Exploratory fishing by R.V. VARUNA

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EXPLORATORY FISHING BY R.V. *VARUNA*

By
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July, 1969

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C O N T E N T S

FOREWORD

The long-felt need of suitable vessels for exploratory cum fisheries oceanography work since the inception of the Central Marine Fisheries Research Institute in 1947 was partially fulfilled first by the provision of the converted fishing trawlers M.O. KRISTENSEN and R.V. KALAVA in 1957 and subsequently in 1962 by the more sophisticated and specially built Research Vessel VARUNA through the courtesy of the Indo-Norwegian Project. Initially, for want of suitable fishing gear, only hydrographical data were collected, but after the later part of 1963 exploratory fishing was integrated with the programmes of the hydrographical studies.

R.V. VARUNA being fully equipped with the modern auxillary fishing appliances such as the echosounder and the Asdic, enabled carrying out exploratory surveys on the continental shelf and also on the continental slope, more particularly off the south-western coast of India, the fishery potential of which was hitherto very insufficiently known. The present report deals with the important findings in the exploratory surveys carried out in the south –western region. A wide variety of fishing gears viz., otter trawls, surface drift nets, handlines, purse-seines, long-lines, surface trolling and midwater trawls has been used with encouraging results. The discovery of varied species of deep sea fishes and deep sea prawns and lobsters some of which occurring in dense concentrations on the sea bed has opened new vistas for prospective commercial exploitation. The exploratory survey of the KALAVA fishing grounds using the echo-sounder in conjunction with the Asdic has furnished very valuable information on the nature, extent and the bathymetric distribution of these grounds. Certain characteristic echo-traces from deep scattering layers furnished evidence of the movements of the shoals of tuna and billfishes indicating their fair abundance in the region. These and other important findings are presented in this Bulletin as a preliminary report to make them available sufficiently in advance to those interested pending the publication of detailed accounts which is bound to take a considerable time.

The cruises were carried out under the leadership of my colleague Dr. E.G. Silas and it gives me great pleasure to place on record my high appreciation of the very arduous task he had undertaken and for furnishing very valuable information on the well coordinated exploratory surveys carried out by him on the south west coast of India in the form of this outstanding contribution. It may not be out of place to state in this connection he had taken upon himself this intensive investigation in addition to his regular programme of work mainly out of his initiative and interest. My thanks are also to other colleagues who participated in the exploratory cruises and extended all help and co-operation to make these investigations yield fruitful results. It is with pleasure that I express my thanks to the Indo-Norwegian Project for making available R.V. VARUNA and extending all possible help to the scientific staff of the Institute to conduct the research and exploratory cruises.

Mandapam Camp
July, 1969

S. JONES
Director
Central Marine Fisheries
Research Institute

EXPLORATORY FISHING BY R.V. *VARUNA*

By

E.G. Silas

Central Marine Fisheries Research Institute, Mandapam Camp.

INTRODUCTION

The rapid strides taken in the development of mechanised fishing fleet for fishing beyond the 5 to 10 kilometre traditional fishing limits in our waters are to some extent due to the encouraging results of exploratory otter trawlings carried out in earlier years. As pathfinders in these exploratory surveys, special mention should be made of the work done by the 'GOLDEN CROWN' (1908-11), "WILLIAM CARRICK" (1921-22), and "LADY GOSCHEN" (1927-30). The results obtained from these and other vessels have been documented on a number of reports (Anon. 1931, 1962; Chidambaram, 1953; Hefford, `1949; John *et al.*, 1959; Raj 1933; and Sorely, 1948). More recently, Rao (1969) has ably analysed and summarised the results of exploratory fishing carried out by many vessels including those of the Deep Sea Fishing Stations of the Government of India during the last 20 years.

Presently fishing by mechanised boats is almost exclusively for groundfish and in some place as off Bombay trawling is carried out in depths upto about 75 metres. Beyond this, the continental shelf has remained virtually a *mare incognitum* as regards the occurrence of fishing grounds, the types of species present, as well as the quantities in which they may occur to permit commercial fishing. Practically no trawls had been operated in the deep waters off the south west coast of India, but for some zoological curiosities collected from the deeper waters (also from the deep waters of the Bay of Bengal and Andaman Sea) by R.I.M.S. "INVESTIGATOR' and reported on by Alcock and others at the turn of the century, R.V. "CONCH" of the University of Kerala., and R.V. "KALAVA" of the Indo-Norwegian Project made a few deep-water trawl hauls along the edge of the continental shelf off the kerala Coast between 1959 and 1961.

In January 1962.the Indo-Norwegian Project made available R.V. VARUNA for fishery oceanographic work in the Indian Seas to be conducted by the Central Marine Fisheries Research Institute. As the Project establishment at Cochin was still in its infancy, sufficient fishing gear had not been available for carrying out any intensive exploratory surveys during the first two and half years, though the vessels was continuously used for collection of valuable hydrographic data off the west and east coasts of India and the Laccadive Sea as well as for participation in some of the cruises of the International Indian Ocean Expedition. Perforce, most of the trawling operations carried out from R.V. VARUNA were from shallow inshore waters. From the latter part of 1963 it has been possible to work out an integrated programme of hydrogrpahy cum exploratory fishing, various fishing gears having been used for the latter. Several factors have intervened on and off to, interrupt the programme. In spite of this with persistent effort it has been possible to collect very useful data regarding bottom topography; demersal fishing grounds and potential fishery resources and the hydrological features of the area, especially off the south west coast of India and the Laccadive Sea. During the last two years, other larger vessels of the Indo-Norwegian Project, namely M.V. KLAUS SUNNANAR (220 H.P), M.V. TUNA (480 H.P.) and M.V. VELAMEEN (480 H.P) have also been closely associated with the exploratory survey programme of R.V.. VARUNA. This report embodies the results of these surveys.

I take this opportunity to express my sincere thanks to Dr. S. Jones, Director, Central Marine Fisheries Research Institute, and to Dr. R.R. Prasad, then Deputy Director, Central Marine Fisheries Research Sub-station, Ernakulam for giving me all facilities for organizing and carrying out the exploratory fishery survey programme of R.V. VARUNA. It gives me great pleasure to record here my sincere thanks to Mr. G.N. Mitra, Joint Commissioner, Fisheries, Government of India for the active interest he has taken in the exploratory cruises of R.V. VARUNA. To the Directors of the Indo-Norwegian Project, I wish to express my thanks for the facilities extended to me and my colleagues from the Central Marine Fisheries Research Institute. It gives me great pleasure to acknowledge the full hearted cooperation I received from the skippers of R.V. VARUNA , namely Captain Sven M. Saetrae, Captain Haga, Captain Sankarankutty, and Captain Joe Fernado, and crew who were always sympathetic to my request of

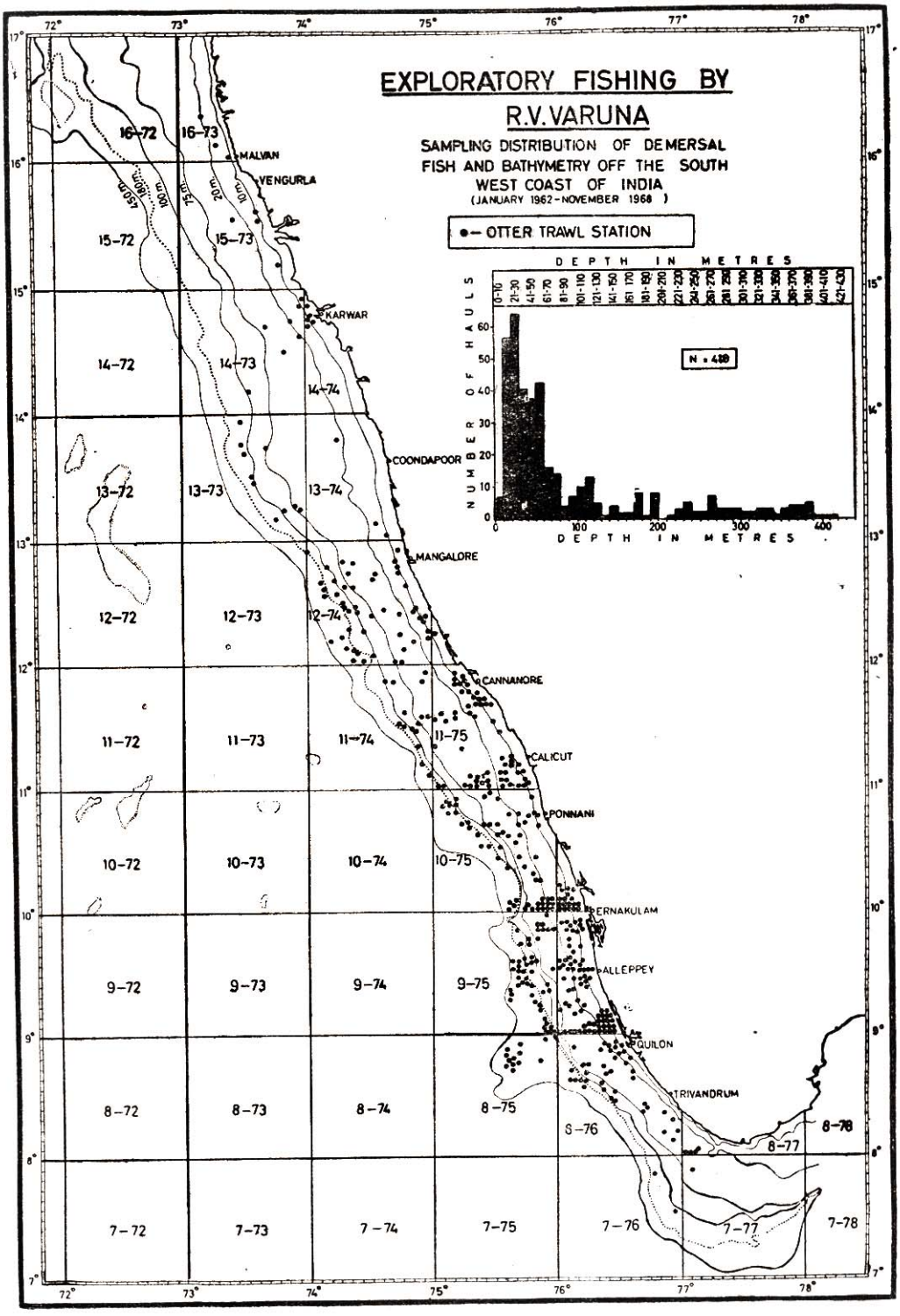


Fig. 1. Sampling distribution of otter trawl stations in relation to bathymetry.

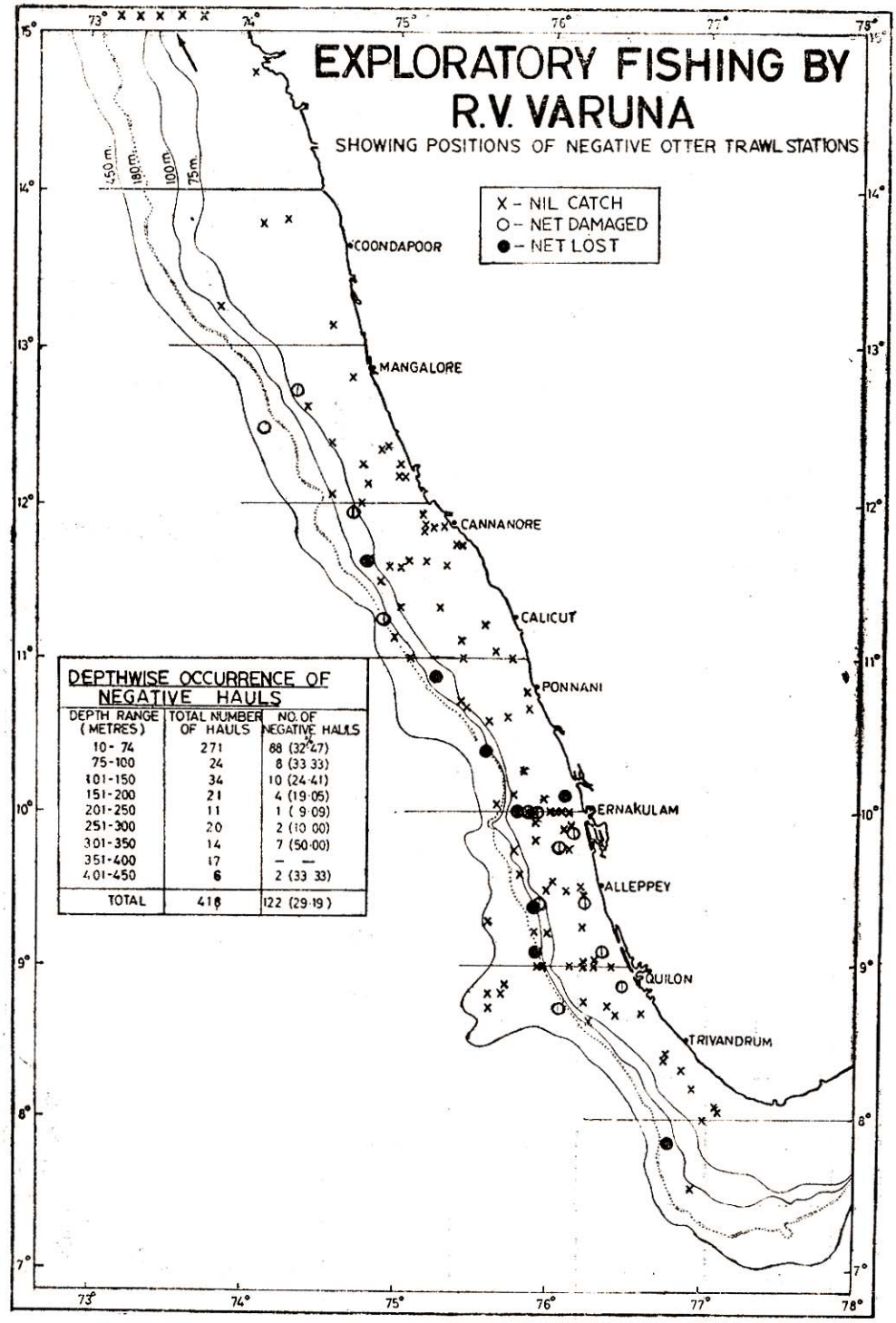


Fig. 2. Map showing locations of negative hauls including places where trawl nets were badly damaged or lost during exploratory surveys by R. V. *VARUNA*.

carrying out exploratory fishing whether it be night or day. I have received help from a number of my colleagues at the Ernakulam Substation in the collection of data to which I am very thankful. I also wish to record my appreciation and thanks to Mr. N.K. Prasad for the help rendered in the preparation of the charts and to Mr. K. Virabhadra Rao and Mr. C. Mukundan for going through the manuscript and for helpful suggestions.

OBJECTIVES OF THE EXPLORATORY SURVEY

Since the exploratory survey was planned as part of an integrated programme of hydrography cum fishing, the scope of the survey was kept sufficiently comprehensive to obtain as much information as possible on several problems. Often non-availability of gear or malfunctioning of shipboard equipment or adverse weather conditions or unpredictable changes in cruise programme, or periods when the vessel was dry docked or tied up did hamper work, but good use was made of available facilities to carry out alternate types of fishing or conducting other observations when on cruise, besides completing on each cruise the routine hydrographic programme.

Some of the salient characteristics of R.V. VARUNA, a 28.0 m (LOA), 182 GT vessel (Plate-I) built in 1961 at a cost of about £ 61,000 at A/S Ankgrlokkenn, Floro, Norway, have been given by Myrland (1962). Capable of a cruising range of 3400 nautical miles at a maximum speed of 9.5 knots, she is provided with a Wichmann 4 AC, 400 HP 350 rpm main engine and two auxiliary engines- Volvo Penta type MD 47A, 52 HP, 1500 rpm connected to two 220 AC generators, each of 20 kilowatts. Presently her fuel capacity is 27 tons which gives her a maximum endurance at sea of about 25 days. She has one set (3 blades 350 rpm) controllable pitch propeller which along with the engine is controlled from the wheel house. In addition to a fish hold of 24 m^3 capacity, she has two deep freezing holds (-32^o C) and one cold storage (+5^o C). Freshwater capacity is 36.5 tons and in addition she has a Nirex evaporator which can supply one ton of freshwater every 24 hours. She has hydraulic steering equipment, electric log, radio direction finder (AVS Electriske Bureau 6 PMZ), and Decca type 404 radar with a range of 48 nautical miles. The radio telephone, Simrad type TA3 is a 100 W. transmitter with 12 frequencies and an

approximate range of 500 miles. Her hydraulic two drum winch (Hydraulik type DLA8) can hold altogether 2520 metres of trawl wire, and her two hydraulic hydrographic winches 4000 and 2000 metres of 4 mm steel wire. She is also fitted with a line hauler and a puretic power block. There are about 50 m^2 of open deck space and one sampling laboratory and two analytical Laboratories (together 19 m^2) There is accommodation for 15 crew and 4 scientists.

In addition to the hydrographic equipments such as Nansen reversing bottles, bathythermographs, etc. the fish locating equipments are:

Echo sounders: Simrad type 513-3, range 1250 metres
" " 513-1, range 12000 metres
" " 516-13, range 180 metres
Asdic – Simrad ype 564-3 with horizontal range of 1500 metres.

The fishing gears used during the exploratory surveys were:

1. Otter trawls
2. Surface drift nets
3. Handlines
4. Purse seine
5. Longlines
6. Surface troll lines
7. Isaacs-Kidd midwater trawl

Thus, during the cruises of R.V. VARUNA the major Objectives were:

1. To investigate the hydrography of the shelf and oceanic waters (data on temperature, salinity and dissolved oxygen from standard depths; *in situ* measurements, at selected stations, of primary organic production using C^{14}; phytoplankton and zoo plankton collections and collection of macro-zooplankton and nekton with the Isaacs-Kidd midwaters trawl.
2. To conduct echosurveys cum fishing;:
   a. For location of subsurface fish shoals and demersal fishing grounds especially in the depth range 75 to 450 metres and assessment of demersal fishery resources of the shelf edge and the upper continental slope.
   b. For obtaining information on bottom topography and bottom contours.
   c. For studying patterns of fish behaviour.

d. To find out the frequency of occurrence of perch fishing grounds in relation to depth range as well as different latitudes.

e. To investigate the deep scattering layers, especially the upper layer where concentration of forage for pelagic fishes such as tunas, marlins, and sharks as well as oceanic squids occur.

3. To carry out a systematic survey of the neritic deep water as well as upper continental slope fauna, especially fishes and crustaceans to help in the resources survey as well as to, facilitate identification of the fish eggs and larvae and the developmental stages of crustaceans in the plankton collections made from various depths.
4. To carry out handline fishing for perches (" Kalava") in order to find out the species composition, their respective abundance, patterns of distribution, behaviour and biology.
5. To carry out drift net (gill net) fishing from the shelf as well oceanic waters for obtaining information on pelagic fishes, especially tunas and related species, their food, fecundity, spawning periods and spawning grounds;and information on the occurrence, distribution and biology of such potential resources as pelagic sharks and oceanic squids.
6. For carrying out purse seining for tunas and related species in the Laccadive Sea (especially for the skipjack tuna and the yellowfin tuna) and in the neritic waters for coastal species of tunas, and for testing the efficiency of the gear.
7. To observe and record fish shoals and also study concentrations of oceanic birds and their behaviour which help considerably visual scouting for surface and subsurface tuna shoals.
8. To observe and record phytoplankton blooms and investigate any fish morality.
9. To observe and record marine mammals, turtles, etc. occurring in the areas of survey.

PART – I

EXPLORATORY OTTER TRAWLING SURVEYS BY R.V. *VARUNA* AND OTHER VESSELS OPERATING IN ASSOCIATION WITH HER FROM THE CONTINENTAL SHELF EDGE AND THE UPPER CONTINENTAL SLOPE OFF THE SOUTH-WEST COAST OF INDIA

EXPLORATORY OTTER TRAWLING SURVEYS BY R.V. *VARUNA*

Between January 1962 and December 1968 R.V. *VARUNA* carried out 418 otter trawling operations from various depths on the continental shelf and the continental slope to a maximum depth of 450 metres in a stretch of about 460 nautical miles between *Karwar and Cape Comorin* (Figure – 1.). The exploited demersal fisheries of the 10-75 metre depth range of this region have been recently discussed by Rao (1969). The fishes most commonly trawled in this depth range were: *Scoliodon palasorrah* (Cuvier), *Rhynchobatis djeddensis* (Forskal). *Pastinachus sephen* (forskal), *Himantura urnak* (Forskal), *Kowala coval* (Cuvier), *Pellona ditchela* Valenciennes, *Opisthopterus tardoore* (Cuvier), *Goniolosa manmina* (Hamilton), *Andaontostoma chacunda* (Hamilton), *Thrissocles mystax* (Bloch & Schneider), *T. malabarica* (Bloch), *Saurida tumbil* (Bolch), *Synodus indicus* (Day), *Netuma thalassinus* (Ruppell), *Holocentrum rubrum* (Forskal), *Myripristis murdjan* (Forskal) *Sillago sihama* (Forskal), *Sphyraena acutipinnis* Day, *Nemipterus japonicus* (Bloch), *Leiognathus spelendens* (Cuvier), *L. bindus* (Valenciennes), *Grammoplites scaber* (Linnaeus), *Suggrundus tuberculatus* (Cuvier), *S. carbunculus* (Valenciennes), *Thysanophrys crocodilus* (Tilesius), *Selar kalla* (Cuvier,) *Carangoides malabricus* (Bloch). *Megalaspis cordyla* (Linnaeus), *Decapterus russelli* (Rupell), *Atropus atropus* (Bloch), *Lutjanua johni* (Bloch), *L. argentmaculatus* (Forskal), *L. kasmira* (Forskal), *L. malabricus* (Schneider), *Pomadasys hasta* (Bloch), *Johnius dussumieri* (Cuvier), *J. diacanthus (*Lacepede), *Otolithus argentatus Cuvier, Drepane punctata* (Linnaeus), *Leptura canthus savala* (Cuvier), *Trichiurus lepturus* Linnaeus, *Pseudorhombus arsius Brachirus orientalis* (Bloch), *Solea elongata Day, Cynoglossus bilineatus* (Lacepede), *C. semifasciatus Day, Polynemus plebius* (Broussonet), *P. sexifilis* Valenciennes, *Lactarius lactarius* (Schneider), *Parastromateus niger* (Bloch), *and Psenes indicus* (Day*)*. On a few occasions *Sardinella longiceps* Valenciennes *and Restrelliger kanagurta* (Cuvier) have also ccurred in the trawl catches. Among prawns, *Metapenaeus dobsoni* (Miers) was the dominant species in catches between 10 and 45 metres. In view of the exploratory surveys being carried out by other agencies including the prawn industry in the 10 to 75m depth range, especially for discovering new prawn fishing

grounds, no special trawling surveys were carried out by R.V. *VARUNA* with this as objective.

