craft brought in about 49 000 metric tonnes of fish.

The traditional craft were of small size. They were either paddled out to sea for fishing operations or driven by sail. The area of the sea exploited by these craft was limited and extension of their operations into deeper regions was not possible until the traditional craft were motorized or replaced by different hulls driven by outboard or inboard motors.

Accordingly, a scheme to motorize the traditional craft was introduced, and by 1963 there were well over a thousand such craft which brought in about 8 000 tonnes of fish (de Zylva 1958, Canagaratnam, 1965). However, considering the small size of the traditional craft and the limited working and storage space on board, it appeared that it was necessary to introduce new types of hulls driven by inboard or outboard motors. The first type of boat to be introduced was the 28 ft fibreglass boats driven by outboard motors. The latter have replaced many of the "orus" and "teppams" and the catch has increased, no doubt, because more fishing gear such as small-meshed nylon nets could be carried in the fibreglass hulls. They were also able to operate at greater distances from the shore and were not at the mercy of the wind or weather. The 28 ft wooden boats driven by 25-40 h.p. diesel engines were equipped with a 100-hook floating longline gear, designed by the Japanese to catch yellowfin, marlin, spearfish and sharks in near-oceanic waters.

The first longline fishing boat went to sea in 1957 and many followed suit soon after. Although the number of yellowfin and marlin caught by this method was small, the many sharks taken in the initial stages made it economical.

A summary of statistics of the longline operations during 1960 (each unit with 100 hooks), and the catches in the near-oceanic waters off Negombo are given below.

Catches by floating longline, 1960. (Numbers caught)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Yellowfin Tuna	10	24	33	34	7	34	13	16	8	24	2	1
Marlin Sailfish	44	77	67	25	9	40	26	33	21	16	26	24
Sharks	134	180	186	80	51	230	156	183	93	82	55	77
Total no. operations	134	135	161	103	70	119	104	155	72	112	34	62

(Compiled by de Bruin, 1960, unpubl.)

Interest in this method of fishing gained momentum as it was a new exciting method and large species like yellofin, marlin and shark were brought ashore. The time taken for each fishing operation was not too long and seldom exceeded 8-10 hours. However, interest soon waned as the price of bait shot up and was sometimes unavailable and the catch/effort did not show any increase with time.

It seemed that the new scheme to construct larger boats and equip them with modern fishing gear was doomed to failure. Fishermen soon stopped operating and sold their boats and fishing gear at very low prices rather than sustain losses.

2. Exploratory Fishing Under the Colombo Plan 1955-1960.

The Department of Fisheries had, however, already carried out experimental fishing with other types of gear such as trawls, bottom longlines, drift nets, shark lines, hand lines, troll lines and lift nets with light attraction, in collaboration with Canadian fisheries biologists under the Colombo Plan (Jean, 1958).

A summary of the results of the operations using the two 45 ft wooden Canadian boats "North Star" and "Canadian" are given below:-

Average catch per man-hour for gear used by "Canadian" and "North Star" from April 1, 1955 - March 30, 1957. Operations by M.F.V. "Canadian".

Gear	Catch (lb)	No. of man-hours	Catch/man-hour
Otter trawl	10.207	1223.2	8.3
Mid-water trawl	8	28.0	0.3
Gill nets	1.762	2041.5	0.9
Hand lines	2.965	521.5	5.7
Troll lines	2.533	2816.6	0.9
Ring net	285	16.4	17.4
Lift net	18.941	244.4	77.5
Porpoise harpoon	600	9.0	66.6
Lobster pots	53	246.0	0.2

Average catch per man-hour from April 1, 1955 - March 30, 1957. Operations by M.F.V. "North Star".

Gear	Catch (lb)	No. of man-hours	Catch/man-hour
Bottom longline	48,944	2427.9	20.2
Shark line	17,844	417.6	42.7
Drift line	1,023	109.5	9.4
Hand line	1,075	207.6	5.2
Troll line	1,868	1624.4	1.1
Squid jigs	0	18.0	-

The best catches were obtained by the "Canadian" with the use of light attraction and lift nets. Curiously enough, gill nets, as fished with the "Canadian", were not successful. The best catches obtained by the "North Star" were with bottom longlines and shark lines.

Bottom longlining. A more detailed picture of the operation of bottom longlines on board the "North Star" is given below.

Longlining operations from April 1, 1955 to March 30, 1957. "North Star".

Total number of sets	224
Total number of hooks	244,276
Total number of hours fished	809.3
Total catch (lb)	48,944
Average duration of set in hours	3.6
Average number of hooks per set	1100
Average catch per 100 hooks	20
Average catch per set	218
Average catch per hour fished	60
Average catch per man-hour	20

The most promising type of gear from the results of the Canadian Experimental Fishing Operations was the bottom longline. The catches around the coast of Sri Lanka were not uniform. Some areas were much better than others, e.g. the Passikudah-Batticaloa sector of the east coast yielded an average of 38.8 lb per 100 hooks, the Pedro Bank yielded 33.1 lb per 100 hooks, the area Virgel-Rocks to Passikudah yielded 28.4 lb per 100 hooks while two different areas off Galle yielded an average of 27.2 and 27.6 lb per 100 hooks respectively. In general bottom longline catches were three times as large on the east coast and south-west coasts than on the west coast, as can be seen below:-

Comparison of longline catches on the east, west and south-west coasts of Sri Lanka from April 1, 1955 - March 30, 1957.

Area	No. of sets	Hours fished	Catch (lb)	Catch/100 hooks
EAST COAST				
Pt. Pedro to Batticaloa	154	545.6	38,551	22.6
WEST COAST				
Puttalam to South of Colombo	44	184.5	3,183	7.9
SOUTH-WEST COAST				
Galle	22	72.6	23,800	27.5

Shark lining. A more detailed account of shark lining is given below. Shark lining was carried out between Chilaw and Puttalam on the west coast and off Mullaitivu on the east coast in 1956. In 1957 several sets were made off Galle on the south-west coast.

Summary of shark lining operations of "North Star" from February 3, 1956 to March 30, 1957.

Total number of sets	34
Total number of hooks	2 632
Total number of hours fished	139.2
Average duration of set in hours	4.1
Average number of hooks per set	77.4
Total catch (lb)	17,844
Average catch per per set	524.4
Average catch per 100 hooks	678.0
Average catch per man-hour	42.7

Shark lining and bottom longlining were carried out simultaneously in the Galle area in 1957.

Comparison of catches made with shark lines and longlines off Galle in January, February, March 1957.

	Shark lines	Longlines
Total number of sets	16	22
Total number of hours fished	57.2	72.6
Total number of hooks	1.220	23.800
Average duration of set in hours	4.6	3.3
Total catch (lb)	13,848	6,542
Average catch per set	865.5	297.4
Average catch per 100 hooks	1135.1	27.5
Average catch per man-hour	80.7	30.0

In spite of the fact that shark lines catch fish of poorer quality, they appear to be as profitable as longlines.

Hand lining. The boats "North Star" and "Canadian" also carried out hand lining operations off the coast of Sri Lanka between November 9, 1955 and February 1, 1957. The results are summarized below:-

Summary of hand lining operations carried out by local fishermen aboard "Canadian" and "North Star" from November 9, 1955 to February 1, 1957.