From 1965 the emphasis had been on trawling from deeper waters, especially beyond the 75-metre depth contour. Thus for the first time in Indian seas an organized effort was initiated for surveying the deeper waters along the edge of the continental, shelf as well as upper continental slope. Echosounders were used continuously on cruises for obtaining information on bottom profiles and bottom conditions, and noting demersal fish concentrations and seeking out trawlable grounds. On the basis of innumerable continuous observations of echo traces as well as the results of fishing as reflected in the catch composition, it has been possible to broadly demarcate three Depth zones beyond the 75 metre depth contour as follows:

1. Depth Zone: I. 75 to 100 metres: Bottom mostly rocky with out crops of rocks forming ideal habitats for several species of sea perches and rock cods known locally as 'Kalava' and "Velameen'. Trawlable grounds in this depth range are very patchy and restricted south of Mangalore. Invariably in all successful trawl hauls the threadfin bream *Nemipterus japonicus* was found to be the most dominant species, often forming over 75% of the catch. *The* other species which commonly occurred in the catch were *Trichiurus lepturus, Decapterus russelli, Psenes indicus Saurida undosguamis* (Richardson) and *Synodus* sp. On the whole, this depth zone is poor as far as trawling grounds go, but as will be discussed in a later section of this report, it is very important on account of the perch fishing grounds or "Kalava grounds' it contains.

2. Depth Zone-II. 101 to179 metres: This depth zone has good trawlable grounds, especially north of Cochin to Karwar. However, between Ponnani and South of Alleppey stray occurrence of rocky outcrops has been detected on the echograms taken in the depth range 100 to 125 metres. In the trawl catches, among fishes *Nemipterus and Synodus indicus* predominate, the other species commonly caught being *Centropristis investigatoris Alcock, Emmelichthys* sp. (a new species being described elsewhere), *Priacanthus* sp. Callionymus sp. *Peristendion* spp. *Trigla spp. Holocentrus sp. Polymixia nobilis* Lowe *and Parascolopsis* sp. Among prawns, species of *Metapenaeopsis* occur in small quantities. It would seem that the

most important crustacean species to inhabit this depth range is the crab *Charybdis (Goniohellenus) edwardsi* Leene & Buitendijk which was invariably present in all trawl catches and sometimes formed bulk of the catch (Plate III). The occurrence, distribution, and abundance of this species and its importance as a potential resource are dealt with in a later section in this report. Depth zones I and II also form part of the neritic deep waters.

3. Depth zone-III. 180 to 450metres: This depth range covers part of the continental slope and for convenience shall be termed the upper continental slope. The slope upto the 450 metre depth contour varies considerably in width from the shelf edge. It is broadest off Quilon where it forms a fairly extensive bank with an average depth of about 300 metres over the bank and having good trawling grounds The species composition shows some difference depth-wise. On the whole, species trawled in 200 metres also occur at 400 metre depth though their relative abundance may vary at different depths.

Nearly 150 species of fishes have been identified from the trawl collections from the upper continental slope. A few of the more important species are shown in Plates I & II. The systematic position and nomenclature of several of these need clarification and revision. This work is under progress. Several of the species are new distributional records for Indian seas, previously having been reported from South African waters, or the Pacific or the Atlantic Ocean. From the commercial point of view the bulk of these species will be classed as trash fish. One note worthy feature is that unlike the species trawled in the continental shelf area, those from the continental slope are relatively smaller in size. In addition, the water content in the meat being high, the flesh in most of the species is not firm, which makes it break up on cooking. But for a few species such as *Cubiceps natalensis* Gilchrist and von Bonde, *Chlorophthalmus agassizi* Bonaparte, *C. corniger* Alcock, *Chascanopsetta lugubris Alcock*, *Epinnula orientalis* Gilchrist and von Bonde, *Synagrops japonicus* (Steindachner and Doderlein), *Polymixia nobilis* Lowe, and *Paseneopsis Cyanea* (Alcock), the bulk of the species will go towards supporting a fish meal or fish paste industry. Among the species listed above, *C. agassizi and C. natalensis* are very important. Both occur in large shoals and form

the bulk of the fish catch within this depth range. The occurrence, depthwise abundance, size composition in the catch, maturity, fecundity and spawning of the above species, as well as others occurring in this depth zone are under study.

The following species of penaeid and non-penaeid prawns have been obtained in the trawl catches from this zone:

Penaeid prawns:

**Aristeus semidentatus (* Bate)
Aristeus alcocki Ramadan
Aristaeomorpha wood-masoni Calman
Metapenaeopsis andamanensis (Wood Mason)
**Penaeopsis rectacutus* (Bate)
Hymenopenaeus aquakis (Bate)
Parapenaeus investigatoris Alcock and Anderson
Solenocera hextii Wood-Mason

Non-Penaeid Prawns:

**Heterocarpus gibbosus* Bate
**Heterocarpus wood-masoni* Alcock
**Parapandalus spinipes* Bate
**Plesionkia martia* (A. Milne-Edwards)
**Plesionkia ensis*
Oplophorus sp.

The catch composition of the deep-sea prawns show that the species marked with an asterisk in the above list are more important as they constitute the bulk of the prawn catch. Good concentration of *Aristeus semidentatus,* the most preferred among the deep-sea prawns on account of its large size, is found to occur in the depth range 275-375 metres, especially around 10^0 41'N. to 10^0 53' N and 75^0 98'E. to 75^0 21'E.

The deep-sea lobster *Puerulus sewelli* Ramadan has been obtained in the depth range 180 to 275 metres, though stray specimens have appeared in hauls taken as deep as 400 metres. This species is of special interest as it occurs in grounds where trawling is possible. Excellent lobster grounds were struck earlier this year in the depth range 180 to 225 metres off Quilon when vessels of the Indo-Norwegian Project working in the

'Varuna Programme' were able to land about 59 tonnes of *P. sewelli* in the course of a few trips undertaken between February and April. The training vessel BLUE FIN of the Central Institute of Fisheries Operatives, Cochin, which was also temporarily engaged in deep-sea lobster fishing, was able to land 89 tones in the course of cruises undertaken during March-June 1969. The catch rates have been very high and as much as two tones of lobsters have been taken in a single haul.

Among molluscs, the deep-sea octopod *Berrya Kerlensis* Oommen has occurred in small quantities in trawl catches between 200 and 350 metres. The gastropod *Pirula investigatoris* Smith* (Plate IV) which I consider as a potential resources occurs in small quantities in trawl catches especially in the depth range 180 to 275 metres.

As already mentioned, the samples collected from the different depth zones are being analysed and in view of the revisional studies under way, it is not possible to give the upto date names of all species in the collections. The list of fishes in the collections given below is incomplete, as more species are likely to be added in the course of future surveys, and specific names in some cases have not been indicated as specific determination is not complete or nomenclature needs revision. However, this will give an idea of the quality of the fish to be expected in the trawl catch from the neritic deep waters and upper continental slope. The genera are arranged alphabetically and under each genus the species likewise (Table-I).

The information gained thus on the ichthyofauna of the shelf edge and the upper continental slope has also gone a long way in helping in the proper identification of the fish larvae obtained in the plankton collections during the research cruises of R.V. VARUNA. Since collections have been made from the same grounds or the depth zones during different months of the year, detailed investigations on the biology of the following species are under way:

Benthodesmus tenuis (Gunther), *Centropristis investigatoris* Alcock, *Chascenopsetta lugubris* Alcock, *Chlorophthalmus agassizi* Bonaparte, *Chlorophthalmus corniger* Alcock, *Cubiceps natalensis* Gilchrist and von Bonde, *Epinnula orientalis* Gilchrist and von Bonde, *Lepidopus caudatus* (Euphrasen), *Pseneopsis cyanea* (Alcock), *Rexea prometheoides* (Bleeeker) and *Scyllium hispidum* Alcock.

*Reidentified as *Pyrula sewelli* Prashad, 1927, *Rec. Ind. Mus.,* p.230, pl. 22, figs. 1, 2 & 4.

TABLE-I

Name	Depth Range (M)		
	75-100	101-179	180-450
Antigonia rubescens (Gunther)	-	X	X
Argyropelicus prox. *aculeatus* Val.	-	-	X
Argyropelicus affinis Garman	-	-	X
Argyropelicus prox. *hemigymnus* Cocco	-	-	X
Argyropelicus prox. *sladeni* Regan	-	-	X
Ariosoma sp.	-	X	X
Arnoglossus sp.	X	X	-
Astronesthes Lucifer Gilbert	-	-	X
Ateleopus indicus Wood-Mason & Alcock	-	-	X
Ateleopus natalensis Regan	-	-	X
Atractophorus armatus Gilchrist	-	-	X
Bathyclupea hoskynii Alcock	-	-	X
Bembrops caudimacula Steindachner	-	X	X
Bembrops prox. *gobioides (Goode)*	-	-	X
Benthobatis moresbyi Alcock	-	-	X
Benthodesmus tenuis (Gunther)	-	X	X
Beryx prox. *splendus* Lowe	-	-	X
Callionymus carebares Alcock	-	X	-
Callionymus sp.	-	X	X
Cataetyx sp.	-	-	X
Centropristis investigatoris Alcock	-	X	X
Chascenopsetta Lugubris Alcock	-	X	X
Champsodon vorax Gunther	-	X	X
Chaunax pictus Lowe	-	-	X
Chauliodus pammeles Alcock	-	-	X
Chirolophius prox. *moseleyi* Regan	-	X	-
Chirolophius mutilis (Alcock)	-	X	X
Chirolophius prox. *papillosus* (Max Weber)	-	X	X
Chirolophius sp.	-	X	X
Chlorophthalmus agassizi Bonaparte	-	X	X
Chlorophthalmus corniger Alcock	-	X	X
Coelorhynchus sp.	-	-	X

Coloconger raniceps Alcock	-	X	X
Cubiceps natalensis Gilchrist & von Bonde	-	-	X
Dactyloptena orientalis (Cuvier & Valenciennes)	X	X	-
Daicocus peterseni (Nystrom)	X	-	-
Darmattus sp.	-	-	X
Decapterus russelli (Ruppell)	X	-	-
Dermatorus trichiurus Alcock	-	X	X
Diaphus prox *leukeni* (Brauer).	-	X	X
Dibranchus nasutus Alcock	-	-	X
Diplophos corythaeolum Alcock	-	-	X
Ebisinus cheirophthalmus (Bleeker)	X	-	-
Echinorhinus brucus (Bonnaterre)	-	-	X
Epinnula orientalis Gilchrist & von Bonde	-	X	X
Gephyroberyx sp.	-	-	X
Glyptophidium argenteum Alcock	-	-	X
Halieutea coccinea Alcock	-	-	X
Halieutea indica Annandale and Jenkins	-	X	X
Halieutea stellata (Vahl)	X	X	X
Halimochirurgus centriscoides Alcock	-	-	X
Hepthocara prox. *sinum* Alcock	-	-	X
Histiopterus spinifer Gilchrist	-	*x*	*X*
Hoplostethus sp.	-	-	X
Holocentrus rubrum (Forskal)	X	-	-
Hemenocephalus sp.	-	-	X
Hypopleuron prox. *caninum* Smith&Radcliffe	-	-	X
Laeops sp.	-	-	X
Lamprogrammus niger Alcock	-	-	X
Lepidopus caudatus (Euphrasen)	-	-	X
Lepidotrigla longipinnis Alcock	-	X	X
Lepidotrigla prox. *natalensis* Gilchrist	-	-	X
Lepidotrigla sp.	-	X	X
Lestidium sp.	-	-	X
Lionurus sp.	-	X	X
Lioscorpius sp.	-	X	X
Lycodes sp.	-	X	-

Macrorhamphosus gracilis I (Lowe)	-	-	X
Macrurus heterolepis Alcock	-	-	X
Macrurus spp.	-	X	X
Malcocephalus prox. *laevis* Lowe	-	X	X
Malthopsis triangularis Lloyd	-	-	X
Malthopsis sp.	-	-	X
Minos intermis Alcock	-	X	X
Myctophium spp.	-	X	X
Myripristis kaianus Gunther	-	X	X
Narke sp.	-	X	X
Narcine brunnea Annandale	-	*X*	-
Nemichthys acanthonotus Alcock	-	-	X
Nemipterus japonicus (Bloch)	X	X	X
Neobythites prox. *conjugator* Alcock	-	-	X
Neobythites prox. *pterotus* Alcock	-	-	X
Neoharriotta pinnata Schnackenbeck	-	-	X
Neoscopeleus microlepidotus Johnson	-	-	X
Nettenchelys sp.	-	-	X
Paralepis sp.	-	-	X
Parascolopsis sp.	-	X	-
Peristedion prox. *pothumaluva* Deraniyagala	-	X	X
Peristedion prox. *rivers-andersoni* Alcock	-	-	X
Peristedion spp.	-	X	X
Peristethus investigatoris Alcock	-	-	X
Photichthys hemingi McArdle	-	-	X
Physiculus argyropastus Alcock	-	-	X
Pleuroscopus sp.	-	-	X
Poecilopsetta prox. *proelonga* Alcock	-	X	X
Poecilopsetta maculosa Alcock	-	-	X
Polyipnus spinosus Gunther	-	-	X
Polymixa nobilis Lowe	-	X	X
Priacanthus spp.	X	X	X
Pseneopsis cyanea (Alcock)	X	X	X

Psenes indicus (Day)	X	X	X
Pseudalutarius nasicornis (Schn)	-	-	X
Quinquarius sp.	-	-	X
Raia powelli Alcock	-	-	X
Raia mamillidens Alcock		-	X
Raia prox. *reversa* Loyd	-	X	-
Raia prox. *smithi* Muller&Henle	-	-	X
Raia sp.	-	-	X
Rexea prometheoides (Bleeker)	-	*X*	*X*
Ruvettus pretiosus Cocco	-	-	X
Saurida undosquamis (Richardson)	X	X	X
Saurenchelys sp.	-	-	X
Scyllium hispidum Alcock	-	X	X
Scyllium prox. *quagga* Alcock	-	X	X
Solea umbralis Alcock	-	-	X
Synagrops prox. *japonicus* (Steindachner & Doderlein)	-	X	X
Synagrops prox. *philippinensis* Gunther	-	-	X
	-	-	X
Synapobranchus sp.	-	-	X
Synaptura altipinnis Alcock	-	X	X
Sudis sp.	-	-	X
Synodus indicus Day	X	X	X
Thyrsitoides marleyi Fowler	-	X	X
Torpedo marmorata Risso	-	-	X
Trachichthoides prox. *spinosus* Gilchrist	-	-	X
Trachinocephalus myops (Schneider)	-	X	X
Triacanthoides aethiops Alcock	-	-	X
Trichurus lepturus	*X*	*X*	-
Trigla picta Gunther	X	X	X
Trigla sp.	-	X	X
Uranoscopus crassipes Alcock	X	X	X
Uroconger lepturus (Richardson)	X	X	-
Xenolepidichthys prox. *dalgleishi* Gilchrist	-	-	X
Zen acutatus (Gilchrist & von Bonde)	-	-	X
*Zenopsis nebulosa (*Temminck & Schlegel)	-	-	X

A list of the trawling stations of R.V. VARUNA is given at the end of this section (Table-10). Of the 418 hauls, 122 were negative hauls and their occurrence depth-wise as well as month-wise is shown in Table-II. The location of these hauls inclusive of places where snags have been encountered resulting in the damage or loss of nets is shown in Figure 2.

In Table-III the catch per hour of trawling for all hauls for different depth ranges has been worked out. The catch rates have also been analysed both for night and day hauls.

In the preparation of these data (Table-III), the depth range 151-200 metres was not split into 151-179 and 180-200 metres mainly as some of the species from the slope have also been trawled from depths between 160 and 180 metres, though we take the 180 metre (100 fathom) contour as representing the continental shelf edge. The grouping is done for convenience and when more trawling stations are occupied in this depth range, it may become necessary to consider Zone-II extending to the shelf edge separately as at present shown for the species trawled (Table-I).

The number of negative hauls was relatively greater in night trawling in the different depth ranges. But for the 75-100 m; 151-200m; and the 351-400 m depth ranges, the catch/hour of trawling in kg., for day hauls was much higher than for night hauls. Partly this may be on account of the few number of night hauls from the depth ranges in depths greater than 101 metres. For the combined day and night hauls the catch/hour of trawling exceeded 200 kg., in the 101-150 m (215-15 kg); 251-300 (258.68 kg); and 300-350 m (285.51 kg) depth ranges.

The following factors were at least partly responsible for the relatively larger number of negative hauls:

1. In depths greater than 100 metres on a few occasions at least the warp paid out was not long enough to permit the net operating at the bottom.
2. The fabrication of the nets was such that it was unsuitable for trawling in deeper waters.
3. These being virgin grounds, lack of knowledge of the environmental conditions resulted in either total loss or heavy damage to the nets meeting obstructions, etc.

TABLE – II

R.V. VARUNA – Number of negative otter trawl hauls (January 1962-December 1968)**

Depth range (metres)	Months											
	J	F	M	A	M	J	J	A	S	O	N	D
10 - 75	3	14	10	16	10	2	2	7	14	7	1	2
76 – 100	1	1	1	-	-	1	1	3	-	-	-	-
101 – 150	1	4	-	-	-	-	-	2	-	2	1	-
151 – 200	-	1	-	1	-	-	-	1	-	-	1	-
201 – 250	-	-	-	-	-	-	-	-	1	-	-	-
251 – 300	-	-	-	1	-	-	-	-	1	-	-	-
301 – 350	1	1	1	-	-	-	-	-	4	-	-	-
351 – 400	-	-	-	-	-	-	-	-	-	-	-	-
401 – 450	-	-	-	1	-	-	1	-	-	-	-	-

** Includes nets lost (8 numbers) or damaged (13 numbers).

TABLE-III

R.V. VARUNA – Exploratory trawling by depth range (1962-1968)*

Particulars	Depth range (metres)									
	10-74	75-100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	Total
I. DAY HAULS										
1. No. of hauls	196	13	22	17	8	18	11	16	6	307
2. Hrs. of fishing	181.77	13.67	23.33	15.75	6.50	19.25	9.33	17.00	4.50	291.10
3. Catch(Kg.)	14735	263	6778	2159	682	5735	3306	1757	255	35670
4. Catch/hr. of trawling in kg.	81.06	19.23	290.53	137.07	104.92	297.92	354.34	103.35	56.67	122.54
II. NIGHT HAULS										
1. No. of hauls	75	11	12	4	3	2	3	1	-	111
2. Hrs. of fishing	72.53	14.25	11.00	4.67	4.67	3.50	4.00	1.50	-	116.12
3. Catch (Kg)	4747	1670	608	715	130	150	100	300	-	8420
4. Catch/hr. of trawling in kg.	65.45	117.19	52.27	153.10	27.84	42.86	25.00	200.00	-	72.51
III. COMBINED DAY AND NIGHT HAULS										
1. No. of hauls	271	24	34	21	11	20	14	17	6	418
2. Hrs. of fishing	254.30	27.92	34.33	20.42	11.17	22.75	13.33	18.50	4.50	407.22
3. Catch (Kg)	19482	1933	7386	2874	812	5885	3406	2057	255	44090
4. Catch /hr of trawling in kg	76.61	69.23	215.15	140.74	72.69	258.68	255.51	111.19	56.67	108.30

*All positive and negative hauls have been included.

4. At least on four occasions the cod-end of the net has not been properly tied by the inexperienced deck hands (trainees).
5. Faulty manoeuvring of the vessel occurred while shooting the net or soon after.
6. A relatively larger number of negative hauls occurred in the inshore waters in the depth range 10-74 metres. The data are being analysed to see whether some of these could be due to the effect of hydrological factors such as a depletion in the dissolved oxygen at the bottom such as a depletion in the dissolved oxygen at the bottom and the absence of fish in the area. It is likely that in such places some other organisms could have been responsible for the echo traces obtained which led to the trawl being operated.

In an exploratory survey where new grounds are being explored, such negative trends are not unusual. In the present programme the results obtained from the successful hauls far outweigh such shortcomings. It is these encouraging results that had led to the more intensive exploration of the deeper waters by other vessels of the Indo-Norwegian Project mentioned earlier. A summary of the results of this combined exploratory survey carried out under the 'Varuna Programme' is given in the ensuing section.

RESULTS OF EXPLORATORY TRAWLING FROM THE NERTIC DEEPWATERS AND THE UPPER CONTINENTAL SLOPE BY R.V. VARUNA AND OTHER VESSELS OPERATING IN ASSOCIATION WITH HER

Between 1966 and 1968 the Indo-Norwegian Project vessels R.V. KALAVA, M.V. TUNA, M.V. VELAMEEN and M.V. KLAUS SUNNANA participating in the 'Varuna Programme' of exploratory fishing made several deep-water trawling off the south- west coast. Figure 3A will show the extensive areas marked in 10 nautical mile squares trawled by R.V. VARUNA (71 squares) and Figure 3B the areas covered by the other vessels (30 squares). The operations from the other vessels were directed more towards intensive fishing bordering commercial interest and the combined results have been remarkably successful in helping to give an idea of the extent of some of the good fishing grounds on the upper continental slope also in drawing attention to the potential resources available for commercial fishing.