	"Canadian"	"North Star"	Both vessels
Total number of days out	32	12	44
Total number of hours fished	129.5	57.2	186.7
Total number of man-hours	521.5	207.6	729.1
Total number of line-hours	607.5	234.1	841.6
Total catch (lb)	2965	1075	4040
Average catch per day out	92.6	89.6	91.8
Average catch per line-hour	4.9	4.6	4.8
Average catch per man-hour	5.7	5.2	5.5

Hand lining operations were also carried out on the Pedro Bank off Point Pedro from July 22 to October 25, 1956. The results are given below:-

Total number of days out	35
Total number of hours fished	211.0
Total number of man-hours	1853.0
Total catch (lb)	8976
Average catch per day out	256.4
Average catch per man-hour	4.8

Lift net fishing. Lift net fishing with light attraction was carried out by Mr. Barry, Canadian Master Fisherman, in Trincomalee Harbour in July 1956. Two 1 000 Watt bulbs were first switched on. The plankton which had been attracted by the bright lights now concentrated under the bulb of low wattage in the form of a red ball about one ft in diameter. Immediately the fish in the vicinity aggregated and started attacking the plankton. The 1" meshed lift net which was lying well under the school of fish was then quickly lifted up.

The results of fishing in Orlando Cove Trincomalee are given below:-

Operation of lift net with lights in Orlando Cove Trincomalee on July 16 - 17, 1956.

Set No.	Time of lifting	Catch (lb)
1	8.15 p.m.	100
2	8.30 p.m.	224
3	8.45 p.m.	280
4	9.00 p.m.	224
5	9.15 p.m.	308
6	9.40 p.m.	182
7	9.50 p.m.	280
8	10.10 p.m.	295
9	10.25 p.m.	125
10	10.35 p.m.	290
11	10.50 p.m.	156
12	11.05 p.m.	127

Set No.	Time of lifting	Catch (lb)
13	11.25 pm	119
14	11.45 pm	127
15	mid-night	84
16	0.15 am	118
17	0.35 am	70
18	0.45 am	28
19	1.00 am	89
20	1.15 am	84
21	1.30 am	20
22	1.50 am	84
23	2.00 am	5
	Total	3466

A total of 46 lb of squid were also taken in these operations.

The results show that the best catches are obtained between 8.30 pm and 10.30 pm. After 10.30 pm the catches get progressively reduced. The main species caught is the Russel's scad which swarms regularly in Trincomalee Harbour in the months of July and August. Other species, apart from Decapterus russelli, which are attracted by light are the Carangids, Selar kalla and Selar malam, but these do not form as dense aggregations under the light as Decapterus russelli. Some squid were also caught during the above operation but not in as large numbers as the Russel's Scad.

Otter trawling. Otter trawling trials were carried out with the "Canadian" using a "three-quarter yankee 35" trawl of the type used by small trawlers along the east coast of Canada. The trawl had a 40 ft head rope and a 50 ft ground rope. The cod end had 3 3/4" stretched mesh. The results are given below:-

Area	No. of tows	No. of hours fished	Total catch (lb)	Catch/tow (lb)
Chilaw	48	42.1	605	12.6
Negombo/Colombo	12	12.8	574	47.8
Mankerni (East Coast)	84	85.1	1093	13.0
Mullaitivu (East Coast)	118	134.0	7399	62.7
Point Pedro (North)	2	2.0	89	44.5
Kayts (North)	5	5.8	42	8.4
Palk Bay	20	24.0	405	20.25
All areas	289	305.8	10,207	35.3

The average catch made by the "Canadian" in trawling operations was only 35.3 lb per tow of an average of one hour's duration. This is extremely poor compared to what might be expected from commercial trawling operations. The poor catch in the initial stages was to be expected as the operations were preliminary survey operations. Many a time the net got caught on rocks and reefs and it took a long time before suitable smooth trawling grounds with adequate concentrations of fish were discovered. Pearson (1926) had already indicated that the continental shelf around Sri Lanka was unsuitable for trawling on account of the rough bottom. He also mentioned that the only ground that would yield good catches was the Palk Bay region, but the fish were of third rate quality and consisted mainly of silver biddies or poor quality fish. Two grounds in Indian waters were discovered by Pearson and Malpas and these trawling grounds have been the subject of continuous study by research officers of the Department of Fisheries (Sivalingam and Medcof 1957, Sivalingam 1964, Mendis 1965, Sivalingam 1966, Sivalingam 1969, Munasingle 1969, Munasingle 1970, Munasingle 1972).

It was thought at that time that trawling grounds around Sri Lanka were not available. However, Mr. Barry, Master Fisherman of the Canadian Fisheries Project and de Bruin carried out preliminary trawling surveys for prawns and demersal fish and found that there were indeed limited areas which could be trawled on a commercial scale.

The trawl used in the preliminary surveys by Barry was considered to have too large meshes in the cod end. New trawls were therefore constructed of 2" mesh or 1 3/4" mesh in the cod end and these were used in the future survey operations.

The trawling grounds located were over the entire Palk Bay area, which in the main had large quantities of silver biddies or Leiognathus. As much as 1 000 lb of Leiognathus per hour of trawling was the average catch in the initial stages with the new trawl net. At night in certain regions, such as off Kayts, near Delft Island, between Kachchitivu Island and Rameshwaran and along the three fathom stretch from Pesalai to Rameshwaran, prawns were also found - the average catch per hour was 20 kg. The species which were predominant in the catches were Penaeus semisulcatus with a small number of Metapenaeus burkenroadi and Penaeus merguiensis.

Trawling grounds were also discovered south-east of the Mullaitivu lighthouse at depth of 4-13 fathoms. Prawns in this region were restricted to depths of 8-13 fathoms south-east of Mullaitivu lighthouse, and these could be caught only at night. The prawn species were: Penaeus semisulcatus, Penaeus indicus, Metapenaeus affinis and Metapenaeus monoceros. These were the larger varieties. Large quantities of small penaeids were also obtained in these operations. They were: Metapenaeus stridulans, Trachypenaeus salaco, Trachypenaeus sedili and Atypopenaeus compressipes. The average catch per hour of trawling consisted of 500 lb fish and 20 lb prawns.

The species of fish caught on the mudbanks off Mullaitivu were: Leiognathus spp., Drepane punctata, Ephippus orbis, Mene maculata, Otolithus ruber Lactarius lactarius and Trichiurus savala, to mention a few.

On occasions, especially during the daytime, and operating with a faster fish trawl, there were considerable numbers of Lactarius lactarius and Caranx carangus in the catches.

Other grounds were discovered lying at a radius of 2 miles from the old railway bridge, Talaimannar Piercruit, which had prawns as well as fish; within Portugal Bay to the north-west of Sri Lanka at depths of 3-5 fathoms; off Chilaw at depths of 3-6 fathoms - a rich trawling ground for prawns; off Negombo at depths of 4-6 fathoms, a ground rich in prawns and small fish; off Mutwal at 3-7 fathoms with fish and prawns and in the 10 fathom stretch between the Drunken Sailor Rock, Galle Bruck, Colombo and Mt. Lavinia.

All these grounds are being fished by local fishermen and are yielding good catches of small fish and prawns - the total yield of prawns, however, from all these regions does not amount to more than 1 000 tonnes per year.

There are two other potential prawn grounds, one lying east of Valaichenai on the east coast at depths of 22-28 fathoms and the other off Flagstaff Point, off Trincomalee, at depths of 17-25 fathoms, but these have not been adequately surveyed as yet.

3. Further Exploratory Fishing Operations

Mr. Illugasson/FAO Master Fisherman and de Bruin continued exploratory trawling for prawns and fish in the continental shelf areas around Sri Lanka from 1961-1963 but were unable to locate grounds in addition to those discovered in earlier surveys. However, more efficient trawl gear was fabricated by Mr. Illugasson and this is now being used by some of the fishermen engaged in commercial trawling for small fish and prawns.

Lobster resources. The genus of lobster in Sri Lanka is Panulirus and consists of six species, namely, homarus, longipes, penicillatus, versicolor, polyphagus and ornatus. Surveys for spiny lobster have been carried out since 1958 on the east coast and on the west coast, but traps, of the Canadian Parlour and Bed-Room type, were inefficient on the east coast. On the west coast traps were effective and on average caught three lobsters per trap per night. The species caught by traps were Panulirus homarus, P. Longipes and P. Penicillatus. On the west coast the dominant species was P. Homarus and it constitutes nearly 90% of all lobsters caught in the island today. On the east coast north of Arugam Bay and on the north-west coast from Silavathurai to Mannar the dominant variety is P. versicolor.

Traps did not prove popular with local fishermen as they were expensive to make and losses were heavy during stormy seas. Local fishermen use bottom set nets from the discards of the drift net fishery. Many divers, about 300 in number, also make a living from catching lobsters, especially at night.

The lobster resources of the Island are found generally at depths of 1-10 fathoms and are being very intensively exploited at the moment. The total catch for the Island does not exceed 150 tonnes per annum.

The methods for capturing lobsters and the distribution and ecological preferences of the different species are discussed by de Bruin, 1960, 1962, 1965.

Gill net fishing. A summary of the gill net operations conducted by the Canadian boat "Canadian" are given by Jean (1958) and appear very discouraging. The nets were, however, anchored as bottom set nets on the floor of the sea.

Summary of gill net operations off "Canadian" from April 19, 1955 - February 8, 1957.

Total number of hours fished	680.5
Total surface of net (ft^2)	393.066
Total catch (lb)	1762
Average catch per unit of gear	44.8
Average catch per man/hour	0.8

Drift net fishing. de Bruin (1970) reports on the results of drift net fishing in Sri Lankan waters during 1966-1968 with nylong gill nets and the results of the operations for 1968 are summarized below. The results showed that drift net fishing was indeed a lucrative method and that a boat the size of "Canadian" could bring in an average weight of 1 000 lb of fish per day if she were to use 30-40 nylon nets in the operations and the nets were set at or a little beyond the continental edge.

Drift Net Fishing off Colombo 1968.

	Jan.	Feb.	March	April	May	June
Total catch (lb)	3532	3302	10055	24276	30425	31912
No. of operat.	8	9	22	39	30	39
Catch/operat. (lb)	441	366	457	622	1014	818
	July	August	Sep.	Oct.	Nov.	Dec.
Total catch (lb)	67572	66681	99678	31469	50605	4365
No. of operat.	45	56	82	53	55	10
Catch/operat. (lb)	1501	1190	1215	593	920	436

Drift Net Fishing off Valaichenai, East Coast, 1968.

	Jan.	Feb.	March	April	May	June
Total catch (lb)	8604	31074	32341	32849	12780	1679
No. of operat.	13	62	44	41	32	7
Catch/operat. (lb)	661	501	735	801	399	239
	July	August	Sep.	Oct.	Nov.	Dec.
Total catch (lb)	3275	3301	6292	14154	15937	37433
No. of operat.	6	16	20	32	9	39
Catch/operat. (lb)	239	206	314	442	1770	959

Drift Net Fishing off Kalpitiya, North-West Coast, 1968.

	Jan.	Feb.	March	April	May	June
Total catch (lb)	45013	30609	11801	9430	-	-
No. of operat.	50	45	17	15		
Catch/operat. (lb)	900	680	694	628		
	July	August	Sep.	Oct.	Nov.	Dec.
Total catch (lb)	-	-	-	39701	40853	34792
No. of operat.				31	46	35
Catch/operat. (lb)				1280	888	994

Drift Net Fishing off Tangalle, South Coast, 1968.

	Jan.	Feb.	March	April	May	June
Total catch (lb)	5037	10780	10120	34606	16734	18257
No. of operat.	16	24	36	64	25	14
Catch/operat. (lb)	314	449	281	540	669	1304
	July	August	Sep.	Oct.	Nov.	Dec.
Total catch (lb)	108055	103557	75300	18179	2965	14553
No. of operat.	58	63	40	13	2	15
Catch/operat (lb)	1862	1643	1882	1013	1482	970

On the west coast the offshore catches consisted predominantly of skipjack, yellowfin tuna, barracudas, frigate mackerel, swordfish, marlin, sailfin and sharks, whereas the sets made within the shelf area caught only a little tuna, and where tuna was caught it was mackerel tuna. Other species caught within the shelf were Spanish mackerel, rainbow runner, som bill fish and jack mackerel. The catch rates were higher off the south and south-west coasts than on the east coast. On the south and south-west coasts there was a special abundance shift with best catches in the south-west monsoon period while on on the east coast the north-east monsoon period gave best catches.

Sivalingam 1964 outlines the results of bottom longlining and hand lining operations on the Pedro Bank in the month of August

1961. In the bottom longline construction, the ground lines were 18 lb steam-tarred cotton rope, each 50 fathoms long with side lines or "gangings" 18" long. 35 hooks were attached to the main line $1\frac{1}{2}$ fathoms apart. Clupeids and squid were used as bait. In the areas where trials were carried out the bottom appeared to change rapidly from one type to another. The initial trials were carried out north-east of Point Pedro at depths of 10-40 fathoms. The average catch for these trials was 8.9 lb per 100 hooks as compared to trials conducted earlier in 1956, which gave 31.6 lb per 100 hooks (Jean, 1958).

In another area east of the Obelisk lying south of Thalayaddy, eight lines were used for hand lining operations, and after $5\frac{1}{2}$ hours the catch was only 15 lb. Two tubs of longlines (with about 560 hooks) were then shot in the same area and the catch in $2\frac{1}{2}$ hours was only 35 lb. Immediately afterwards, hand lining was again tried and resulted in a catch of 88 lb after two hours fishing.

At greater depths, 38-45 fathoms, the catches were slightly better and worked out to 26 lb per man-hour for hand lining and 18.2 lb per man-hour for bottom longlining. On the average for three trips the catch per man-hour for hand lining was 9.7 lb and that for bottom longlining was 19.4 lb at depths of 38-45 fathoms.

Berg 1971 carried out investigations into the bottom conditions and the possibilities for marine prawn and fish trawling on the north and east coast of Sri Lanka. He mentions that there are 3 000 km^2 of soft bottom situated in the Palk Bay and south-east of Mullaitivu and 5 000 km^2 of hard bottom on the Pedro Bank and the regions north of Pedro Bank along the south-east coast of India. The soft bottoms consist of mud, including organic material, and the hard bottoms of coral, shell and flat rocks covered with gorgonids and sponges. About 2 000 km^2 in the Batticaloa and Trincomalee regions are partially rough and steep bottoms and are impossible to trawl.

Berg refers to a prawn trawling operation carried out by Mr. Roy Pyne, a canadian Master Fisherman. In 11 hours fishing on the traditional prawn fishing grounds off Chilaw-Karukupone a total catch of 532 lb of prawns and 32 lb of fish were taken in December 1963. In January 1963 a total weight of 426 lb of prawns and 11 lb of fish were taken in a period of six hours, while in April 1963 a total weight of 333 lb of prawns and 2, 198 lb of small fish were taken in 42 hours fishing.

Off Kalpihya on the north-west coast there were hardly any prawns, but the average catch per hour of fish amounted to 386 lb. The varieties were mainly silver biddies, skate, catfish and the giant perch Lates calcarifer. Off Mannar, in the north of Ceylon, a total of 380 lb prawns were caught in 63 hours fishing, while the corresponding weight of fish was 47, 513 lb. Off Talaimannar the total weight of prawns caught was 106. 5 lb while the weight of fish was 18, 608 in 39 hours fishing.