It will be seen from Figure 4, that a total 417 trawling operations have been carried out by all vessels including R.V. VARUNA from the three depth zones of 75-100, 101-179 and 180-450 metres till the end of November 1968. In effort, this will represent 450 hours of trawling. The number of trawl hauls by depth range as well as effort in number of hours of trawling in the three depth zones are shown in Figure 4. It will be seen that the maximum number of hauls and consequently the maximum effort expended have been in the depth range 301-360 metres. The effort in hours of trawling from the depth zones I-III in which 22, 47 and348 hauls were taken was 27.8, 43.7 and 378.5 hours respectively. Figure 4 also shows the number of trawl hauls and the effort in hours for each 10 nautical mile square for the areas fished in the three depth zones. More intensive fishing has been carried out off Quilon, wherein, in a single 10 nautical mile square, 107 hauls have been taken representing in effort 112 hours of trawling.

The results of the combined investigations by all vessels have helped to confirm the findings resulting from the R.V. VARUNA cruises, especially as to the presence of good trawling grounds on the upper continental slope and their potential importance. In Figure 5 the average catches of fishes and crustaceans have been shown for the different depth zones for different depth ranges. The average catch was less than 40 kg/hr in Zone I. In Zone II it exceeded 130kg/hr in each of the

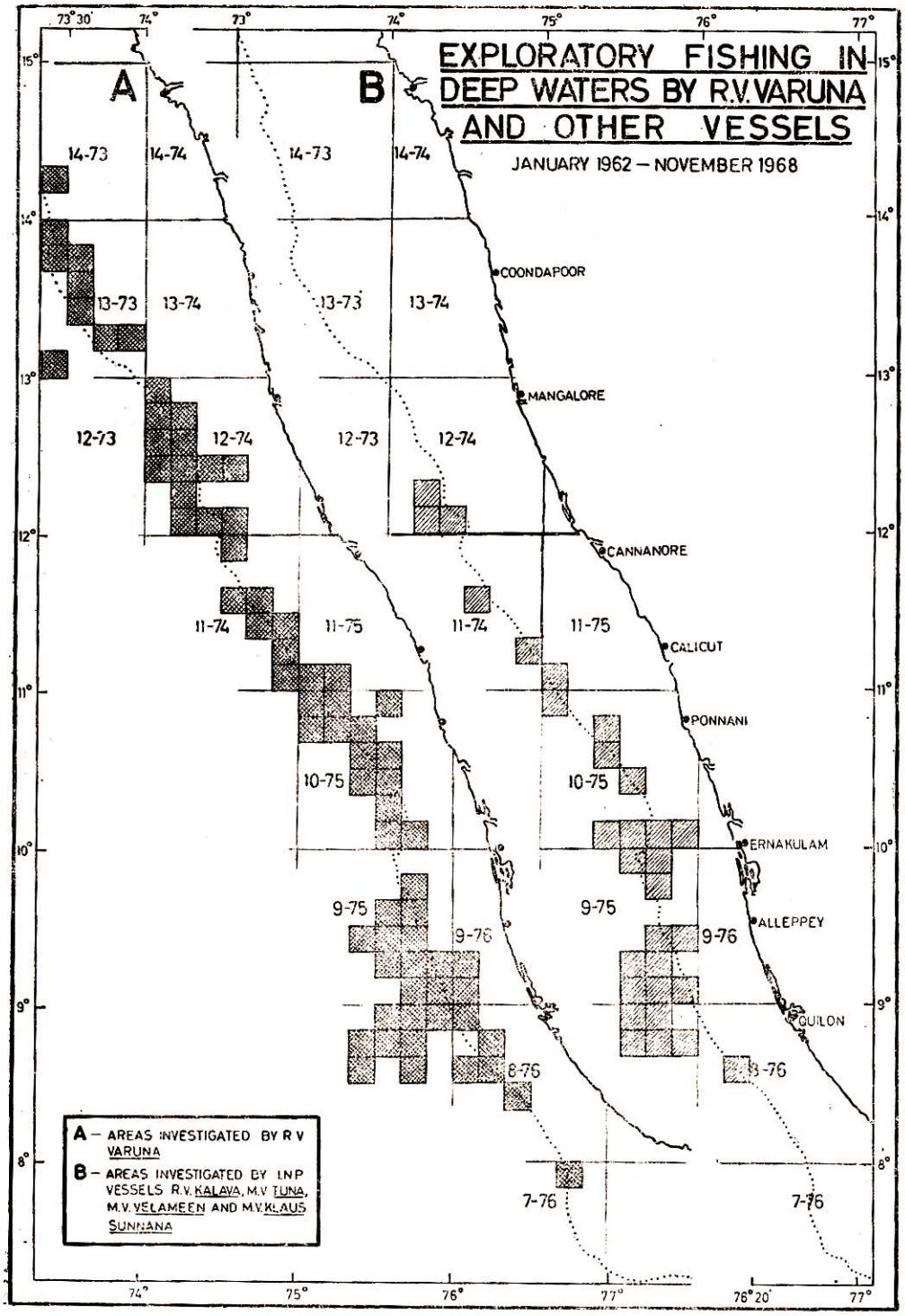


Fig. 3. Ten nautical mile latitude squares on the continental shelf edge and the upper continental slope from where exploratory otter trawling were carried out by (A) R. V. *VARUNA*, and (B) other vessels of the Indo-Norwegian Project operating in association with R. V. *VARUNA*.

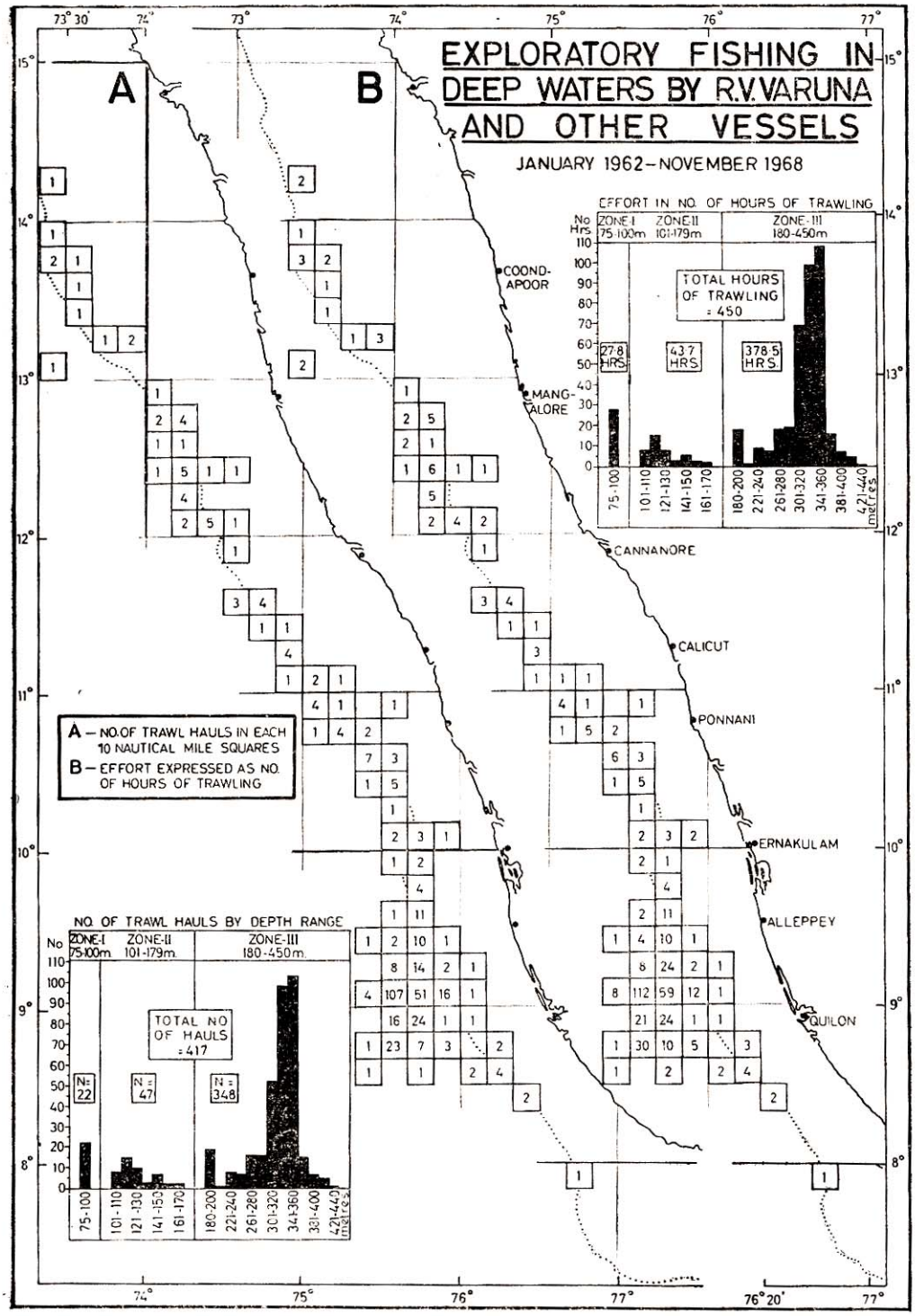


Fig. 4. Exploratory otter trawling on the continental shelf edge and the upper continental slope by R. V. *VARUNA* and other vessels. A. Total number of otter trawl hauls in ten nautical mile squares; B. Effort expended expressed as number of hours of trawling. The frequency of occurrence of A & B in relation to depth ranges investigated are also shown.

10-metre depth ranges between 111 and 160 metres, showing a maximum of 625 kg/hr (average) in the depth range 141-150 metres wherein the total number of hauls and the effort expended were 7 and 5.2 respectively.

In Zone III the average catch for depth range 261 to 280 metres was about 350 kg/hr, while it was between 220 and 280 kg/hr for the depth ranges 301-320, and 341-360 metres. It was between 120 and 170 kg/hr in the depth ranges 180-200, 321-340, 361-380, 381-400, and 421-440 metres

The catch data considered separately as to the frequency of occurrence of hauls with more than 200 kg/hr point to the potential richness of the grounds in Zones II and III. Of the 395 hauls from these two zones, the catch/hour of trawling in as many as 104 hauls exceeded 200 kg/hr as shown in Table IV.

The frequency of sampling by otter trawl depth-wise as well as month-wise is given in Table V. The total number of negative hauls for all vessels operating in the 75-450 depth range was 77 inclusive of 34 of R.V. VARUNA. It will be clear that the negative hauls were more than the positive hauls in Depth Zone I (11 out of 20). In Depth Zone II it was 13 out of 49 (36.1%), while in Depth Zone III it was 55 out of 348 (15.8%). The relatively lower number of negative hauls from the continental slope is noteworthy. This combined with the catch rates expressed as kg./hr of trawling would show the richness of the grounds as well as the feasibility of more intensive fishing on the upper continental slope.

TABLE IV

Frequency of occurrence of catch/hour of trawling exceeding 200 Kg/hr.

Catch/hour of trawling in kg.			No. of hauls
200-300	..	..	38
301-400	..	..	27
401-500	..	..	9
501-600	..	..	7
601-700	..	..	4
701-800	..	..	5
801-900	..	..	1
901-1000	..	..	3
1001-1100	..	..	1
1101-1200	..	..	1
1201-1300	..	..	-
1301-1400	..	..	-
1401-1500	..	..	1
1501-1600	..	..	3
1601-1700	..	..	-
1701-1800	..	..	-
1801-1900	..	..	1
1901-2000	..	..	-
2001-2100	..	..	-
2101-2200	..	..	-
2201-2300	..	..	1
2301-2400	..	..	-
2401-2500	..	..	-
2501-2600	..	..	2
		Total	**104**

TABLE V

Sampling distribution of Trawl stations arranged month-wise and depth wise indicating also positive and negative hauls

Depth Range (Metres)		Months												**Positive & Negative ****
Depth Range(Metres)		J	F	M	A	M	J	J	A	S	O	N	D	(Total)
ZONE I:	75-100	-	2(3)	-(1)	-	3(1)	-	1(3)	-(3)	1(-)	1(-)	1(-)	-	9+11 (20)
ZONE II:	101-120	-	2(4)	-	-	3(-)	-	1(-)	4(2)	3(-)	(1)	2(1)	2(-)	17+8 (25)
	121-140	-	-	-	1(-)	2(-)	-	-	1(-)	1(-)	-	1(-)	5(1)	11+1 (12)
	141-160	1(-)	1(-)	-	-	-	1(-)	-(2)	-	3(1)	-	-	-	6+3 (9)
	161-179	1(-)	-	-	-	-	-	1(-)	-(1)	-	-	-	-	2+1 (3)
ZONE-III:	180-200	1(-)	-	1(-)	4(1)	1(1)	1(-)	1(-)	-	3(-)	2(-)	-(1)	-	14+3 (17)
	201-220	-	-	-	-	-	-	-(1)	-	-	-	-	-	-+1 (1)
	221-240	1(-)	-	-	2(-)	-	-	-	-	4(-)	-	-	-	7+- (7)
	241-260	1(1)	-(1)	-	1(-)	-	-	-	-	3(1)	1(-)	-	-	6+3 (9)
	261-280	-	1(-)	-	5(-)	3(1)	-	-	-	2(-)	4(-)	-	-	15+2(17)
	281-300	-	2(-)	-	-	-	-	1(-)	-	4(1)	3(3)	-(2)	1(-)	11+6 (17)
	301-320	10(-)	1(-)	-(1)	2(-)	-	-	1(-)	1(2)	16(2)	10(2)	6(-)	-	47+7(54)
	321-340	34(4)	8(2)	-	1(-)	4(1)	-	-	-	-(1)	12(2)	11(1)	17(2)	87+13(100)
	341-360	27(-)	20(3)	-	2(-)	5(2)	-	-	-	-	16(8)	2(1)	9(1)	81+15(96)
	361-380	2(-)	-	-	5(-)	5(1)	-	-	2(-)	-	-	-	1(1)	15+2(17)
	381-400	-	-	-	2(-)	2(1)	-	-	-	-	1(-)	-	1(-)	6+1 (7)
	401-420	-	-	-	1(1)	-	-	2(1)	-	-	-	-	-	3+2 (5)
	421-440	-	-	-	-	-	-	1(-)	-	-	-	-	-	1+- (1)
	Total	78(5)	37(13)	1(2)	26(3)	28(8)	2(-)	9(7)	7(6)	25(6)	56(16)	27(8)	42(5)	338+79(417)

** Negative hauls are indicated in parenthesis under each month for the different depth ranges.

SIZES OF FISHES AND CRUSTACEANS IN TRAWL CATCH FROM THE UPPER CONTINENTAL SLOPE

The average weight of some of the fishes frequently caught (Families of fishes) by trawling from the shelf edge as well as the upper continental slope is shown in Figure 6. It will be seen that most of the families are represented by species with average weights less than 100 gm. Exceptions are the deep-sea sharks *Echinorhinus brucus* (Family Dalatiidae) and *Atractophoris armatus* (Family Squalidae); the deep-sea rays, *Raia* spp. (Family Raiidae); and the Chimaeroid *Neoharriotta pinnata* (Family Rhinochimaeridae), which were larger than any of the other species trawled from these depths. It is not unlikely that a few similar large sized species could have escaped capture by avoiding the nets. However, by and large the species of fishes and invertebrates (Prawns, lobsters, crabs, and cephalopods) caught are relatively smaller in size and weight compared to those generally trawled in the shallower neritic waters.

With the exception of *Aristeus* and *Heterocarpus,* the sizes of most of the sepecies of prawns as well as the species of fishes constituting the bulk of the catch from the upper continental slope shown in Figure 7 would explain this. In the case of crustaceans, the black horizontal bar represents the average size of the species in the catch. For the eight species of fishes, the length range in the catch represented by the horizontal black bar, while the thin short vertical line on it represents the mean length. The maximum weights attained by the species in grams (on basis of catch examined) as well as the mean weight are also shown in the Figure.

On account of the small size and the relatively high moisture content of the meat of many of the fish species trawled from the continental slope, most of the species qualify only as trash fish.

ANALYSIS OF FISH OIL AND MUSCLES OF THE LARGER SHARKS AND CHIMAEROID FISH FROM THE UPPER CONTINENTAL SLOPE

Through the kindness of Dr. V.K. Pillai of the Central Institute of Fisheries Technology to whom my sincere thanks are due, it was possible to have the analysis of the liver and muscles of two species of deep-water sharks (*Echinorhinus brucus* and *Atractophorus armatus)* and

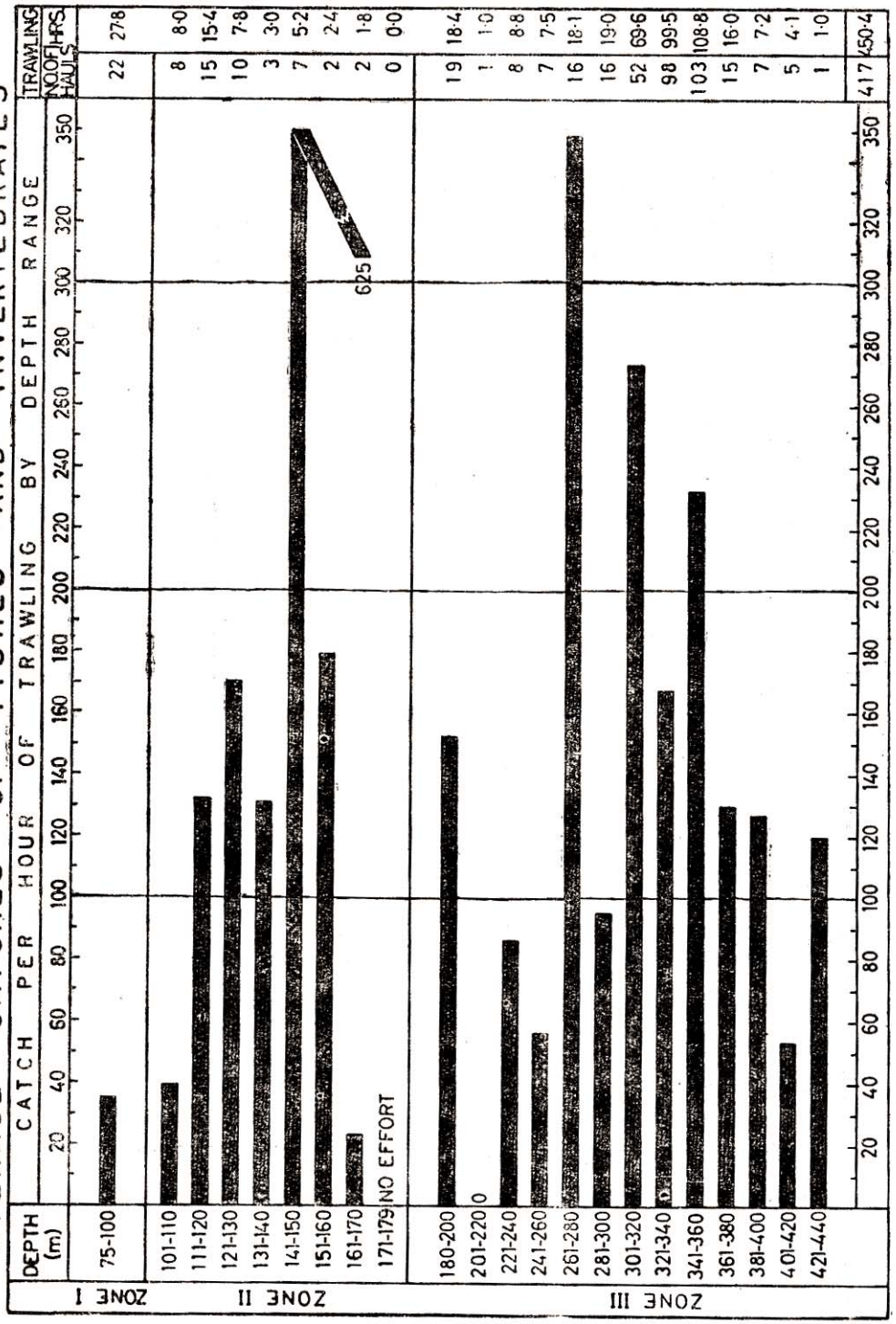


Fig. 5. Average catch of fish and invertebrates per hour of trawling in kg in the three different depth zones.

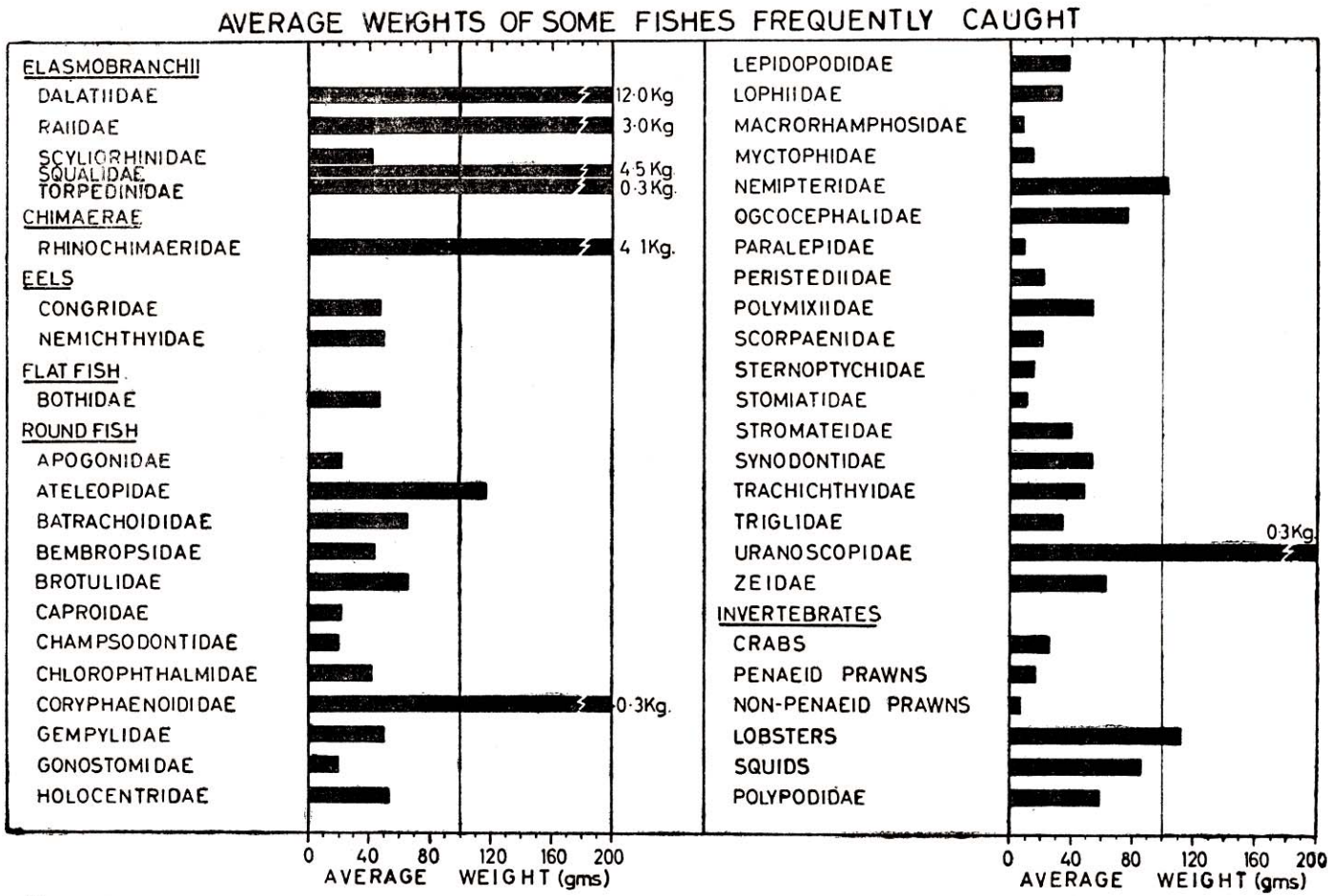


Fig. 6. Average weight of fishes and invertebrates (Families or groups) most frequently occurring in otter trawl catch from the upper continental slope.

the chimaeroid *(Neoharriotta pinnata)* made. The details of the analysis are given in Table VI.

In these species, the moisture content of the muscles is above normal and the Vitamin A potency of the oil is very low compared to commercial species of sharks and rays.

In the case of *N. pinnata,* adult specimens in the catch (Silas, *et al.* 1969) while being examined fresh were found to exude thin clear oil through the skin and the liver at the slightest pressure virtually "dissolved" into thin clear oil which was practically odourless. This characteristic of the liver was also to some extent seen in the livers of the two species of sharks mentioned above. The meat of these sharks was also devoid of the pungent smell of the commercial species of sharks found in our coastal waters.

TABLE VI

Analysis of fish oil and muscles of deep-water sharks and chimaeroid fish

Particulars		*N. pinnata*	*E. brucus*	*A. armatus*	
				Specimen A	Specimen B
I. ANALYSIS OF LIVER:					
Weight of liver sample		750 gm	5000 gm		
Percentage of oil		66.67*	78.07	72.5	96.4
Vitamin A in USP/gm of oil		1180**	360	90	103
Colour	..			Glassy white	Glassy white
II. ANALYSIS OF MUSCLES:* **					
Moisture	..	80.89%	78.66%	77.6%	75.32%
Ash	..	0.793%	1.187%	1.204%	0.963%
Protein	..	16.76%	18.68%	21.73%	21.825%
Fat	..	0.345%	0.425%	0.811%	1.326%
Vitamin A	..	Negligible	Nil	Nil	Nil
Total Nitrogen	..	-	-	3.477%	3.492%
Phosphorus	..	-	0.2674%	0.194%	0.1712%
Iron	..	-	0.0022%	0.002181%	0.006616%

* 66.67 g/ 100 g. wet liver; ** Average of 3 batches of extraction;

*** % gm/100 gm wet muscle.

POTENTIALLY IMPORTANT INVERTERRATES

The importance of penaeid and non-penaeid prawns of the deep-waters of the continental slope has already been stressed. The Indo-Norwegian Project has already found export market for these as frozen product. Surplus catch is also sometimes sold locally through their Marketing Department.

The discovery of excellent grounds for the deep sea lobster *Puerulus sewelli* between Quilon and south of Alleppey earlier this year and the very high catch rates and the landing of about 150 tons of this species at Cochin within a short time has fully justified views expressed earlier (Kurian, 1965) about its potential importance.

Among the several species which are trawled from the deep waters at least two which deserve special attention are the swarming crab *Charybdis (Goniohellenus) edwardsi* and the gastropod *Pirula investigatoris* Smith.

C. edwardsi is an ubiquitous species occurring in different situations, but at the same time found in dense concentrations along the shelf edge, particularly in depth Zone. II. Details of the occurrence and abundance of this species as observed during R.V. VARUNA cruises is shown in Figure 10. The largest single haul of this species was made by R.V. VARUNA during her 71st cruise on 27-2-65' at 11^{o}34' N., 74^{o}43' E from 142 metres depth when over 3500 kg were caught. This species has also been observed at night solitarily swimming at the surface or passively floating at several places off the south west coast and the Laccadive Sea. It has also been taken in drift net where it gets caught while feeding on gilled fish (Plate III C). On several occasions I have observed it in the stomachs of pelagic sharks and suckerfish *(Echeneis naucrates)* caught in drift net, and also in the stomachs of perches *(Epinephelus* spp. and *Pristipomoides typus)* caught by handlines. The abundance of this species as noted from trawl catch is indicated in Figure 10. The highest catch rates (50 kg/hr and more) were obtained in depth zone II between latitudes 11^{o} N and 13^{0} N. Sexual segregation at least during some seasons is suspected in this species as often only males or only females appear in the trawl catch. Males are larger than the females. The percentage of meat weight in body weight was found to vary from 25.55 to 32.05 per cent (mean 28.5%). In berried females with carapace width of 4.6 to 5.2 cm and weighing from 17.0 to 33.0 gm the egg counts varied from 11363 to 29154 (mean 21956). Detailed investigations

SIZES OF PRAWNS AND FISHES FROM THE UPPER CONTINENTAL SLOPE FREQUENTLY OCCURING IN THE CATCH

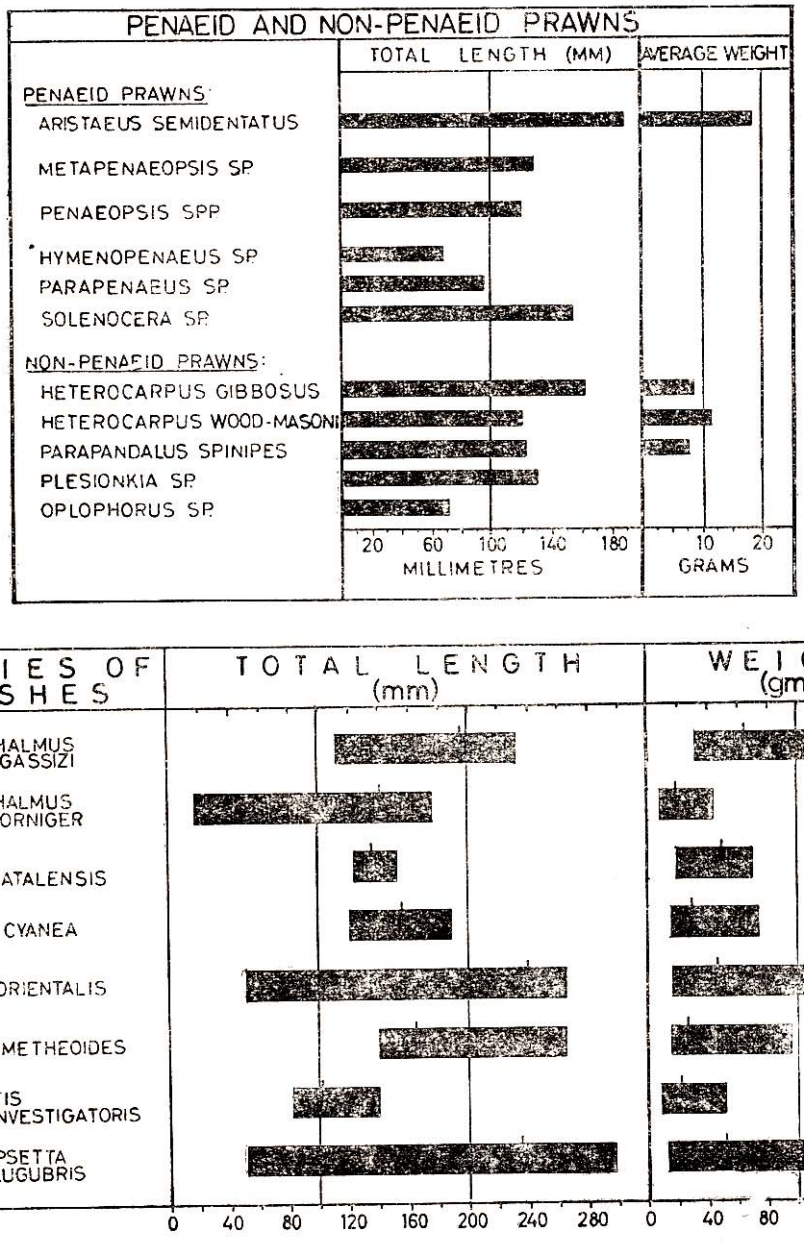


Fig. 7. Lengths and weights of the common fishes and prawns in otter trawl catch from the upper continental slope (Horizontal black bar indicates range and short vertical bar the mean.)

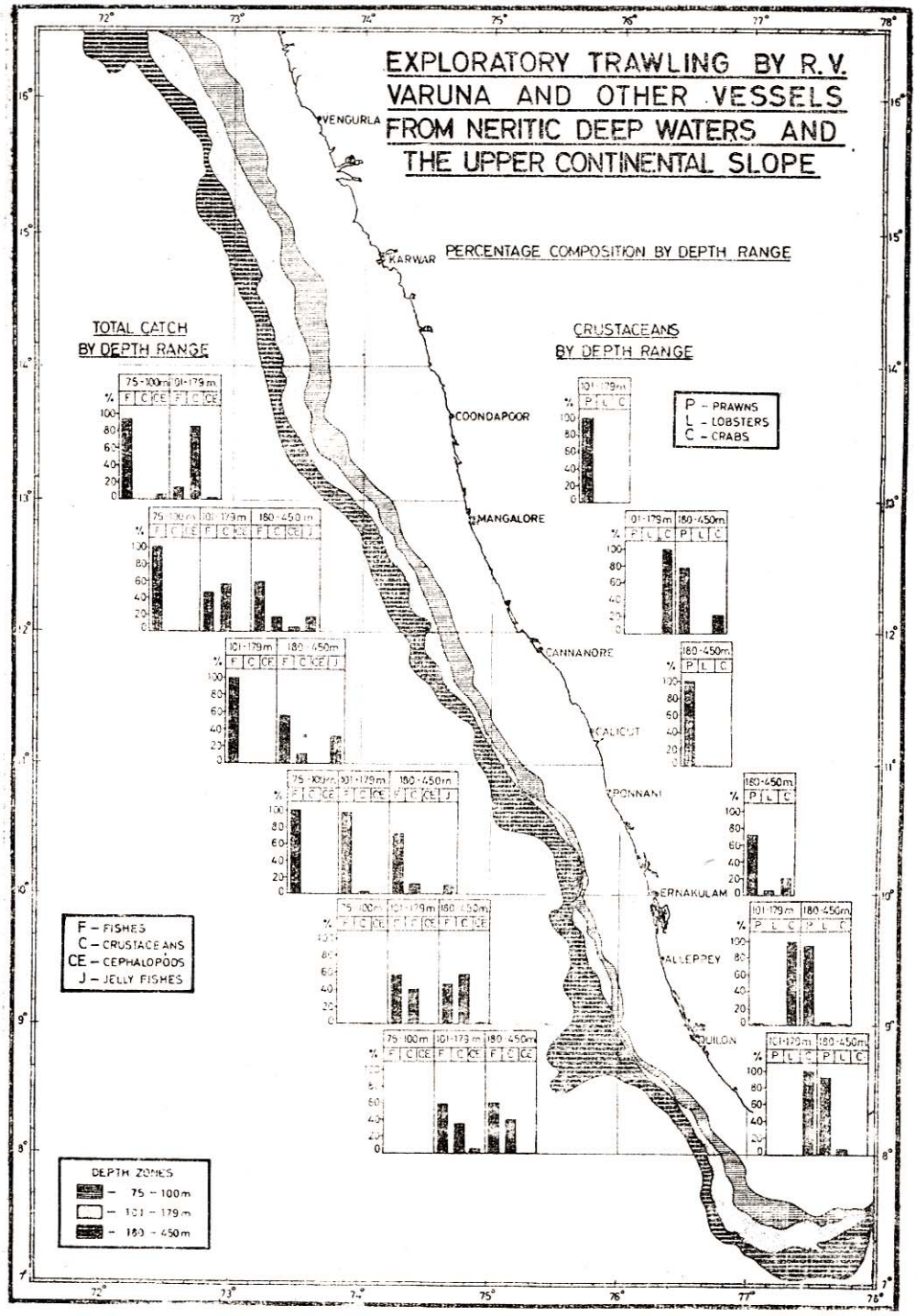


Fig. 8 Percentage composition of fishes and crustaceans in otter trawl catches for each depth zone.

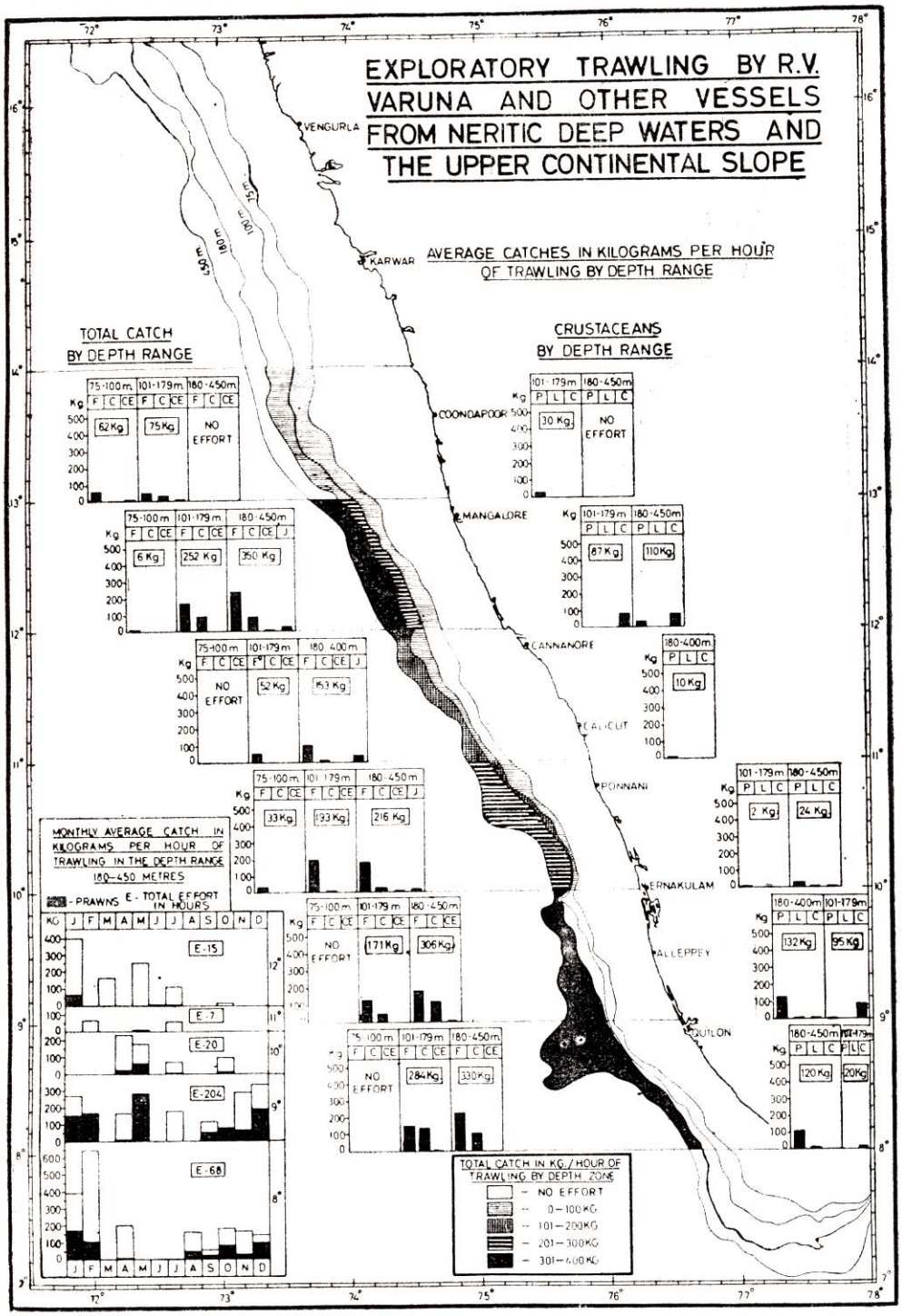


Fig. 9. Average otter trawl catch in kg/hour of trawling for each depth zone. Details for total catch and the crustacean catch are also shown.

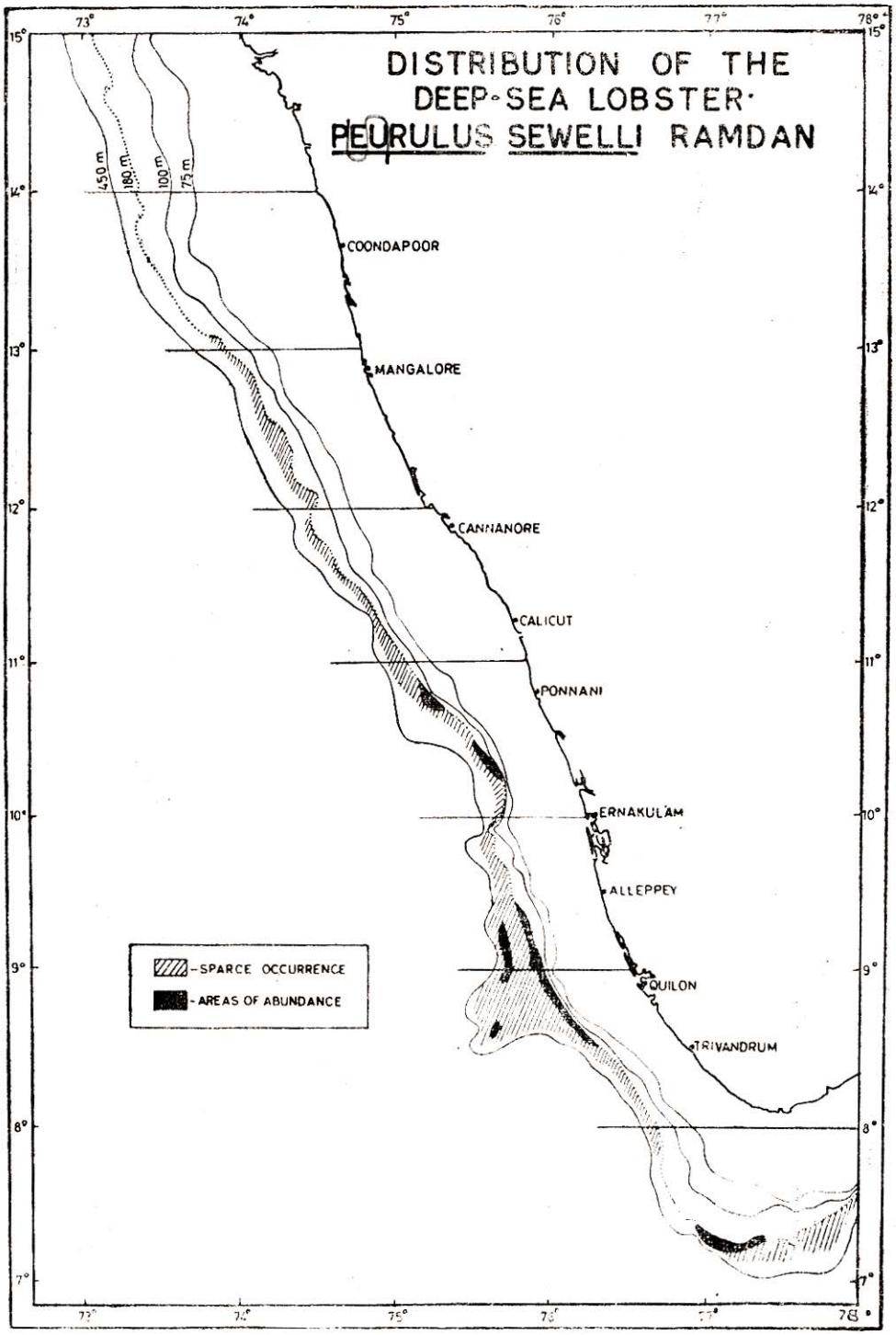


Fig. 10. Areas of occurrence and abundance of the deep-sea lobster *Puerulus sewelli* Ramdan off the south west coast.

on the biology of this species are being carried out. It is felt that if not as food, it could very well be used for the manufacture of crab meal.