Off Pesalai in the Mannar region 1650 lb prawns were caught in 155 hours fishing while the corresponding weight of fish was 37, 997 lb. Off Kayts the total weight of prawns in 49 hours fishing was 80 lb while fish amounted to 8581 lb. Off Kankesanturai (K. K. S.) only two lb prawns were caught in 10 hours fishing while the weight of fish was 2465 lb. Off Boulder Point on the east coast 18 lb of prawns were fished in 7 hours while the weight of fish was 318 lb. Off Nayaru, further north, 28 lb of prawns and 450 lb of fish were taken in two hours fishing; off Kokkilai no prawns were caught in three hours fishing while the weight of fish was 180 lb. Off Mullaitivu, south-east of the lighthouse, 1922 lb prawns were captured in 305 hours fishing while the corresponding weight of fish was 55,634 lb.

On the Pedro Bank, fishing during June, the average catch/hour was 300 kg. The species were predominantly snappers, breams and groupers and Carangidae. The best catches were made at depths of 10-40 fathoms.

In Palk Bay the average yield was 800 kg fish and consisted mainly of Leiognathus and Drepane.

The Trincomalee and Batticoloa regions averaged 130 lb/hour. Berg estimates that a catch of 5 000 to 10 000 tonnes may be expected annually from the Pedro Bank and could accomodate a trawler fleet of 6-8 trawlers.

Demidenko 1972 outlines the results of the joint fishery investigations with the Soviet SRTM "Optimist" (of about 500 GRT) during March - December 1972. The survey covered the north-west and north-east of Sri Lanka and the Wadge Bank. The survey included 400 trawl hauls as well as some experimental fishing with gill nets.

The major new discovery was the location of a deepwater prawn and lobster ground west of Kudremali Point: 79°23' E - 79°40' E, 08°30' N - 08°48' N.

The area was about 200 miles^2.

The total catch including fish	-	49157 lb (22344 kg)
The total catch prawns	-	10,519 lb (4781 kg)
The total catch lobsters	-	12,963 lb (5892 kg)

Catch per hour:

Prawns	-	82.5 lb or 37.40 kg
Lobsters	-	101.67 lb or 46.21 kg
Prawns/lobsters/fish	-	385.5 lb or 175.24 kg

Some of the species of fish, Centrolophus, Cubiceps and Chlorophthalmus, are edible and formed a greater part of the catch. The depths at which these trawlings took place varied from 200 - 350 m.

In comparison the catches made on a similar ground off Quilon, India, ranged (for prawns) from 118 - 224 kg per hour while the catch for lobster ranged from 245 kg - 346 kg per hour. The catches off Ceylon were thus much poorer than off Quilon.

The pelagic waters were found to be very poor in fish. During the entire period of scouting only seven schools of fish were seen off the continental shelf.

Trawling for fish on the Wadge and Pedro Banks ranged from a few pounds to 100 - 200 kg per hour of trawling.

Some catches of deep sea lobster were found on the Pedro Bank slopes and varied from 30 - 150 kg per two hours trawling.

Pelagic trawling for Carangids proved a failure.

Joseph 1975, describes the results of purse seining for small pelagic species of fish at the tail-end of the north-east monsoon. Surface lamps, each of 500 watts in intensity were used for attraction of pelagic fish. The light intensity was changed to 1 500 watts between December 1973 and January 1974 and again changed to 3 000 watts between February and May.

On the west coast between November 1973 and April 1974 the major species caught in the purse seine were sardines, redbait and anchovies in the order of 34.5%, 30.8% and 13.6% respectively. On the south-west coast during the same period the major species caught were sardine, herring, anchovy and redbait in the order of 30.1%, 23.4%, 15.0% and 10.8% respectively. On the north-north-east coast the major species were sardine and anchovy which amounted to 76.5% and 19.2% respectively; on the north-east coast the major species were sardine, herring and Carangids forming 43.2%, 29.2% and 10.2% of the catch, while on the east coast during the same period the major species were sardine and herring forming 46.3% and 44.6% respectively.

In the western and south-western sectors high values of the major species were observed during December and January. These values gradually decreased in both areas from January to April. Catch per unit effort was higher in the west than in the south-west.

On the east coast high catch rates were observed during June, July, August and September. In north-eastern areas the monthly catch rate increased from 300 kg per set in May to 1 000 kg per set in July and dropped gradually to record 600 kg per set in October.

Sardinella jussieu, Sardinella longiceps, Sardinella fimbriata were the most abundant species among sardines. The Indian herring Amblygster sirm was caught in large quantities in the areas south-west, north-east and east with a bimodale distribution of length groups of 12.3 cm and 22.5 cm in the month of June.

Joseph indicates that there are 350 large outriggger canoes engaged in the pole and line fishery on the south-west coast between November and April and on the east coast between June and October. They use the redbait Dipterygonatus lencogrammicus as the main bait in pole and line fishing. These boats average only 9-10 days per month fishing due to the shortage of bait.

Sivasubramaniam 1975, states that of the estimated production of 100,000 tonnes of fish, skipjack tuna contributes about 10-12% which comes mainly from the drift net fishery. The potential for increased production is expected chiefly from the surface and sub-surface tuna, marlin and shark resources in the offshore and oceanic ranges.

Three boats of the Nichiro Fishing Company of Japan undertook a skipjack survey using the pole and line method of fishing. One of the boats also conducted drift net fishing operations. The bait species used in the pole and line fishery were Dipterygonatus leucogrammicus, Sardinella jussieu, Decapterus russelli, Caesio species (fusiliers), Allanetta forskali and Apogonid species. These showed low mortality rates in the bait tank. 36% of the live bait catches were made close to Chilaw on the west coast, 26% close to Boulder Point on the east coast, 26% off Trincomalee, 3.5% were made between Colombo and Galle, 2.4% between Galle and Batticoloa and 0.3% between Batticaloa and Trincomalee.

The capture of bait was possible only during the calm seasons on either coast. 66% of the total days spent at sea were spent on the capture of bait.

Approx. 410 tonnes of tuna (64.3% skipjack, 35.4% yellowfin and 0.3% mackerel tuna) were taken by the three vessels during the period of 579 days. Bait fishing took 384 days which left only 195 days for active pole and line fishing. Of this period, 148 days were spent on active pole and line fishing.

Wide coverage was achieved during the two inter-monsoon periods (2nd and 4th quarters); the highest catch/effort was obtained on the west coast and relatively high catch/effort was also made on the east coast during the 4th quarter of the year.

54.3% of the total catch was made during the 4th quarter, 16.7% during the 2nd quarter, 14.6% in the 3rd quarter and 14.4% in the 1st quarter. 211,225 kg (51.6%) of the catch was from the eastern side, 149,549 kg (11.9%) was from the south.

The pole and line fishery was successful within 60 miles from the shore except in the north-east and south-west quarters where there was only small success beyond this limit. Even within the 60 mile limit pole and line fishing began to decline towards the outer boundary.

Traditionally, the pole and line fishing seasons in Sri Lanka are August and September on the east coast and October to February on the south-west coasts. The results of the experimental fishing confirmed this. In the monsoon months on both coasts skipjack is caught by the drift net fishery; in the north-east monsoon on the east and north-east coasts; in the south-west monsoon on the north-west, west and south-west coasts, showing large quantities of skipjack below the surface during these seasons.

Anon. 1975, reports on the program carried out with the 500 GRT vessel "Hoyo Mara" from January to March 1975 which included hand lining, drift netting, and shrimp basket fishing off the north-west and north-east coasts. Demersal fish were located by echo sounder and fished with a vertical baited line. There were altogether 54 experiments. The best concentrations of demersal fish were located on the continental shelf in the north-eastern area. Closer to the coast the fish schools observed were smaller and only small quantities were caught.