The second species of *Pirula investigatoris* (Figure 11 and Plate IVA) occurs in small quantities in most of the deep water trawl hauls from the continental edge and slope, and this or other species (*Fucus* sp.?) have occasionally been trawled from the neritic deep waters. In view of its fairly regular occurrence and its possible use as a source of food more information about this species will be desirable.

Among cephalopods, small quantities of the deep-sea octopod *Berrya Keralensis* Oommen occurs along with catches of deep-sea prawns especially *Heterocarpus* and *Penaeopsis* from the continental slope. More data on this cephalopod and a few species of *Sepia* occurring between 75-350 m are being collected in view of their possible utilization as food.

OCCURRENCE OF JELLY FISHES

During exploratory trawling from R.V. VARUNA sometimes jellyfishes constituted a real hindrance to fishing as large quantities were caught especially in depth zone III often badly clogging the trawl net, making cleaning the net a nuisance. When jellyfishes occurred in large quantities, sorting of prawns was handicapped. The largest catches of jellyfishes occurred in depth zone III between Mangalore and Quilon during the months July-September. During this period, they were also found in depth zone II, but not in large quantities. Exceptionally large quantities of jellyfishes were noticed in 1964 and 1967. More information on the species occurring, factors influencing or responsible for their periodic abundance, etc., will be desirable.

AVERAGE OTTER TRAWL CATCH IN KILOGRAMS PER HOUR OF TRAWLING

In Figure 8 the percentage composition of the fishes, crustaceans and cephalopods constituting the three major groups in the catch has been shown for the three depth zones for each 1^0 latitude starting with 8^0 N.latitude. Among crustaceans a similar breakdown is given for prawns, lobsters and crabs in the same figure.

The average catch in kg/hr for the three depth zones is shown in Figure 9. In depth zone I (75-100 m) it is least, being less than 100 kg/hr

between latitudes 10° N to 11° N., and 12° N to 14° N.

In depth zone II (101-179 m), the average catch rate was 201-300 kg/hr between latitudes 12° N and 13° N, while it was between 101-200 kg/hr between latitudes 10° N and 11° N. In the same zone, it was less than 100 kg/hr between latitudes 11° N to 12° N, and 13° N to 14° N.

In depth zone III (180-450 m), the average catch was between 301-400 kg/hr in latitudes 8° N to 9° N, and 12° N to 13° N,. It was between 201-300 kg/hr between latitudes 10° N to 11° N and between 101-200 kg/hr between 11° N and 12° N.

At present there is no ready market for the fish caught from depth zone III, while the prawns are processed and exported. However, these prawns are susceptiable to easy damage and relatively quick deterioration if they are not ice-packed and stored properly in the ship's refrigerated hold. On account of these, some of the vessels trawling in depth zone III have dumped back into the sea the entire fish catch. However, from R.V. VARUNA data, as well as from the skipper's log of the other vessels it has been possible to obtain the relevant data to enable estimation of the crustaceans in the total catch. On the upper continental slope (depth zone III) it was 56% fishes, approximately 39% crustaceans and the rest cephalopods, gastropods and other invertebrates.

The total effort in hours of trawling expended by all vessels in depth zone III up to the end of November 1968 was 378.50 hrs (= 379 hrs), during which 348 trawling operations were carried out, Of these, data are available for most of the hauls as to the quantity of crustaceans in relation to total catch, but correct information about the proportion of prawn catch in total catch is available for about 70% of the positive hauls. On the basis of these data, the monthly average catch in kg/hr of trawling for the total as well as prawn catch and the total effort expended in hours for each 1^0 latitudes is also shown in Figure 9. One significant thing that emerges from this is the absence of prawns in some of the areas during some months. There is indication that penaeid and non-penaeid prawns are found in greater concentration in some depth ranges and this may show slight shifts with time suggesting periodic large scale bathymetric migrations of these within the depth zone. Trawling at night on the slope has not resulted in good catches of prawns, apparently as they may not be staying close to the bottom during night. However, much remains to be

known about the habits and behaviour of the deep-sea prawns and other organisms, the knowledge of which will go a long way in the better exploitation of this new resources.

It is a well known fact that catch rates may be high in virgin grounds being commercially fished for the first time. With my close association with the Varuna exploratory programme it may be stated that the average catch rates obtained should be considered minimal due to several initial attempts involving trial and error.

ESTIMATION OF POPULATION SIZE

An approximation of the standing crop for the shelf edge and the upper continental slope may be obtained by utilizing the average exploratory catch rates, average trawling speed, average working gape of the standard trawl and the area of the shelf considered. During the cruises of R.V. VARUNA and other vessels, trawl nets of different sizes have been used, the three types mainly used having horizontal mouth openings of 21.0m, 27.0 m, and28.1 m. At an average trawling speed of two knots, the area covered by these nets during a one-hour haul would be 0.077833, 0.100071, and 0.104148 square kilometers respectively. For the gross estimation of the population size, the mean of these (= 0.094017 sq.km) along with the average catch per hour of trawling and estimated area of the shelf edge and the upper continental slope to the 450 metre depth contour are considered. Assuming that the trawl captured all demersal fishes (within the range of sizes retained) in its path to a height of about 2.5. metres above the ocean floor, the population magnitude can be calculated by multiplying the number of 0.094017 sq.km units contained in the depth zone by the yield in kg./hr of trawling. Estimates of the total standing crop (all species combined) as well as for crustaceans (prawns, lobsters and crabs combined) calculated in this manner for the three depth zones considered here are given below (Tables VII-IX).

TABLE – VII

POTENTIAL DEMERSAL FISHERIES RESOURCES OF THE CONTINENTAL SHELF EDGE OFF THE SOUTH WEST COAST OF INDIA

	PARTICULARS	DEPTH ZONE-I (75-100 m)	DEPTH ZONE-II (101-179 m)
1.	Estimated area in sq.km between 7^0 N to 15^0 N	11363	11916
2.	Total number of trawl hauls/Effort in hours	22/27.83	47/43.75
3.	Total catch (Kg.)	1020	8990
4.	Average catch in kg/hr of trawling (based on total effort)	36.55	205.49
5.	No, of hauls with net fouled or damaged or not having touched bottom*	10	11
6.	Effort in hours for item against No.5	11.50	8.75
7.	No. of trawls considered satisfactory/ Effort in hours of trawling	11/16.33	36/35.00
8.	Average catch in kg/hr of trawling based on data against item No.7	62.46	256.87
9.	Estimated area in sq.km covered by trawl with 25.25 metre foot-sweep at average trawling speed of 2 knots	0.094017	0.094017
10.	Estimated potential trawlable demersal fishery resources of Depth Zone-I and II (Calculated at 36.65 and 205.49 kg/hr for the two zones respectively)	4428390 kg. (=4428 tonnes)	26044425 kg. (=26044 tonnes)
11.	Estimated potential sustainable yield at 60%.	2657 tonnes	15627 tonnes
12.	Estimated potential trawlable demersal fishery resources of Depth Zone-I and II (Calculated at 62.46 and 256.87 kg/hr for the two zones respectively)	7542159 kg (=7542 tonnes)	32556482 kg (=32556 tonnes)
13.	Estimated potential sustainable yield at 60%	4525 tonnes	19539 tonnes

* The trawl boards would easily indicate whether they had scrapped along the bottom or not.

TABLE-VIII

POTENTIAL DEMERSAL FISHERIES RESOURCE OF THE UPPER CONTINENTAL SLOPE OFF THE SOUTH WEST COAST OF INDIA

	PARTICULARS	DEPTH ZONE-III (180-450 m)	
1.	Estimated area of upper continental slope in sq.km. between 7^0 N. and 15^0 N.	20240	
2.	Total number of trawl hauls/Effort in hours of trawling	348/378.50	
3.	No. of hauls with net fouled or damaged/effort in hours of trawling	34/29.50	
4.	No. of hauls considered satisfactory/Effort in hours of trawling	318/349.00	
5.	Total catch by all vessels from Depth-Zone III in Kg.	95505	
6.	Estimated quantity of Crustaceans (Prawns, Lobsters, and crabs) in total catch (Kg).	37288	
7.	Percentage of crustaceans in total catch	39.04	
8.	Average catch in kg/hr of trawling for all fish and crustaceans	273.65	
9.	Average catch in kg/hr of trawling for crustaceans	106.84	
10.	Estimated area in sq.km. covered by trawl with 25.25 m foot-sweep at average trawling speed of 2 knots	0.094017	
11.	Estimated potential demersal fisheries resources of the area (at 273.65 kg/hr of trawling)	58891.142	Tonnes
12.	Estimated potential sustainable yield at 60%	35334.685	"
13.	Estimated potential crustacean resource of the area (at 106.85 kg/hr of trawling)	23000.537	"
14.	Estimated potential sustainable yield of crustaceans at 60%	13800.322	"
15.	*Estimated demersal fishery resource (Total) at 400 Kg/hr of trawling	86112.084	"
16.	*Estimated potential sustainable yield at 60%	51667.250	"
17.	Estimated potential crustacean resource at average catch of 200 kg/hr of trawling	43056.042	"
18.	*Estimated potential sustainable yield of crustaceans at 60%	25833.336	"

* In commercial fishing the catch rates may be expected to be higher and as such estimates based on 400 kg/hr for total catch as well as 200 kg/hr. for crustaceans are given here.

From Table VII it might appear that the trawling operations carried out in depth zone-I are few. However, as mentioned earlier, trawlable grounds are very few in this zone, especially between 8^0 N. and 12^0 N. The perch fishery resource found chiefly in this depth zone, will be dealt with in a later section of this report.

Though in area depth zones I & II are more or less of the same extent, good trawling grounds are present in the latter and this is reflected in the average catch in kg/hr of trawling.

The details for the upper continental slope are given in Table-VIII.

The estimated demersal fishery resource of the shelf edge and the upper continental slope depth zone-wise is shown in Table-IX.

TABLE-IX

ESTIMATED POTENTIAL DEMERSAL FISHERY RESOURCE OF THE CONTINENTAL SHELF EDGE AND THE UPPER CONTINENTAL SLOPE OFF THE SOUTH WEST COAST OF INDIA**

DEPTH ZONES	AREA (Sq.km)	Estimated total demersal fishery resource based on average catch rates@	Estimated potential sustainable yield at 60%
Depth Zone-I (75-100 m)	11363	7542 tonnes	4525 tonnes
Depth Zone-II (101-179 m)	11916	32556 tonnes	19539 tonnes
Depth Zone-III (180-450)	20240	58891 tonnes	35335 tonnes
Total	43519	98989 tonnes	59399 tonnes

**From trawling grounds only. This will not include demersal resources such as 'Kalava' or perches found in Depth Zone-I.

@ Estimated at average catch of 62.42, 256.87 and 273.65 kg/hr of trawling for Depth Zones I, II and III respectively.

On the basis of exploratory trawl survey, for an area of approximately 43519sq.km the potential demersal fishery resources is estimated to be around 99000 tones. Average catch rate of about 400 kg/hr may be expected if depth zone-III is commercially fished. At this catch rate, the estimated total demersal fishery resources for the shelf edge and the upper continental slope between 7^0 N and 15^0 N would be around 1,26,210 tonnes and the estimated potential sustainable yield at 60% about 75,000 tonnes. Trawling for deep-sea shrimps should be possible on the continental slope even up to a depth of 800 metres. The richness of the grounds as well as the fact that some of the constituents in the catch such as the deep sea prawns and lobsters are exportable commodities should attract commercial trawling in these deep waters on a large scale. The larger squaloid sharks (*(Atractophorus armatus, Echinorhinus brucus)* and other fishes such as *Cubiceps natalensis, Chlorophthalmus agassizi, C. corniger, Epinnula orientalis, Pseneopsis cyanea* and *Chascenopsetta lugubris* occurring at these great depths could be exploited for being utilized as quality fishes. The possibilities of utilizing much of the trash fish catch from these waters for manufacturing fish meal, fish paste or other products and *Charybdis* abundant along the shelf edge for crab meal will have to be explored. It is a matter of gratification to say that this exploratory survey of the demersal fishing grounds of the deep waters has thrown open new areas where commercial fishing could be successful. At the same it has also given guide lines for future surveys of the deeper waters of our coasts.

NEW FINDINGS ON TRAWLING GROUNDS ON THE CONTINENTAL SLOPE BORDERING THE WADGE BANK AND EXTENDING TO THE GULF OF MANNAR

In March 1969. R.V. VARUNA undertook a special cruise in order to investigate (1) the extent and nature of the continental slope from the outer edge of the Wadge Bank and adjacent areas; (2) the existence of suitable trawling grounds on the upper continental slope; (3) the qualitative and quantitative sampling of fish, crustaceans, and other benthic organisms by 'try net'; (4) the benthos and nature of the substratum by operating the grab and dredge; and (5) the hydrography of the area.

During the cruise 53 sounding tracks between the depths 7 and 860 fathoms plus (12.6 and 907 metres plus) were completed and a total of 12 dry net hauls were taken from depths between 180 and 360 metres (Table-X). The combined data on echosurvey cum fishing along with the information from hydrographic stations taken along the continental shelf edge and the slope have given some idea of the extent of potential trawling grounds on the upper continental slope to a depth of 450 metres (Figure-12).

TABLE-X

'TRY NET' STATION DATA

Sl No.	Date	Position		Depth (Metres)	Duration*	Catch (Kg.)			
		Latitude	Longitude			Fish	Crust	others	Total
1.	9-3-69	$8^0$41'N	$74^0$27'E	189	0640-0715	0.25	0.50	1.25	2.00
2.	10-369	$8^0$41'N	$78^0$21'E	360	1133-1230	1.50	1.00	0.50	3.00
3.	11-3-69	$7^0$43'N	$78^0$11'E	360	1200-1254	1.00	3.50	5.50	10.00
4.	11-3-69	$7^0$46'N	$78^0$07'E	216	1300-1400	1.00	2.00	0.50	3.00
5.	12-3-69	$7^0$20'N	$77^0$45'E	180	1650-1725	0.50	2.50	1.00	4.00
6.	12-3-69	$7^0$10'N	$77^0$36'E	288-342	1820-1900	1.00	2.00	4.00	7.00
7.	13-3-69	$7^0$23'N	$77^0$23'E	180	0615-0655	4.00	-	2.00	6.00
8.	13-3-69	$7^0$05'N	$77^0$12'E	360	1718-1805	1.25	0.35	0.75	2.35
9.	13-3-69	$7^0$05'N	$77^0$19'E	352-360	1850-1930	3.00	0.25	7.00	10.25
10.	13-3-69	$7^0$09'N	$77^0$17'E	324-352	2000-2045	8.50	1.50	240.00	250.00
11.	13-3-69	$7^0$12'N	$77^0$14'E	180	2220-2245	5.00	35.00	5.00	45.00
12.	13-3-69	$7^0$05'N	$77^0$17'E	180	2330-2400	0.50	2.00	3.00	5.50

*Towing was done for 15 minutes/haul. 'Duration' includes shooting and hauling time as well.

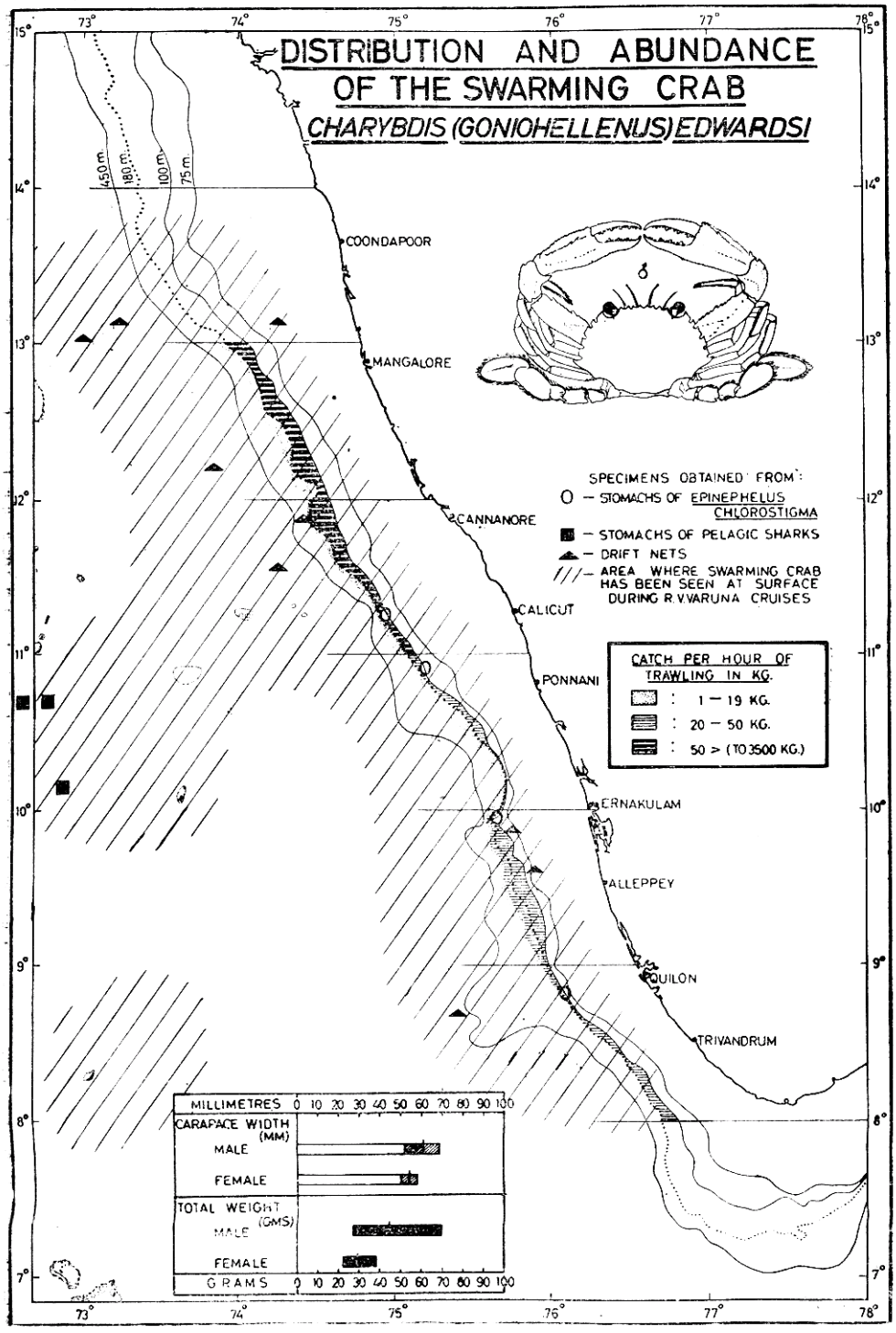


Fig. 11. Distribution and abundance of the swarming crab ***Charybdis (Goniohellenus) edwardsi*** off the south west coast. Data on size (carapace width) and weight are also shown.

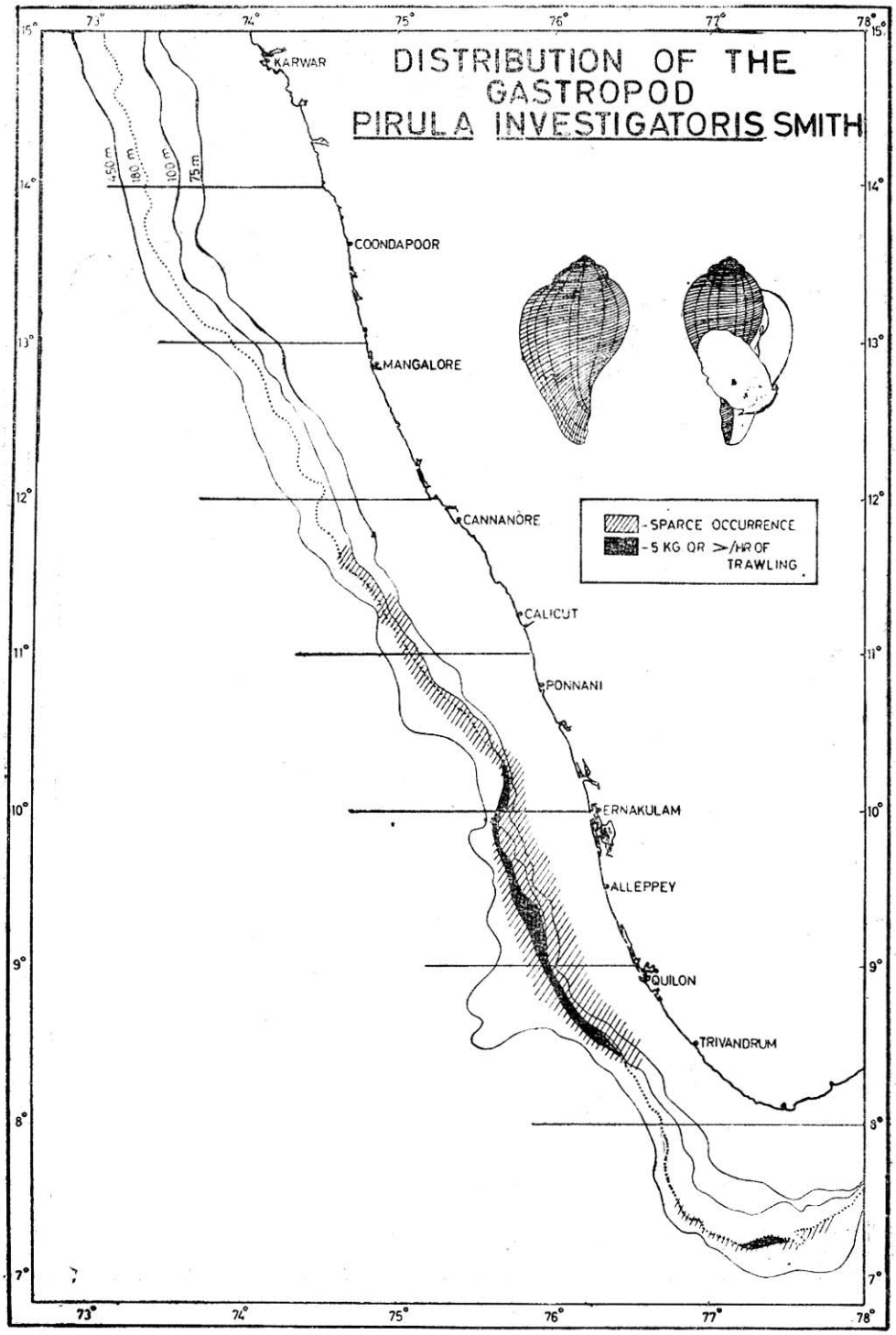


Fig 12. Distribution and abundance of the gastropod *Pirula investigatoris* Smith off the south west coast as seen from deep water otter trawl catches. (This has since been re-identified as *P. sewelli* Prashad)

The continental slope is widest along the south and south eastern edge of the Wadge Bank where the slope is gentle and the distance between the 180 m and 450 m contour lines is as much as 10 nautical miles. On the eastern side of the Wadge Bank and in the Gulf of Mannar, the slope is precipitous beyond about 500 m, and in the 180 to 450 m depth range the bottom topography undulates.