In the north-west area less demersal fish were caught and their sizes were smaller than in the eastern area. Good concentrations of fish were, however, observed on the echo sounders when steaming around the southern part of the island but no fishing was attempted here. The hand line catches were dominated by reef cod in the north-west and white snapper in the north-east. Drift net catches were highest in the offshore waters of the north-west area and consisted of skipjack, yellowfin, mackerel tuna, sword fish and Spanish mackerel.

Sivasubramaniam 1977, describes the experimental fishery survey for skipjack and other tuna species by pole and line and drift net method in Sri Lanka conducted by the Japanese chartered vessel "Kosei Maru". The charter vessel was not able to carry out purse seining for live bait and had to rely on the lift net for this purpose. The redbait was outstanding as a live bait species followed by cardinal fish, fusiliers, tembang sardine, fringe-scale sardine and others. Pole and line methods are successful on the west coast in February, March, April and November. There are possibilities of establishing small-scale pole and line fisheries in Chilaw, Negombo, Colombo and Mullaitivu. Pole and line fisheries must be combined with drift net fisheries on a year-round basis for the maximum catch. Pole and line vessels should have sufficient fish storage facilities to permit longer endurance at sea which would increase the time for scouting and tuna fishing and thus the average catch for the day.

There is reasonably good similarity in the seasonal pattern in the catches of live bait and tuna which are very necessary for an effective combination of both fisheries.

"Kosei Maru" conducted pole and line fishing for 88 days - 32 days were devoted entirely to this method, while the balance was used for a combination of bait fishing and pole and line fishing or drift netting.

During this period only 60 tonnes of tuna were caught by the pole and line method. This was made up of 61% skip-jack tuna, (Euthynnus pelamis), 35.3% yellowfin tuna (Thunnus albacares) and 3.7% small tuna (Auxis thazard and Auxis rochei).

Using 100 drift nets an average of 208.26 kg of fish were caught per day. Drift net fishing was conducted for 49 days and the total catch was 10 tonnes approximately. The poor results were probably due to the fact that all the nets were of 7" mesh.

Surface schools of tuna showed heavier concentrations within the 50 mile limit and were very poor beyond 50 miles. Surface schools were very rare during the period June to September on the west coast.

Pajot 1977, as a result of exploratory fishing for live bait for the skipjack fishery and other commercially important small species of fish around the island from 1972 - 1977, makes the following recommendations:

There are sufficient live bait resources around the island for an expansion of the existing pole and line fishery as well as for an offshore pole and line fishery. Experiments with live bait showed that the traditional live bait Dipterygonatus lenco-grammicus showed no mortality in bait pens even after 36 hours. Sardinella jussieu, Sardinella finibriata and Sardinella albella had an average mortality rate of 20-25% after 6-9 hours in the bait pen which increased to 40% after 12 hours. Anblygaster sirm showed a mortality rate of 20-25% after 18 hours and 35% after 36 hours. Decapterus russelli showed a mortality rate of 2.5% after 8 hours, 13% after 18 hours and 2% after 36 hours.

Purse seining with light attraction proved to be a very efficient and economically feasible method for catching small pelagic species of fish. Introduction of purse seining within the limits set by the resources and existing fishing should be encouraged.

The average catch/purse-seine set calculated for each area was as follows: north-north-east - 1200 kg, north-east 721 kg, north-west 475 kg, east - 433 kg, west - 420 kg, south-west - 368 kg, south - 256 kg. The distribution of species vulnerable to light attraction is generally restricted to the 15 fathom depth line. Therefore, the actual exploitable area varies with the geographical position and tends to be much larger off the northern than off the southern part of the island. This may explain the better catch rates in the northern areas.

Three types of gear were used for capturing live bait and other small pelagic species. The overall average catch with these three types of gear were 56 kg, 262 kg and 580 kg for the lampara net, half ring net and purse seine respectively. There was a seasonal shift in catches in the west and south with peak catches in January and a decline till April; in the east with a peak in September; in the north-east in July and the north-north-east in May. It is concluded that the current (estimated) yield of 40,000 tonnes (mainly taken by beach seine) does not represent a full exploitation of these resources and the introduction of small purse seines is recommended.

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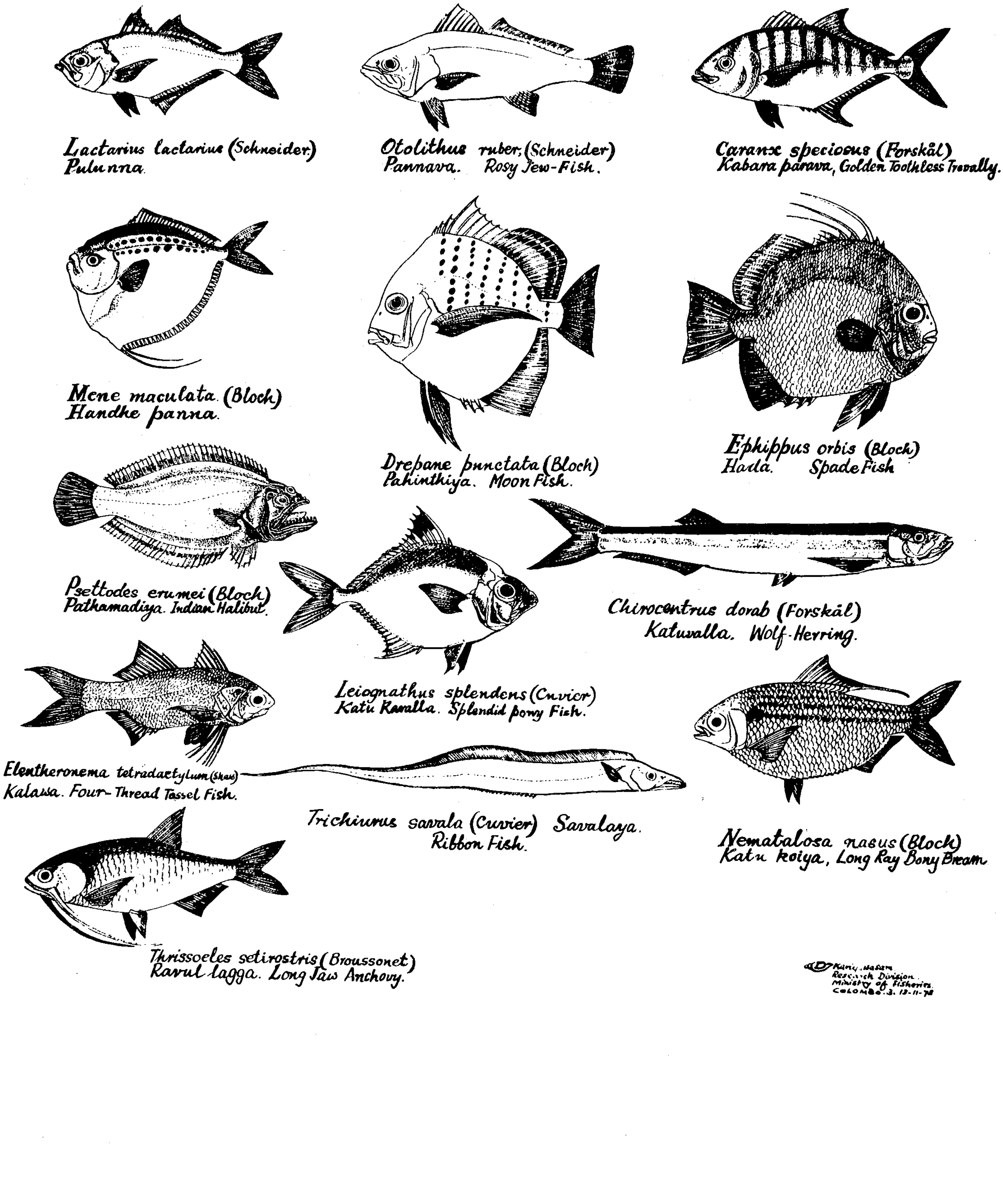
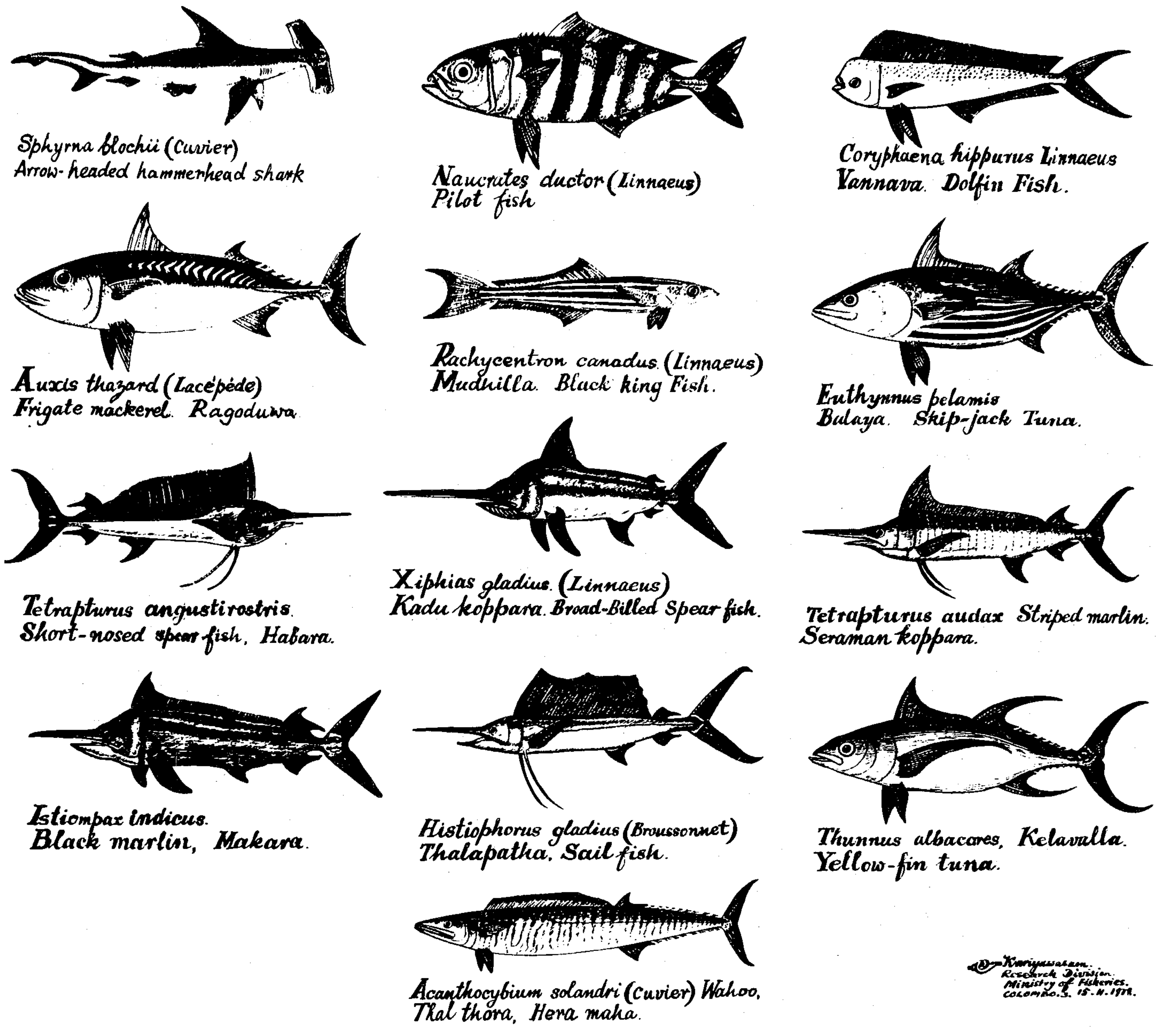
ANNEX II.

ILLUSTRATIONS OF FISH ACCORDING TO HABITAT

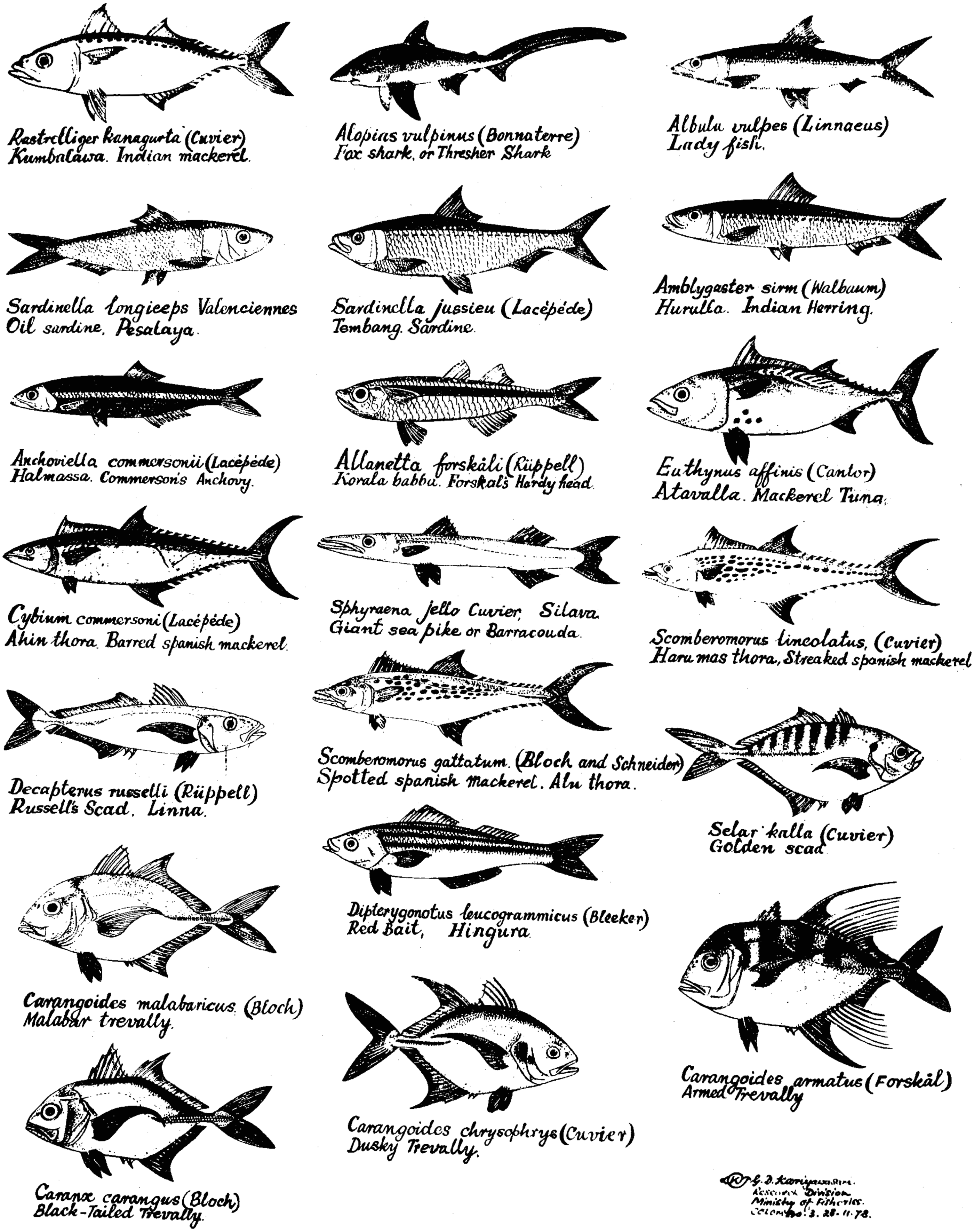
Drawings prepared by Mr. Kariyawasacu, Artist, Fisheries Research Station, Colombo, - from "Fishes of Ceylon" by I. S. R. Munro.