The faunal element of the upper continental slope shows very great similarities to the earlier explored areas between 8°N and 15°N latitudes. The catch composition given in Table XI would explain this better. However, one noteworthy feature, not observed in the 'Quilon Bank' was the occurrence of the deep sea echinoid *Elipneustes denudatus* (Keehler) (Plate IV) in relatively large number in depths between 288 and 360 metres. In the specimens collected in March the gonads were not fully m ature, but possibilities of utilizing fully developed ovaries of this species for the manufacture of 'fish paste' should be explored. On account of the apparent abundance of this species and its possible utility, this may be considered a potentially important species which needs to be investigated further.

TABLE-XI
SPECIES COMPOSITION IN 'TRY NET' CATCH**

Particulars of species	Try Net hauls:											
	1	2	3	4	5	6	7	8	9	10	11	12
CRUSTACEA:												
Lobster (*Peurulus sewelli)*	-	-	X	-	-	-	-	-	X	X	-	-
Crab (*Charybdis* spp.)	X	-	X	-	-	-	-	-	X	-	-	X
Prawns:												
Penaeopsis rectacuta	-	-	X	-	-	X	-	-	-	X	-	-
Plesionika martia	-	-	X	-	-	-	-	X	-	X	-	-
Metapenaeopsis andamensis	-	-	X	X	-	X	-	X	-	-	-	-
Heterocarpus gibbosus	-	-	X	-	-	-	-	-	-	-	-	-
Heterocarpus wood-masoni	-	-	-	-	-	X	-	X	-	-	-	-
Parapandalus spinipes	-	-	-	-	-	X	-	X	-	X	-	-
Parapenaeus investigatoris	-	-	-	-	-	X	-	-	-	X	-	-
Aristeus semidentatus	X	-	-	-	-	-	-	X	-	-	-	-
Hymenopenaeus aequalis	-	-	-	-	-	-	-	X	-	-	-	-
Oplophorus gracilirostris	-	-	-	-	-	-	-	X	-	-	-	-
MOLLUSCA:												
Cephalopods *(Octopus)*	X	-	X	X	X	-	X	-	X	X	X	X
(Cuttlefish)	X	-	X	-	X	-	-	-	X	X	X	X
Pirula investigatoris & other Gastropods	X	-	X	-	-	-	X	-	X	-	-	-
Miscel. Shells (Bivales)	X	-	-	-	X	X	-	X	X	X	X	-
ECHINODERMS:												
Elipneustes denudatus (Koehler)	-	-	X	-	-	X	X	-	-	X	-	-
Holothurians	-	-	-	-	X	-	-	-	-	-	-	-
FISHES:												
Cholorophthalmus agassizi	-	-	-	-	-	-	-	-	X	X	-	-
Chlorophthalmus corniger	-	-	X	-	-	-	-	-	-	X	-	-
Chascanopsetta lugubris	-	-	X	-	-	-	-	-	-	X	-	-
Other flatfishes	X	-	X	X	X	X	X	X	-	-	X	X
Bembrops caudimacula	-	-	X	-	X	X	X	-	X	X	-	X
Synodus sp.	-	-	-	X	X	-	X	-	-	-	X	X
Scorpaenoid fishes	-	-	-	-	-	-	-	-	-	-	X	-
Puffer fishes	-	-	-	-	-	-	X	-	-	-	X	X
Congridae	-	-	-	-	-	-	-	-	-	-	X	X
Lophiidae	-	-	X	X	X	-	-	X	X	X	-	-
Nemipterus sp.	X	-	-	X	-	-	X	-	-	-	X	X
Trigla picta & Trigla sp.	X	-	X	X	X	-	X	-	-	-	X	X
Halieutia sp.	X	-	-	-	-	-	-	X	-	-	-	-
Uranoscopus sp.	X	-	-	-	-	-	-	-	-	-	-	-
Holocentrus rubrum	X	-	-	-	-	-	-	-	-	-	-	-
Callionemidae	X	-	-	-	-	-	X	-	-	-	X	X
Macruridae	X	-	X	-	-	-	-	X	X	-	-	-
Trichiuridae	-	-	X	-	-	-	-	-	-	X	-	-
Myctophidae	-	-	-	-	-	-	-	X	-	-	-	-
Peristedion sp.	-	-	-	-	-	-	-	X	-	-	-	-
Miscel. Fishes	X	-	X	-	X	-	X	-	X	X	-	X
Sharks (small)	X	-	X	-	X	-	X	-	-	-	-	X

** The station positions are listed in Table. XIII. The species of prawns listed here were identified by the Crustacean Division, CMFRI Sub-Station, Ernakulam and the echinoid *(E. denudatus)* by Mr. D.B. James of this institute.

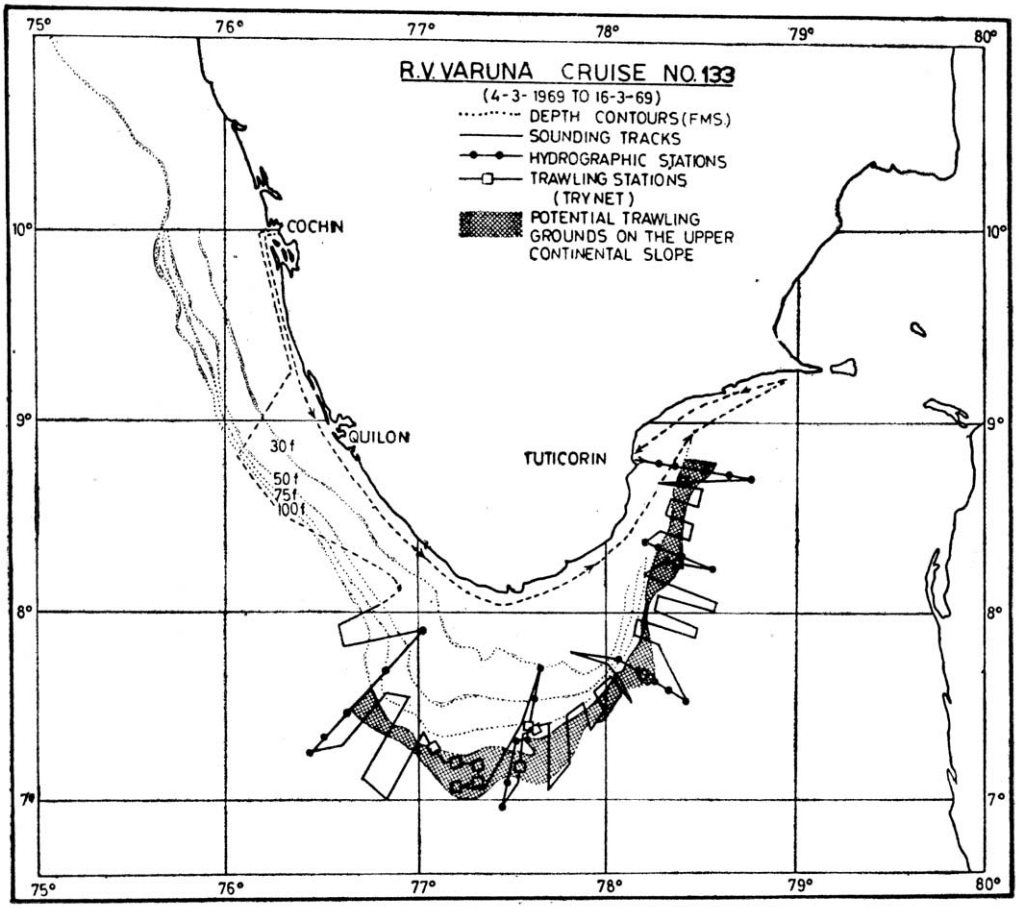


Fig. 13. Potential trawling grounds on the upper continental slope bordering the Wadge Bank investigated during R. V. *VARUNA* cruise 133 in March 1969.

SOME HYDROLOGICAL FEATURES OF THE SHELF EDGE AND THE UPPER CONTINENTAL SLOPE

The hydrographic data pertaining to the region along the south west coast of India between 75 and 500 metres depth from off Cape Comorin northwards to Karwar collected during the research cruises of R.V. VARUNA, R.V. KALAVA and other vessels have been analysed for hydrographic parameters such as temperature, salinity, dissolved oxygen and density (Sigma-T). The data has also been averaged out month-wise for 1^0 latitude square pertaining to this investigational area. Surface and bottom temperatures and samples for salinity and oxygen determinations were specially taken at some of the trawl stations on the shelf edge and continental slope. Detailed comparison of the catch data with environmental data will be published elsewhere (Silas, Rao and Ramamirtham, 1969).

In Table XII data for three parameters, namely temperature, salinity and dissolved oxygen are presented just to given an idea of the average conditions that may be expected in each of these depth zones from depths which have been actually fished (the range given not being for the complete depth range of each depth zone). For instance, if trawling had been done during the month of January in depth zone II from 160 m at 12^0 N and from 110m at 14^0 N, the temperature range shown as 15.5^0C to 23.0^0C refers to average values at the respective depths of fishing and not the average maximum and minimum values at 100m-179 m. As such, these figures will not give finer details, but only a gross picture of some of the conditions which have obtained where trawling has been carried out.

This, in depth zone II the average temperature values in the depth fished may vary between 15^0C and 23^0C decreasing with depth. The salinity differs very little, the range being 34.8 to $35.8^0/_{00}$. Oxygen levels show some difference, being lowest during the months July August, September and November (.5ml/L or slightly less) and highest during February/April (2.0 to 3.0 ml/L), the depths fished being repeated during some of the months.

In depth zone III the difference in the average temperature which decrease with depths is between 9^0C and 18^0C for the fishing depths. Salinity showed hardly any variation being 35.0 to $35.2^0/_{00}$. Similarly oxygen levels (average values) were also uniformly low being about 0.5 to 1.0 ml/L.

TABLE-XII

AVERAGE VALUES OF TEMPERATURE, SALINITY AND DISSOLVED OXYGEN FOR ACTUAL TRAWLING DEPTHS ON THE SHELF EDGE AND THE UPPER CONTINENTAL SLOPE

MONTH	DEPTH ZONE-II (101-179 Metres)				DEPTH ZONE-III (180-450 Metres)			
	Latitudes from Where fishing has been carried out	T°C	$S^0/_{00}$	0_2 ml/L	Latitudes from where fishing has been carried out	T°C	$S^0/_{00}$	0_2 ml/L
JANUARY	12^0N - 14^0N	15.5-23.0	35.2-35.4	0.5-1.5	8^0N-13^0N	11.0-15.0	35.2	0.5
FEBRUARY	11^0N - 12^0N	22.0	35.4	2.5-3.0	8^0N-13^0N	12.0-13.0	35.2	0.5-1.0
MARCH	-	-	-	-	9^0N-13^0N	9.0-15.0	35.2	0.5-1.0
APRIL	12^0N - 13^0N	22.0	35.6-35.8	2.0-2.5	8^0N-11^0N	12.0-14.0	35.2	0.5-1.0
MAY	10^0N - 14^0N	19.0-22.0	35.2-35.4	1.0-1.5	9^0N-13^0N	11.0-13.0	35.2	0.5-1.0
JUNE	10^0N - 11^0N	16.0-17.0	35.0-35.2	1.0	12^0N-13^0N	15.0-16.0	35.0-35.2	1.0
JULY	10^0N - 11^0N	18.0-19.0	35.0-35.2	0.5-1.0	8^0N-13^0N	11.0-16.0	35.0-35.2	0.5-1.0
AUGUST	9^0N - 13^0N	17.0-20.0	34.8-35.0	0.5-1.0	8^0N-9^0N	11.0-12.0	35.0	0.5-1.0
SEPTEMBER	8^0N - 14^0N	16.0-18.0	35.2	0.5-1.0	8^0N-10^0N	12.5-14.0	35.0-35.2	0.5-1.0
OCTOBER	9^0N - 10^0N	18.0-19.0	35.0-35.2	1.0	8^oN-13^0N	12.0-12.5	35.0-35.2	0.5-1.0
NOVEMBER	9^0N - 14^0N	18.0-20.0	35.0-35.6	0.5-1.0	8^0N-12^0N	12.0-18.0	35.0-35.2	0.5-1.0
DECEMBER	10^0N - 11^0N	21.0-22.0	35.2-35.4	1.5-2.0	8^oN-10^0N	12.0-14.0	35.2	0.5

Table – XIII

R.V. VARUNA OTTER TRAWL STATIONS

Serial No.	Cruise No.	Date	Position		Depth (m)	Duration* of haul	TotalWeight of catch (Kg)
			Latitude	Longitude			
1	2	3	4		5	6	7
1.	V-1	4-1-62	$11^0$00'N	$75^0$15'E	19	1220-1330	100
2.	"	6-1-62	$09^0$59'N	$75^0$54'E	80	0230-0645	@1500
3.	"	6-1-62	$09^0$45'N	$75^0$47'E	110	1620-1850	nil
4.	"	7-1-62	$09^0$12'N	$76^0$00'E	92	1800-1930	nil
5.	"	8-1-62	$08^0$45'N	$76^0$23'E	@60	1630-1810	nil
6.	V-3	1-2-62	$11^0$44'N	$75^0$26'E	10-20	1345-1430	nil
7.	"	2-2-62	$11^0$10'N	$75^0$34'E	@35	1220-1250	15
8.	"	2-2-62	$10^0$55'N	$75^0$31'E	50-55	1600-1640	60
9.	"	2-2-62	$10^0$42'N	$75^0$26'E	75	1915-1950	nil
10.	"	3-2-62	$10^0$38'N	$75^0$42'E	30	0445-0555	nil
11.	"	3-2-62	$10^0$48'N	$75^0$42'E	32	0745-0850	nil
12.	V-4	12-2-62	$11^0$55'N	$75^0$10'E	20	1640-1715	nil
13.	"	12-2-62	$11^0$37'N	$75^0$05'E	@50	1740-1800	nil
14.	"	13-2-62	$10^0$40'N	$75^0$51'E	10-15	1315-1345	nil
15.	V-5	20-2-62	11^o35'N	$74^0$59'E	53	1045-1115	nil
16.	"	22-2-62	$10^0$07'N	$75^0$46'E	62	1025-1130	nil
17.	"	24-2-62	$08^0$41'N	$76^0$26'E	60	0745-0830	nil
18.	"	24-2-62	$08^0$41'N	$76^0$38'E	40	1030-1100	nil
19.	V-6	2-3-62	$08^0$46'N	$76^0$14'E	72	1025-1130	nil
20.	"	4-3-62	$08^0$20'N	$76^0$51'E	30	1900-2000	nil
21.	"	5-3-62	$08^0$03'N	$77^0$08'E	48	0815-0910	nil
22.	"	5-3-62	08^o03'N	$77^0$08"E	48	1020-1120	nil
23.	"	7-3-62	$10^0$11'N	$76^0$00'E	22	1910-1945	30
24.	V-7	27-3-62	$14^0$42'N	$73^0$40'E	40	1120-1215	15
25.	"	5-4-62	$14^0$45'N	$74^0$05'E	30	1615-1645	nil
26.	V-8	21-5-62	$19^0$58'N	$70^0$40'E	80	2315-0045	-
27.	"	21-5-62	$20^0$01'N	$69^0$27'E	94	1830-1940	75
28.	"	23-5-62	$19^0$16'N	$70^0$26'E	70-84	0305-0400	-

* Duration of haul= From start shooting net to stop hauling

ND=Net damaged

1	2	3	4		5	6	7
29	V-8	23-5-62	19^{0}16'N	72^{0}01'E	30-34	1725-1835	55
30	V-9	13-6-62	07^{0}31'N	76^{0}57'E	@100	1735-1835	nil
31	"	14-6-62	08^{0}22'N	76^{0}40'E	65	1100-1300	5
32	V-10	20-6-62	09^{0}30'N	76^{0}11'E	23	0900-0940	nil
33	"	22-6-62	09^{0}28'N	76^{0}15'E	20	1835-2000	1000
34	V-21	18-12-62			18	0900-0915	15
35	"	18-12-62	14^{0}46'N	74^{0}04E	16	1045-1120	200
36	"	18-12-62	14^{0}51'N	73^{0}59'E	20	1235-1400	100
37	"	18-12-62	14^{0}57'N	74^{0}01'E	18	1430-1545	500
38	"	19-12-62	14^{0}53'N	74^{0}01'E	15	0910-1010	270
39	"	19-12-62	16^{0}01'N	73^{0}25'E	10	1035-1145	300
40	"	19-12-62			12	1510-1615	200
41	"	23-12-62	N.W. of Cannanore		18	1345-1515	200
42	V-32	28-5-63	11^{0}08'N	75^{0}25'E	38	1130-1230	nil
43	"	29-5-63	09^{0}50'N	75^{0}54'E	43	1335-1415	@50
44	"	29-5-63	09^{0}50'N	75^{0}55'E	45	1510-1550	nil
45	V-33		08^{0}12'N	76^{0}58'E	60	-	nil
46	"	-	Off Quilon (Neendakara)		30	-	20
47	V-34	7-8-63	Off Tellicherry		16	-	nil
48	"	7-8-63	Off Cannanore		22	-	nil
49	"	7-8-63	Off Calicut		35	-	nil
50	V-35	12-8-63	-		55	-	20
51	V-35	12-8-63	-		50	-	nil
52	"	12-8-63	10^{0}15'N	75^{0}50'E	52	-	500
53		13-8-63	10^{0}05'N	75^{0}57'E	20	-	nil
54	"	13-8-63	-		20	-	50
55	"	13-8-63	09^{o}51;N	75^{0}52"E	57	-	20
56	V-36	20-8-63	11^{0}07'N	75^{0}18'E	62	0630-0730	200
57	"	21-8-63	11^{0}30'N	74^{0}458E	125	1330-1415	20
58	"	21-8-63	11^0 50'N	74^{0}38'E	80	1640-1740	10
59	"	22-8-63	12^{0}28'N	74^{0}37'E	60	0825-0910	10
60	"	22-8-63	11^{0}56'N	74^{0}57'E	57	1235-1330	10
61	"	23-8-63	09^{0}51'N	75^{0}51'E	62	0610-0700	10

1	2	3	4		5	6	7
62	V-37	5-9-63	$08^0$39’N	$76^0$39’E	47	1625-1725	20
63	“	6-9-63	$08^0$46’N	$76^0$13’E	64	1100-1200	10
64	“	6-9-63	$09^0$04’N	$76^0$26’E	40	1400-1500	100
65	“	7-9-63	$09^0$22’N	$76^0$09’E	42	1225-1325	20
66	“	7-9-63	$09^0$15’N	$76^0$05’E	54	1410-1510	200
67	“	7-9-63	$09^0$15’N	$76^0$12’E	18	1715-1800	nil
68	V-38	19-9-63	$15^0$10’N	$73^0$43’E	23	1100-1200	nil
69	“	19-9-63	$15^0$31’N	$73^0$39’E	22	1425-1525	nil
70	“	21-9-63	$16^0$22’N	$73^0$12’E	43	1755-1855	nil
71	“	21-9-63	$16^0$09’N	$73^0$19’E	36	2030-2130	nil
72	“	22-9-63	$15^0$32’N	$73^0$26’E	47	1630-1730	nil
73	“	22-9-63	$15^0$35’N	$73^0$39’E	18	1920-2020	8
74	V-40	22-10-63	$11^0$03’N	$75^0$24’E	55	0715-0815	200
75	“	22-10-63	$11^0$00’N	$75^0$02’E	150	0900-0930	nil
76	“	23-10-63	$10^0$58’N	$75^0$29’E	45	1010-1115	1500
77	V-41	3-11-63	$08^0$10’N	$76^0$55’E	60	1935-2035	5
78	V-42	17-11-63	$10^0$41’N	$75^0$31’E	76-88	0830-0930	2
79	V-43	12-12-63	$13^0$49’N	$74^0$15’E	45-50	0815-0915	nil
80	V-45	26-2-64	$12^0$00’N	$74^0$45’E	60	1030-1115	nil
81	“	26-2-64	$12^0$16’N	$74^0$00’E	20	1320-1400	70
82	“	26-2-64	$11^0$45’N	$75^0$25’E	10	1745-1820	10
83	“	27-2-64	$11^0$06’N	$75^0$25’E	40	1520-1610	5
84	“	27-2-64	$11^0$13’N	75^0 40’E	30	1740-1815	10
85	V-47	18-3-64	$08^0$00’N	$77^0$00’E	54	1447-1515	nil
86	“	19-3-64	$09^0$00’N	$75^0$58’E	320	1900-1930	nil
87	“	19-3-64	$08^0$27’N	$76^0$46’E	54	0100-0300	nil
88	“	19-3-64	$08^0$25’N	$76^0$45’E	50	0330-0430	nil
89	“	19-3-64	$09^0$00’N	$76^0$18’E	60	1400-1500	nil
90	“	19-3-64	Off Kozhitottam, N. of Quilon		18	1830-1930	75
91	“	19-3-64	$09^0$30’N	$76^0$10’E	50	2300-2330	1
92	“	20-3-64	$10^0$00’N	$75^0$55’E	65	0845-0945	2
93	V-48	24-3-64	$11^0$12’N	$75^0$43’E	14	1745-1815	25