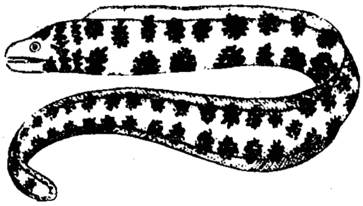
1. Mud-bottom fish



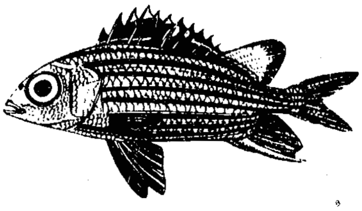
2. Oceanic fish



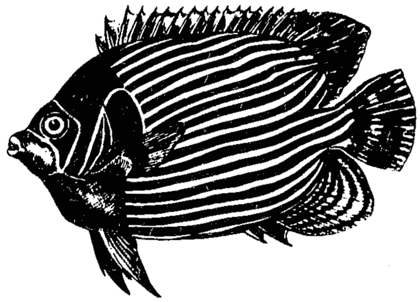
3. Neritic fish (on continental shelf)



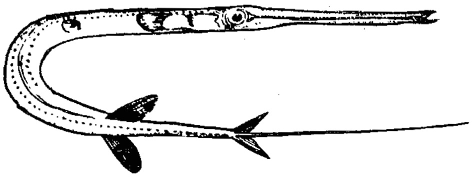
Echidna nebulosa. (Ahl)
Starry moray eel, Pulli gal-gulla.



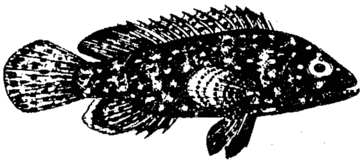
Holocentrus diadema Lacèpède.
Soldier Fish.



Pomacanthodes imperator (Bloch)
Imperial Angel Fish.
Kaha ivi namba.

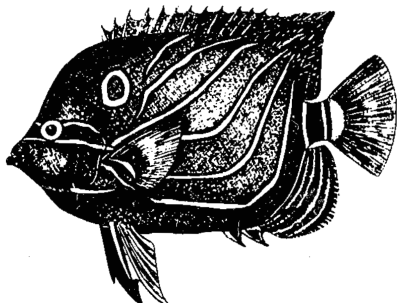


Fistularia villosa Klunzinger
Rough Flute mouth, Bombiliya.

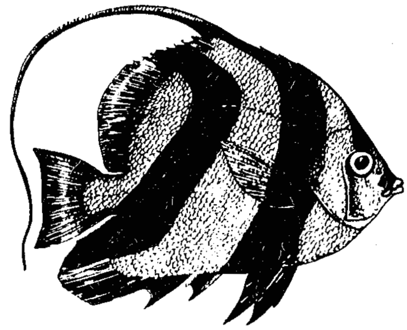


Epinephelus tauvina (Forskål)
Giant Grouper, Gal kossa.

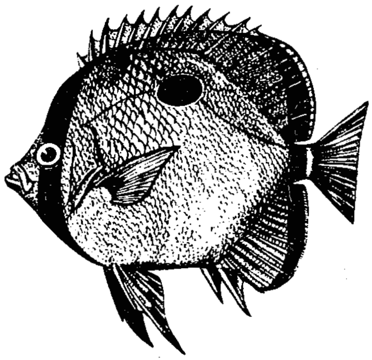
Dipterygonotus leucogrammicus Bleeker.
Red Bait, Hingura.



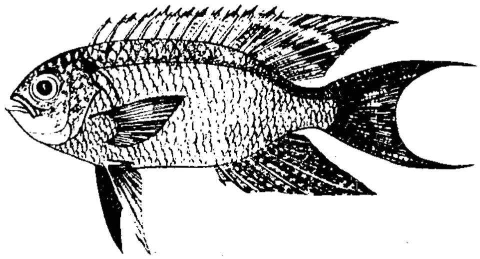
Pomacanthodes annularis (Bloch)
Ringed Angel Fish. Manamalaya.



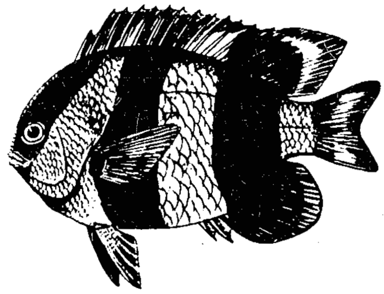
Heniochus acuminatus (Linnaeus)
Pennant coral Fish.



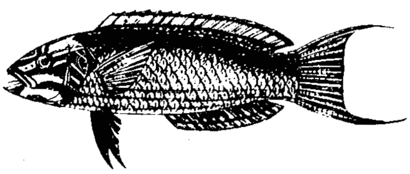
Chaetodon unimaculatus Bloch.
One-spot Coral Fish.



Pomacentrus cyanomos
Violet demoiselle.

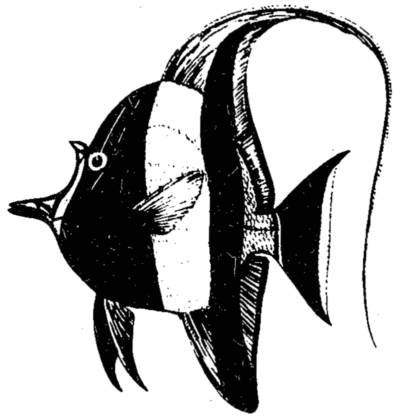


Dascyllus aruanus (Linnaeus)
Gal handha.

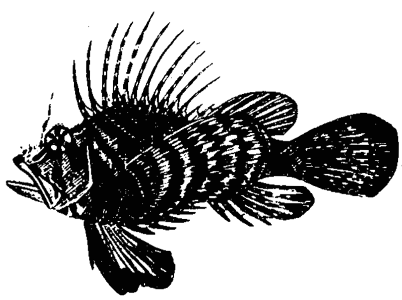


Thalassoma lunare (Linnaeus)
Green Wrasse.

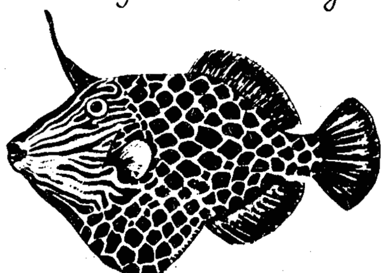
Acanthurus lineatus (Linnaeus)
Blue-Lined Surgeon-Fish. Seveya.



Zanclus cornutus (Linnaeus)
Moorish Idol.