1	2	3	4		5	6	7
94	V-48	24-3-64	$11^0$05’N	$75^0$53’E	38	2045-2115	30
95	“	25-3-64	$10^0$36’N	$75^0$36’E	60	0915-0945	30
96	“	25-3-64	$10^0$43’N	$75^0$34’E	38	1100-1130	25
97	V-49	8-4-64	$09^0$30’N	$76^0$06’E	40	0245-0335	nil
98	“	8-4-64	$10^0$00’N	$76^0$23’E	28	0800-0900	50
99	V-50	19-4-64	$09^0$00’N	$76^0$06’E	64	1000-1055	21
100	“	19-4-64	09^o00’N	$76^0$12’E	52	1115-1245	nil
101	“	09-4-64	$09^0$00’N	$76^0$18’E	40	1330-1415	nil
102	“	19-4-64	$09^0$00’N	$76^0$28’E	22	1510-1600	200
103	“	19/20-4-64	$10^0$00’N	$76^0$00’E	32	2340-0035	25
104	“	20-4-64	$10^0$00’N	$75^0$54’E	44	0115-0230	nil
105	“	20-4-64	-		50	0915-1000	nil
106	“	20-4-64	$11^0$00’N	$75^0$21’E	50	2100-2200	50
107	“	21-4-64	$11^0$00’N	$75^0$33’E	40	0030-0130	5
108	“	21-4-64	$11^0$00’N	$75^0$44’E	20	0155-0300	nil
109	V-51	26-4-64	$12^0$43’N	$74^0$35’E	45	1740-1810	40
110	“	26-4-64	$12^0$38’N	$74^0$22’E	60-70	2010-2050	nil
111	“	27-4-64	$12^0$10’N	$74^0$50’E	40-50	-	nil
112	“	27-4-64	$11^0$37’N	$75^0$10’E	50-55	-	50
113	“	28-4-64	$11^0$00’N	$75^0$25’E	40-45	-	nil
114	“	28-4-64	$11^0$05’N	$75^0$34’E	25-30	-	10
115	V-52	10-5-64	$08^0$10’N	$76^0$55’E	58	1115-1210	15
116	“	10-5-64	$08^0$49’N	$76^0$29’E	30	1630-1720	300
117	V-53	20-5-64	$09^0$00’N	$76^0$13’E	60	0245-0345	nil
118	“	20-5-64	$09^0$30’N	$76^0$10’E	24	0810-0845	150
119	“	20-5-64	$10^0$00’N	$76^0$52’E	47	1420-1520	nil
120	“	21-5-64	$11^0$00’N	$75^0$44’E	26	0745-0830	120
121	“	21-5-64	$10^0$41’N	$75^0$41’E	50	1100-1140	60
122	V-54	26-5-64	$12^0$14’N	$75^0$00’E	22	1305-1345	250
123	“	27-5-64	$12^0$38’N	$74^0$20’E	78	0740-0840	10
124	“	27-5-64	$12^0$49’N	$74^0$45’E	28	1130-1215	15
125	“	30-5-64	$11^0$45’N	$75^0$22’E	20-34	0150-0210	nil
126	“	30-5-64	$11^0$35’N	$75^0$00’E	40-60	0440-0540	nil

1	2	3	4		5	6	7
127	V-54	30-5-64	11^{0}04’N	75^{0}21’E	48	1805-1845	10
128	“	30-5-64	11^{0}21’N	75^{0}49’E	24	2140-2245	120
129	V-56	1-7-64	09^{0}24’N	76^{0}13’E	10	2015-2115	5
130	V-58	26-7-64	12^{0}44’N	74^{0}20’E	80	1725-1800	nil (ND)
131	V-59	13-8-64	10^{0}00’N	75^{0}46’E	60	-	Net lost
132	V-60	26-8-64	09’48’N	76^{0}02’E	40	1330-1415	1 (ND)
133	V-61	12-9-64	09^{0}33’N	76^{0}10’E	35	1515-1600	200
134	V-62	23-9-64	10^{0}00’N	75^{0}59’E	35	2030-2130	15
135	“	24-9-64	11^{o}11’N	75^{o}35’E	26	0845-0915	5
136	V-63	10-10-64	08^{0}48’N	76^{0}34’E	30	0815-0900	15
137	“	10-10-64	08^{0}30’N	76^{0}38’E	30	0945-1050	30
138	“	11-10-64	09^{0}28’N	76^{0}12’E	30	0940-1025	nil
139	“	11-10-64	09^{0}30’N	75^{0}59’E	52	1200-1240	nil
140	V-64	24-10-64	09^{0}00’N	76^{0}23’E	31	0230-0330	nil
141	“	24-10-64	09^{o}00’N	76^{0}07"E	58	0610-0745	nil
142	“	24-10-64	09^{0}33’N	76^{0}02’E	40	1600-1645	200
143	“	24-10-64	10^{0}00’N	75^{0}53’E	58	2145-2245	5
144	“	25-10-64	10^{0}58’N	75^{0}24’E	60	1250-1345	100
145	“	25-10-64	11^{0}42’N	75^{0}21’E	20	2120-2200	2
146	“	25/26-10-64	11^{0}37’N	75^{0}10’E	48	2345-0040	nil
147	“	26-10-64	12^{0}08’N	74^{0}47’E	61	1605-1700	nil
148	“	26-10-64	12^{0}15’N	75^{0}00’E	20	1905-1945	nil
149	“	26/27-10-64	12^{0}46’N	74^{0}43’E	22	2340-0030	2
150	“	27/28-10-64	10^{0}45’N	75^{o}38’E	46	2315-0015	5
151	V-66	20-12-64	11^{0}49’N	75^{0}15’E	25	0555-0700	5
152	“	20-12-64	11^{0}51’N	75^{0}18’E	12	0730-0830	nil
153	V-68	6-1-65	09^{0}00’N	76^{0}26’E	22	1620-1725	200
154	“	6-1-65	09^{0}00’N	76^{0}20’E	36	1745-1850	200
155	“	7-1-65	09^{0}30’N	76^{0}15’E	20	1030-1120	10
156	“	21-1-65	14^{0}30’N	73^{0}50’E	45	0945-1045	2
157	V-69	31-1-65	10^{0}00’N	76^{0}03’E	28	1025-1115	nil
158	“	31-1-65	10^{0}00’N	75^{0}49’E	54	1330-1500	nil (ND)
159	“	1-2-66	10^{0}00’N	76^{0}01’E	30	1320-1410	nil
160	“	1-2-65	10^{0}00’N	76^{o}06’E	20	1530-1630	200

1	2	3	4		5	6	7
161	V-70	4-2-65	$09^0$10’N	$76^0$09’E	50	1450-1550	15
162	“	4-2-65	Off Quilon		30	1650-1715	20
163	“	8-2-65	$10^0$00’N	$76^0$07’E	30	1000-1100	70
164	“	8-2-65	$9^0$55’N	$76^0$10’E	25	1120-1240	20
165	“	12-2-65	$14^0$11’N	$73^0$32’E	108	1545-1700	30
166	“	13-2-65	Off Mangalore		82	1700-1815	100
167	“	13-2-65	Off Mangalore		74	1900-2015	20
168	“	14-2-65	$11^0$46’N	$75^0$18’E	43	0415-0515	300
169	“	14-2-65	$10^0$53’N	$75^0$13’E	150	1355-1425	Net lost
170	V-71	23-2-65	Off Alleppey		30	1945-2030	100
171	“	23-2-65	Off Alleppey		30	2045-2130	5
172	“	25-2-65	09024’N	$75^0$55’E	60	1610-1625	nil (ND)
173	“	25-2-65	09038’N	$75^0$47’E	100	1845-1920	nil
174	“	26-2-65	$10^0$00’N	$75^0$52’E	50	0220-0330	nil (ND)
175	“	26-2-65	$10^0$41’N	$75^0$26’E	110	1200-1330	nil
176	“	26-2-65	$11^0$01’N	$75^0$18’E	70	1850-1945	15
177	“	26-2-65	$11^0$09’N	$75^0$28’E	40	2200-2315	15
178	“	27-2-65	$11^0$34’N	$74^0$51’E	76	1015-1130	30
179	“	27-2-65	$11^0$34’N	$74^0$43’E	142	1250-1350	3500
180	“	28-2-65	$12^0$42’N	$74^0$32’E	56	0945-1045	150
181	“	28-2-65	$12^0$29’N	$74^0$08’E	340	1435-1535	nil (ND)
182	“	28-2-65	$11^0$56’N	$74^0$41’E	120	2255-2330	nil (ND)
183	V-72	12-3-65	$10^0$00’N	$75^0$46’E	60	0010-0045	20
184	“	20-3-65	$10^0$00’N	$76^0$07’E	30	0420-0540	50
185	“	20-3-65	$12^0$05’N	$74^0$26’E	200	1330-1400	125
186	“	20-3-65	$11^0$30’N	$74^0$51’E	100	2215-2315	nil
187	“	21-3-65	$10^0$33’N	$75^0$40’E	60	1000-1050	75
188	V-73	26-3-65	$09^0$00’N	$76^0$26’E	20	0010-0110	50
189	“	26-3-65	$10^0$00’N	$76^0$08’E	26	1555-1645`	50
190	“	26-3-65	$10^0$00’N	$76^0$03’E	26	1700-1730	75
191	“	27-3-65	$11^0$08’N	$75^0$32’E	40	0925-1110	2
192	“	27-3-65	$11^0$12’N	$75^0$39’E	30	1210-1320	125
193	“	27-3-65	$11^0$28’N	$75^0$33’E	20	1530-1615	75

1	2	3	4		5	6	7
194	V-73	27-3-65	$11^0$43’N	$75^0$20’E	26	1830-1915	80
195	“	28-3-65	$12^0$15’N	$74^0$45’E	60	1030-1145	nil
196	“	28-3-65	$12^0$25’N	$74^0$54’E	20	1400-1500	150
197	“	28-3-65	$12^0$28’N	$74^0$52’E	20	1545-1640	100
198	“	28-3-65	12^o38’N	$74^0$49’E	20	1745-1845	100
199	“	29-3-65	$11^0$52’N	$74^0$53’E	64	0935-1010	1
200	“	29-3-65	$11^0$37’N	$75^0$18’E	40	1245-1320	nil
201	“	29-3-65	$11^0$09’N	$75^0$41’E	24	1455-1525	60
202	“	29-3-65	$11^0$08’N	$75^0$42’E	24	1540-1615	120
203	“	29-3-65	$11^0$06’N	$75^0$44’E	24	1710-1745	150
204	“	29-3-65	$11^0$45’N	$75^0$22’E	18	1920-2030	30
205	V-74	2 -4-65	$09^0$55’N	76^o10’E	25	1845-2045	350
206	“	2-4-65	$09^0$53’N	76^o08E	24	2100-2200	nil
207	“	5-4-65	$08^0$50’N	$76^0$30’E	20	0920-0950	6
208	“	5-4-65	$09^0$26’N	$76^0$13’E	20	1150-1250	50
209	“	6-4-65	$10^0$00’N	$75^0$50’E	60	0925-1000	nil
210	“	6-4-65	$10^0$00’N	$76^0$05’E	30	1200-1240	nil
211	“	6-4-65	$10^0$00’N	$76^0$04’E	25	1245-1320	10
212	V-75	23-4-65	Off Cannanore		30	1015-1040	nil
213	“	23-4-65	Off Cannanore		30	1050-1115	nil
214	“	26-4-65	$10^0$00’N	$76^0$07’E	26	0645-0715	5
215	“	27-4-65	$09^0$00’N	$76^0$22’E	50	1200-1300	1
216	“	28-4-65	Off Quilon		40	1100-1200	60
217	“	28-4-65	Off Quilon		40	1335-1420	nil (ND)
218	“	28-4-65	$09^0$04’N	76^o26’E	18	1640-1710	30
219	“	28-4-65	09^o06’N	$76^0$24’E	10-20	(1 hour)	30
220	V-76	3-5-65	$10^0$00’N	$75^0$56’E	38	1945-2120	30
221	“	6-5-65	$09^0$00’N	76^o28’E	30	1300-1345	35
222	“	11-5-65	$11^0$35’N	$75^0$20’E	33-36	0935-1035	50
223	“	11-5-65	$11^0$40’N	$75^0$18’E	36	1130-1230	145
224	“	12-5-65	$13^0$43’N	$73^0$40’E	72-75	1020-1130	25
225	“	12-5-65	$13^0$41’N	$73^0$30’E	120-124	1430-1530	55
226	“	12-5-65	$13^0$16’N	$73^0$55’E	75	2300-2400	75

1	2	3	4		5	6	7
227	V-76	13-5-65	13^{0}08’N	74^{0}32’E	40	0330-0430	nil
228	“	13-5-65	12^{0}30’N	74^{o}16’E	120	1100-1200	75
229	“	13-5-65	12^{0}24’N	74^{0}31’E	70-74	1330-1430	nil
230	“	14-5-65	11^{0}30’N	74^{0}50’E	130	0145-2030	3
231	“	14-5-65	11^{0}20’N	74^{0}52’E	120	0240-0330	100
232	“	14-5-65	10^{0}37’N	75^{0}31’E	100	1130-1215	25
233	“	14-5-65	10^{0}30’N	75^{0}32’E	110	1345-1445	75
234	“	14-5-65	10^{0}26’N	75^{0}41’E	68	1745-1840	162
235	“	14-5-65	10^{0}21’N	75^{0}45’E	65-68	1930-2020	60
236	V-80	24-7-65	13^{0}13’N	73^{0}58’E	70	1000-1150	150
237	“	24-7-65	12^{0}27’N	74^{0}51’E	26	1745-1815	100
238	“	25-7-65	11^{0}02’N	75^{0}37’E	38	0730-0830	nil
239	“	25-7-65	10^{0}38’N	75^{o}32’E	73	1425-1535	nil
240	V-81	4-8-65	07^{0}50’N	76^{o}46’E	170	1445-1530	Net lost
241	“	6-8-65	08^{0}24’N	76^{o}28’E	120	0900-1030	1500
242	“	6-8-65	08^{0}45’N	75^{o}50’E	370	1030-2000	300
243	“	6-6-65	08^{0}40’N	76^{o}13’E	120	2315-0030	nil
244	“	7-8-65	08^{0}45’N	75^{o}38’E	365	1015-1215	250
245	“	8-8-65	09^{0}42’N	75^{o}44’E	120	0820-0940	300
246	“	8-8-65	09^{0}50’N	75^{o}40’E	105	1140-1250	50
247	V-82	18-8-65	11^{0}20’N	75^{o}00’E	80	0715-0830	nil
248	“	18-8-65	11^{0}20’N	75^{0}15’E	80	1200-1245	nil
249	“	19-8-65	12^{0}04’N	74^{o}31’E	120	2100-2215	nil
250	“	20-8-65	12^{0}25’N	74^{o}23’E	120	0130-0230	50
251	“	21-8-65	13^{0}15’N	73^{0}50’E	100	0915-1030	nil
252	“	22-8-65	14^{0}43’N	73^{0}53’E	20	1730-1830	150
253	Sp.Fi Cruise	31-8-65	09^{0}54’N	76^{0}05’E	26	1845-2000	50
254	“	31-8-65	09^{0}48’N	75^{0}50’E	56	2200-2300	75
255	“	1-9-65	09^{0}48’N	75^{0}46’E	260	0615-0700	10
256	“	1-9-65	09^{0}36’N	76^{0}00’E	50	1030-1115	60
257	“	1-9-65	09^{0}42’N	76^{0}07’E	30	1255-1410	250
258	“	1-9-65	09^{0}42’N	76^{0}02’E	10	1500-1600	300
259	“	1-9-65	09^{0}34’N	76^{0}10’E	32	1740-1845	150

1	2	3	4		5	6	7
260	Sp.Fi Cruise	1-9-65	09^{0}27'N	76^{0}03'E	58	2000-2115	100
261	"	2-9-65	09^{0}20'N	75^{0}53'E	180	0115-0230	10
262	"	2-6-65	09^{0}15'N	75^{0}49'E	270	0330-0500	100
263	"	2-9-65	09^{0}05'N	75^{0}55'E	330	0630-0740	Net lost
264	"	2-9-65	09^{0}14'N	76^{0}05'E	70	1030-1130	500
265	"	2-9-65	09^{0}24'N	76012'E	30	1415-1500	nil (ND)
266	"	6-9-65	09^{0}36'N	75^{0}44'E	240	1200-1300	50
267	"	6-9-65	09^{0}33'N	75^{0}45'E	200	1410-1440	200
268	"	6-9-65	09^{0}29'N	75^{0}45'E	230	1610-1710	100
269	"	6-9-65	09^{0}25'N	75^{0}45'E	240	1810-2010	25
270	"	6-9-65	09^{0}25'N	75^{0}45'E	240	2050-2230	100
271	"	6-9-65	09^{0}25'N	75^{0}42'E	200	2330-0045	5
272	"	7-9-65	09^{0}19'N	75^{0}45'E	240	0130-0230	5
273	"	7-9-65	09^{0}40'N	76^{0}08'E	40	0730-0830	7
274	"	14-9-65	09^{0}46'N	76^{0}05'E	32	1915-2015	nil
275	"	14-9-65	09^{0}32'N	76^{0}00'E	54	2200-2300	nil
276	"	14-9-65	08^{0}54'N	75^{0}41'E	315	0445-0615	nil
277	"	15-9-65	08^{0}50'N	75^{0}33'E	306	0730-0800	nil
278	"	15-9-65	08^{0}50'N	75^{0}40'E	297	1045-1245	nil
279	"	15-9-65	08047'N	75^{0}36'E	297	1405-1515	50
280	"	15-9-65	08^{0}46'N	75^{0}33'E	288	1615-1745	140
281	"	15-9-65	08^{0}50'N	75^{0}35'E	306	2000-2200	100
282	"	15-9-65	08^{0}45'N	75^{0}40'E	297	2330-0130	50
283	"	16-9-65	08^{0}59'N	75^{0}59'E	118	0530-0630	50
284	"	16-9-65	09^{0}00'N	75^{0}55'E	270	0915-1045	1000
285	"	16-9-65	09^{0}06'N	75^{0}56'E	288	1330-1445	200
286	"	16-9-65	09^{0}13'N	75^{0}52'E	243	1610-1715	nil
287	"	16-6-65	09^{0}18'N	76^{0}10'E	46	1730-1815	50
288	"	16-9-65	09^{0}05'N	76^{0}20'E	27	2130-2300	50
289	"	17-9-65	09^{0}05'N	76^{0}20'E	10	0015-0200	nil (ND)
290	"	22-9-65	12^{0}23'N	74^{0}58'E	13	1300-1400	nil
291	"	22-9-65	12^{0}22'N	75^{0}57'E	15	1420-1525	nil
292	"	22-9-65	Off Mangalore		18	1930-2100	nil

1	2	3	4		5	6	7
293	Sp.Fi. Cruise	24-9-65	13^{0}57’N	73^{0}27’E	120	1215-1315	20
294	“	24-9-65	13^{0}45’N	73^{0}28’E	150	1530-1645	20
295	“	24-9-65	13^{0}28’N	73^{0}33’E	110	1815-1915	150
296	“	25-9-65	12^{0}17’N	74^{0}29’E	140	1250-1350	30
297	“	25-9-65	12^{0}40’N	74^{0}12’E	148	1450-1500	300
298	“	25-9-65	12^{0}27’N	74^{0}20’E	160	1720-1845	300
299	V-83	12-10-65	09^{0}30’N	75^{0}45’E	180	2330-2435	200
300	“	13-10-65	09^{0}21’N	75^{0}65’E	120	0245-0345	Net lost
301	“	14-10-65	08^{0}42’N	75^{0}35’E	335	0900-1030	1
302	“	14-10-65	08^{0}45’N	75^{0}38’E	360	1230-1335	1
303	“	14-10-65	08^{0}35’N	76^{0}22’E	70	1930-2030-	2
304	“	14-10-65	08^{0}40’N	76^{0}22’E	60	2330-0030	3
305	“	15-10-65	07^{0}53’N	77^{0}04’E	68	0730-0830	15
306	“	17-10-65	09^{0}26’N	76^{0}08’E	50	1730-1830	175
307	V-85	10-11-65	09^{0}35’N	76^{0}12’E	20	1415-1530	55
308	“	12-11-65	08^{0}33’N	76^{0}23’E	110	1330-1430	22
309	“	12-11-65	08^{0}52’N	76^{0}08’E	106	1830-1915	nil (ND)
310	“	13-11-65	09^{0}36’N	75^{0}50’E	130	2245-2345	250
311	V-86	26-11-65	14^{0}39’N	73^{0}58’E	40	1830-1930	55
312	“	27-11-65	13^{0}30’N	73^{0}32’E	120	1250-1345	100
313	“	29-11-65	11^{0}35’N	74^{0}55’E	180	1200-1315	nil(ND)
314	V-87	6-12-65	09^{o}55’N	76^{0}12’E	25	2000-2040	5
315	“	6-12-65	09^{0}55’N	76^{0}12’E	25	2100-2130	7
316	V-89	4-1-66	11^{0}45’N	75^{0}25’E	16	0840-0945	100
317	“	4-1-66	11^{0}50’N	75^{0}18’E	20	1140-1245	100
318	“	6-1-66	13^{0}09’N	73^{0}45’E	165	1400-1505	50
319	“	7-1-66	12^{0}55’N	74^{0}00’E	190	1815-1915	500
320	“	8-1-66	12^{0}40’N	74^{0}07’E	240	0800-090O	300
321	“	8-1-66	12^{0}28’N	74^{0}17’E	150	1045-1145	600
322	“	8-1-66	12^{0}27’N	74^{0}24’E	100	1230-1330	6
323	V-90	4-2-66	08^{0}00’N	77^{0}02’E	50	1715-1815	10
324	“	5-2-66	08^{0}29’N	76^{0}23’E	105	1855-1930	5
325	“	6-2-66	09^{0}00’N	76^{0}00’E	110	0915-1015	nil