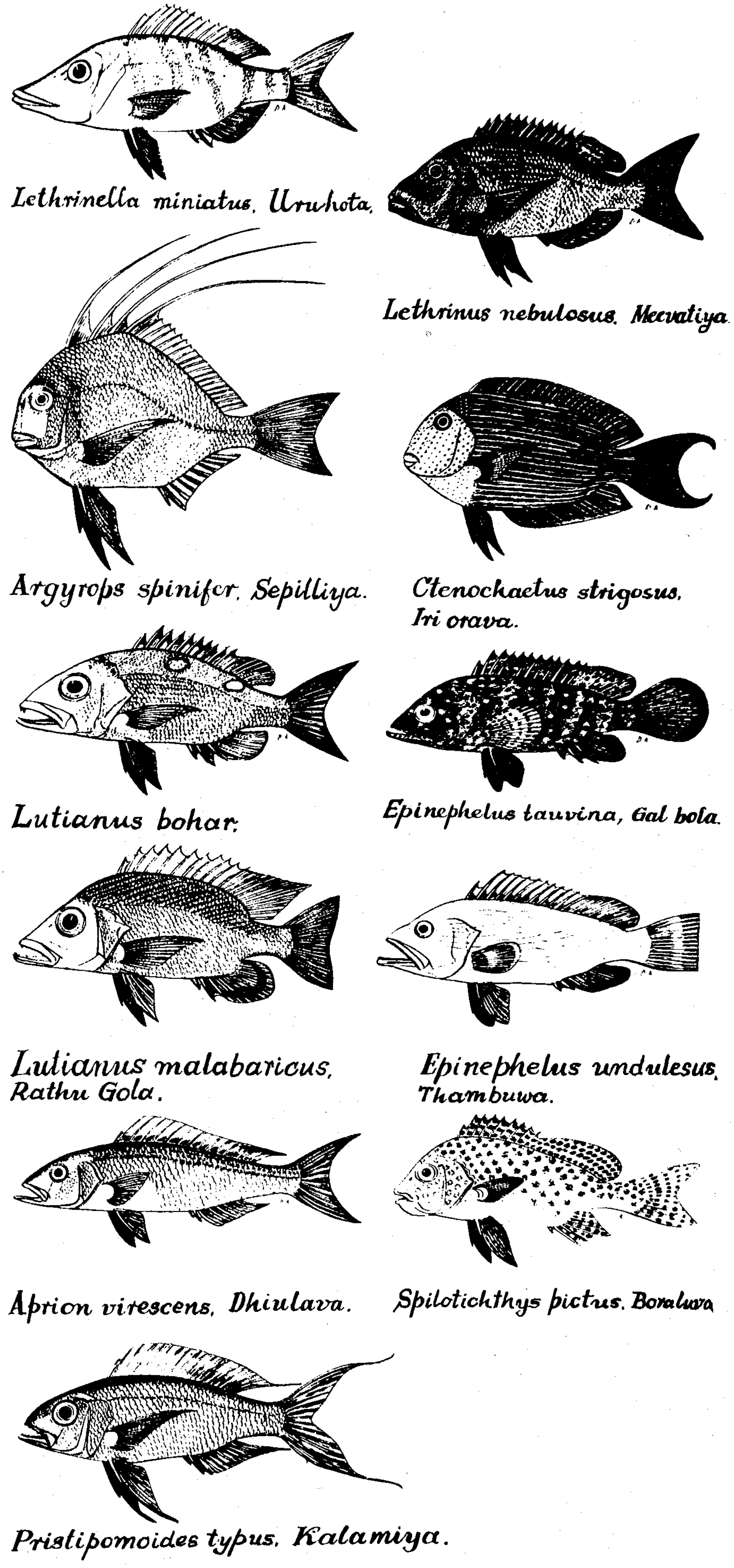
Dendrochiras zebra (Quoy and Gaimard)
Zebra Fire Fish.



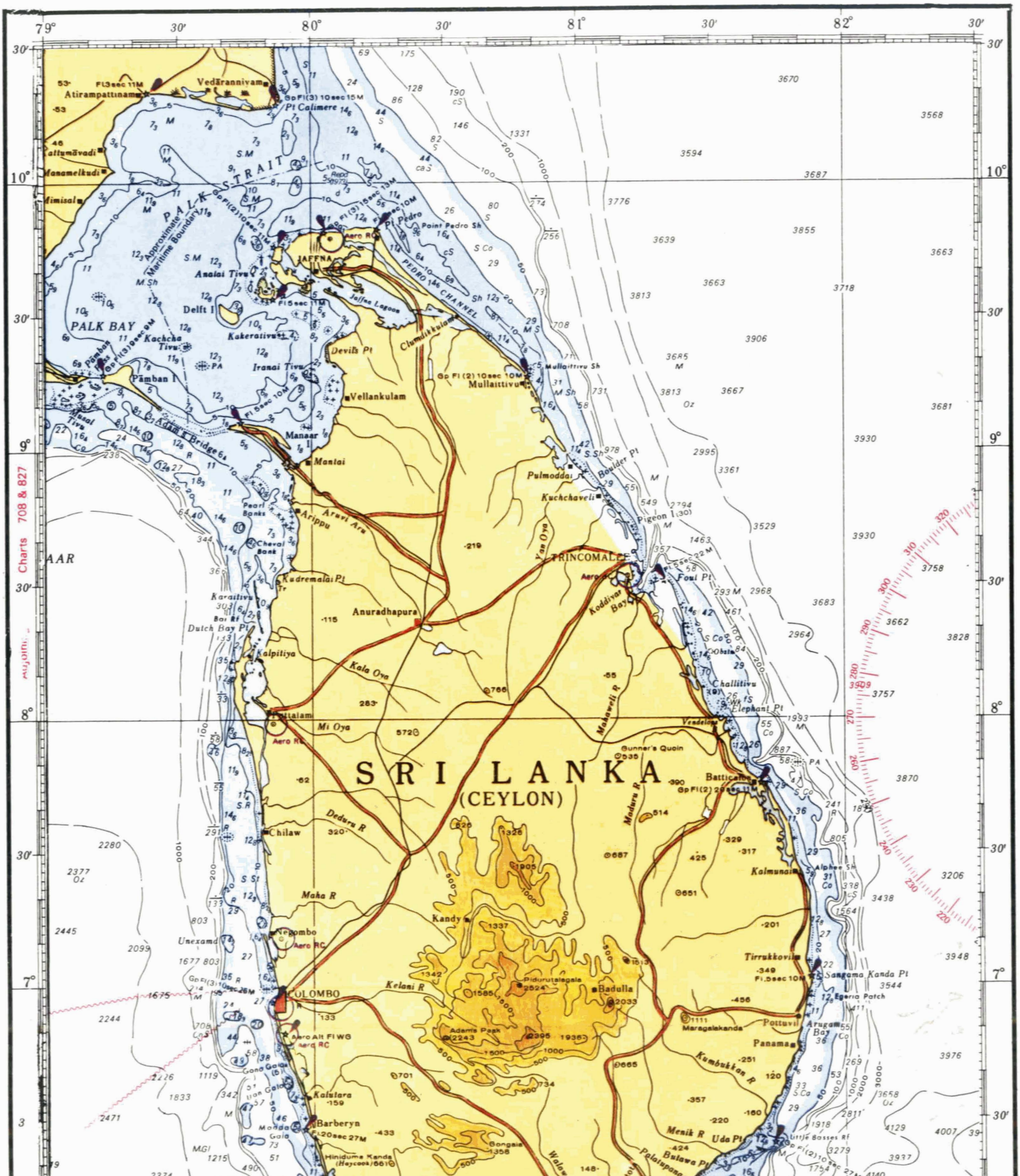
Amanses pardalis (Rüppell)
Spotted Leather-Jacket.

Kariyawasam.
Research Division.

4. Coral fish



5. Hard bottom fish



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