1	2	3	4		5	6	7
326	V-90	6-2-66	08^{0}58'N	75^{0}52'E	340	1200-1300	1600
327	"	7-2-66	09^{0}30'N	75^{0}45'E	290	1000-1100	300
328	V-92	22-4-66	12^{0}34'N	74^{0}14'E	120-125	1345-1445	81
329	V-94	23-5-66	10^{0}10'N	76^{0}02'E	25	1500-1630	9
330	"	23-5-66	10^{0}06'N	76^{0}05'E	20	1215-1400	30
331	"	28-5-66	10^{0}06'N	76^{0}05'E	20	0630-0700	Net lost
332	V-95	6-6-66	09^{0}30'N	76^{0}03'E	12	1530-1630	11
333	"	6-6-66	09^{0}30'N	76^{0}03'E	20	1635-1800	9
334	"	8-6-66	09^{0}33'N	75^{0}46'E	160	1730-1830	170
335	v-96	20-6-66	10^{0}47'N	75^{0}01'E	15	-	nil
336	"	23-6-66	10^{0}48'N	75^{0}50'E	21	1815-1915	250
337	"	26-6-66	12^{0}18'N	74^{0}21'E	200	0700-0815	2
338	"	27-6-66	10^{0}02'N	76^{0}11'E	8	0500-0645	6
339	V-98	18-7-66	10^{0}25'N	75^{0}50'E	29	1800-1900	2
340	V-100	22-8-66	12^{0}52'N	74^{0}45'E	12	1100-1140	6
341	"	25-8-66	12^{0}00'N	74^{0}42'E	90	1740-1845	80
342	"	26-8-66	10^{0}46'N	75^{0}46'E	30	0755-0910	8
343	"	26-8-66	10^{0}10'N	75^{0}04'E	16	1245-1400	3
344	V-101	5-9-66	09^{0}52'N	76^{0}04'E	20	1600-1730	10
345	"	6-9-66	08^{0}52'N	76^{0}21'E	30	1200-1300	110
346	"	8-9-66	08^{0}55'N	76^{0}23'E	25	0830-0930	160
347	V-104	19-12-66	12^{0}21'N	74^{0}57'E	27	2100-2230	92
348	"	21-12-66	11^{0}32'N	75^{0}30'E	20	0530-0730	275
349	V-105	7-2-67	10^{0}10'N	76^{0}07'E	18	1720-1930	49
350	V-106	22-2-67	11^{0}32'N	75^{0}06'E	56	1350-1530	3
351	"	23-2-67	11^{0}38'N	74^{0}47'E	160	0800-0900	Net lost
352	V-107	9-3-67	09^{0}36'N	76^{0}04'E	45	0810-0910	43
353	V-108	28-3-67	16 Km. SW of Cochin		20	0930-1130	175
354	V-109	13-4-67	10^{o}05'N	76^{0}04'E	20	0930-1100	60
355	V-110	25-4-67	11^{0}42'N	75^{0}24'E	22	0725-0925	88
356	"	1-5-67	11^{0}07'N	75^{o}45'E	15	1800-1900	72

1	2	3	4		5	6	7
357	V-120	8-10-67	13^{0}05’N	74^{0}40’E	18	1345-1515	20
358	“	9-10-67	12^{0}35’N	74^{0}08’E	260	0715-0850	25
359	V-121	3-11-67	09^{0}52’N	76^{0}10’E	23	1735-1805	nil
360	“	5-11-67	09^{0}20’N	76^{0}08’E	50	1740-1810	100
361	V-123	10-1-68	09^{0}12’N	75^{0}51’E	250	1200-1245	130
362	“	11-1-68	09^{0}12’N	76^{0}10’E	42	1640-1730	5
363	“	12-1-68	08^{0}42’N	75^{0}36’E	330-350	0930-1000	nil
364	“	12-1-68	08^{0}37’N	75^{0}13’E	325	1210-1230	40
365	V-125	3-4-68	08^{0}39’N	76^{0}12’E	180	0830-0910	205
366	“	3-4-68	08^{0}39’N	76^{0}10’E	225	1130-1210	60
367	“	3-4-68	08^{0}39’N	76^{0}09’E	270	1410-1445	250
368	“	3-4-68	08^{0}39’N	76^{0}08’E	333	1605-1640	95
369	“	4-4-68	09^{0}01’N	75^{0}58’E	180	0750-0830	250
370	“	4-4-68	09^{o}01’N	75^{0}57’E	225	1010-1040	40
371	“	4-4-68	09^{0}01’N	75^{0}56’E	270	1215-1245	120
372	V-126	19-4-68	09^{0}32’N	75^{o}42’E	387	1015-1130	10
373	“	19-4-68	09^{0}28’N	75^{0}42’E	387	1340-1505	55
374	“	19-4-68	09^{0}26’N	75^{0}42’E	360	1620-1735	110
375	“	20-4-68	09^{0}22’N	75^{0}38’E	415	0730-0900	70
376	“	20-4-68	09^{0}20’N	75^{0}38’E	370	1345-1535	87
377	“	20-4-68	09^{0}18’N	75^{0}38’E	405	1715-1810	nil
378	“	21-4-68	09^{0}32’N	75^{0}40’E	270	0815-0925	130
379	“	21-4-68	09^{0}35’N	75^{0}40’E	310	1105-1250	1520
380	“	21-4-68	09^{0}32’N	75^{0}42’E	370	1358-1538	210
381	“	21-4-68	09^{0}31’N	75^{0}42’E	180	1715-1820	125
382	“	22-4-68	09^{0}51’N	76^{0}06’E	25	0638-0745	30
383	“	22-4-68	09^{0}55’N	76^{0}03’E	30	0830-0925	150
384	V-127	24-4-68	10^{0}03’N	75^{0}41’E	270	0815-0905	280
385	“	24-4-68	10^{0}03’N	75^{0}40’E	279	1035-1135	nil
386	“	24-4-68	10^{0}03’N	75^{0}41’E	270	1240-1330	350
387	“	24-4-68	10^{0}03’N	75^{0}39’E	378	1550-1635	32
388	“	25-4-68	10^{0}20’N	75^{0}39’E	180	0945-1040	300
389	“	25-4-68	10^{0}24’N	75^{0}34’E	180	1245-1330	Net lost
390	“	26-4-68	10^{0}43’N	75^{0}18’E	180	0840-1030	300

1	2	3	4		5	6	7
391	V-127	26-4-68	$10^0$41’N	$75^0$18’E	252	1145-1235	220
392	“	26-4-68	$10^0$43’N	$75^0$18’E	360	1500-1550	75
393	“	27-4-68	$10^0$53’N	$75^0$12’E	180	0835-0910	130
394	“	27-4-68	$10^0$53’N	$75^0$06’E	360-380	1055-1140	125
395	“	27-4-68	$10^0$49’N	$75^0$06’E	360-375	1350-1440	140
396	V-128	20-5-68	$09^0$00’N	$76^0$00’E	35	1715-1800	400
397	“	22-5-68	$10^0$39’N	$75^0$25’E	387	0820-0920	570
398	“	22-5-68	$10^0$41’N	$75^0$12’E	280	1215-1315	560
399	“	22-5-68	$10^0$53’N	$75^0$08’E	370	1700-1800	50
400	“	23-5-68	$10^0$55’N	$75^0$08’E	325-360	0815-0915	20
401	“	24-5-68	$12^0$17’N	$74^0$13’E	360	0700-0800	12
402	“	24-5-68	$12^0$12’N	$74^0$10’E	360-400	1010-1110	10
403	“	24-5-68	$12^0$04’N	$74^0$22’E	280	1315-1415	2000
404	“	24-5-68	$12^0$04’N	$74^0$27’E	180	1640-1710	3
405	V-129	22-7-68	$10^0$30’N	$75^0$27’E	315	1000-1030	50
406	“	22-7-68	$10^0$30’N	$75^0$25’E	423-450	1200-1230	60
407	“	23-7-68	$11^0$11’N	$74^0$57’E	414	0930-0955	50
408	“	23-7-68	$11^0$08’N	$75^0$00’E	414	1320-1345	nil
409	“	25-7-68	$12^0$09’N	$74^0$20’E	288-315	0830-0915	100
410	“	25-7-68	$12^0$06’N	$74^0$23’E	405	0915-1000	75
411	V-130	13-9-68	$09^0$06’N	$76^0$22’E	40	1830-1930	1365
412	“	15-9-68	$09^0$00’N	$76^0$22;E	38	0805-0905	35
413	“	15-9-68	$09^0$02’N	$76^0$22’E	38	1025-1130	248
414	“	18-9-68	$09^0$00’N	$76^0$22’E	42	0715-0845	755
415	“	20-9-68	$08^0$55’N	$76^0$23’E	42	1325-1430	50
416	V-131	26-9-68	$13^0$46’N	$74^0$07’E	50	0815-0915	nil
417	“	26-9-68	$14^0$10’N	$73^0$13’E	216	1700-1730	2
418	“	27-9-68	$15^0$10’N	$72^0$49’E	343	1005-1035	nil

* Duration of haul = From start shooting net to stop hauling

ND = Net damaged.

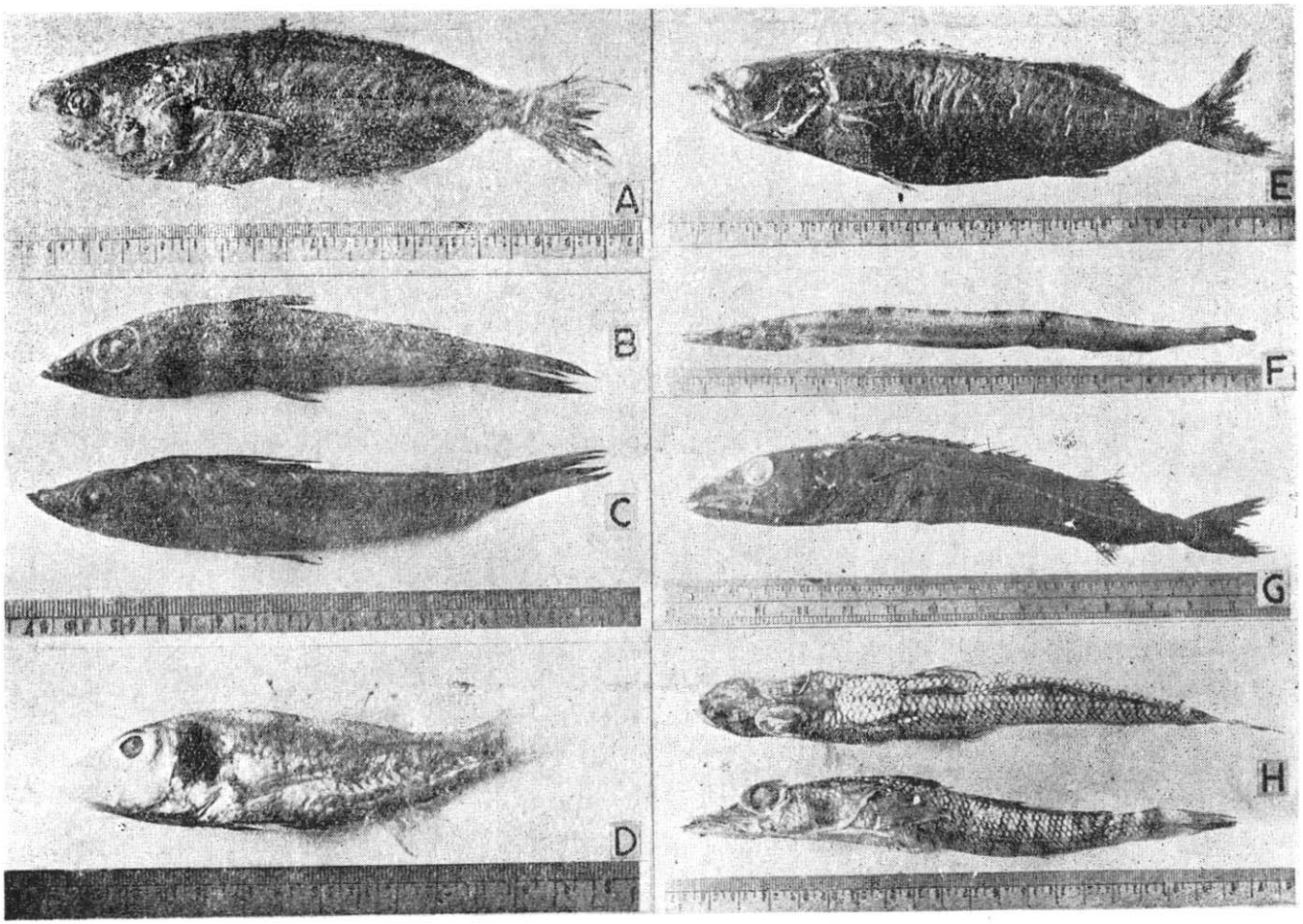


Plate I. Deep water fishes trawled from the continental shelf edge and the upper continental slope. A. *Pseneopsis cyanea* (Alcock); B. *Chlorophthalmus corniger* Alcock; C. *C. agassizi* Bonaparte; D. *Centropristis investigatoris* Alcock; E. *Epinnula orientalis* Gilchrist and von Bonde; F. *Lestidium* sp.; *Thyrsitoides marleyi* Fowler; and *Bembrops caudimacula* Steindachner. Scale in cm. (Photos: E. G. Silas.)

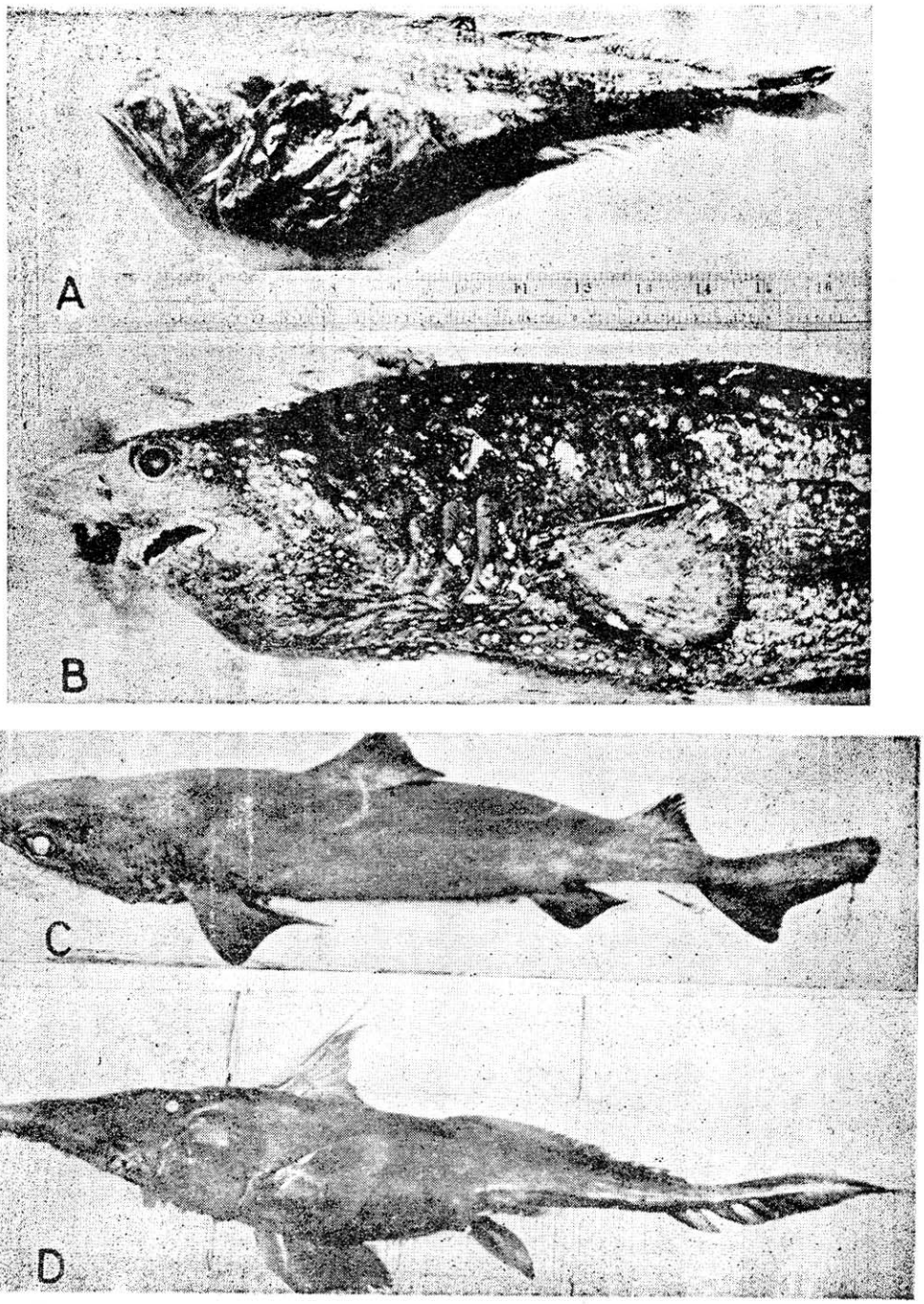
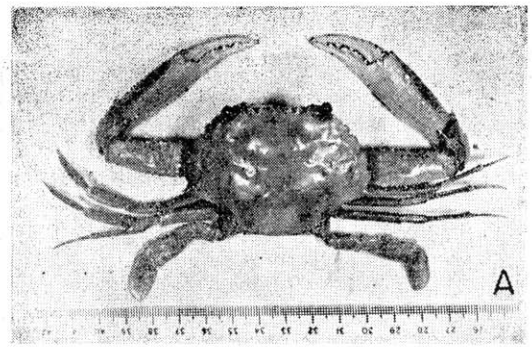
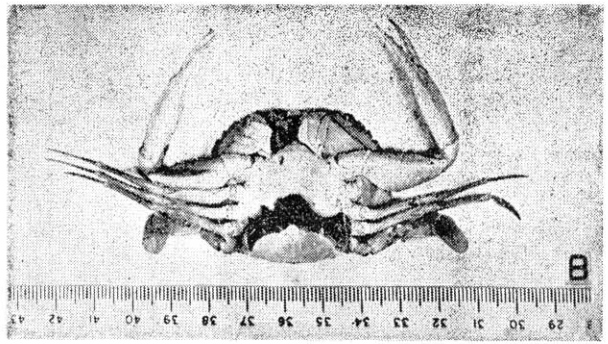
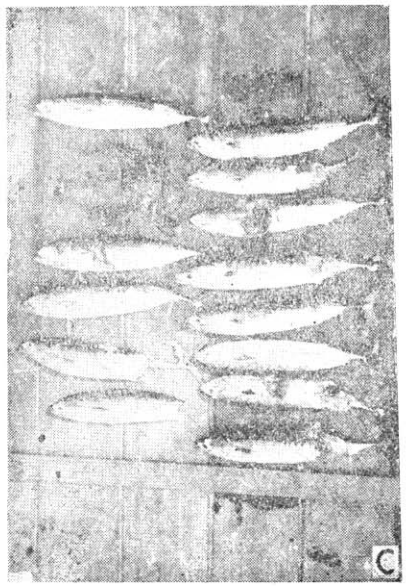
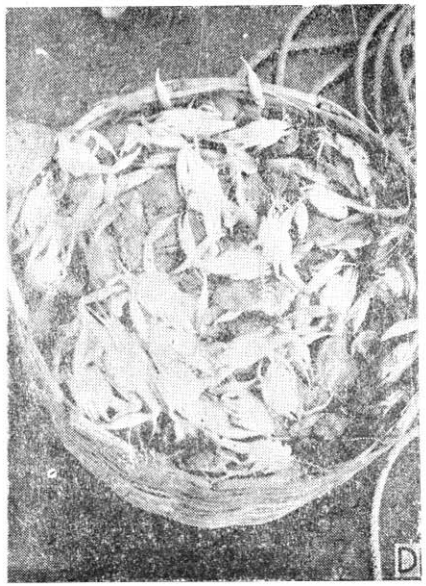


Plate II. Deep water fishes trawled from the continental shelf edge and the upper continental slope. A *Chascenopsetta lugubris* Alcock; B *Echinorhinus brucus* (Bonnaterre) head and anterior part of body; C. *Atractophorus armatus* Gilchrist; and D. *Neoharriotta pinnata* Schnackenberg (Photos E.G. Silas)









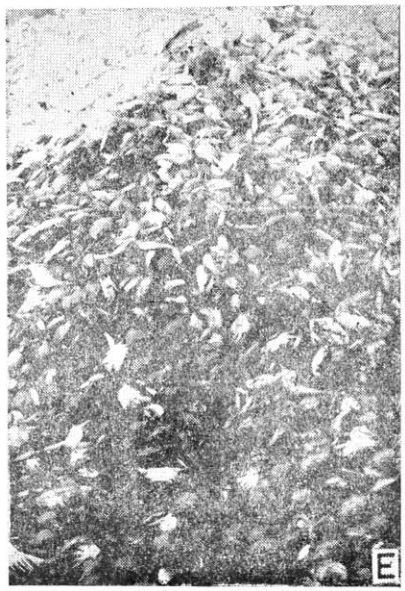
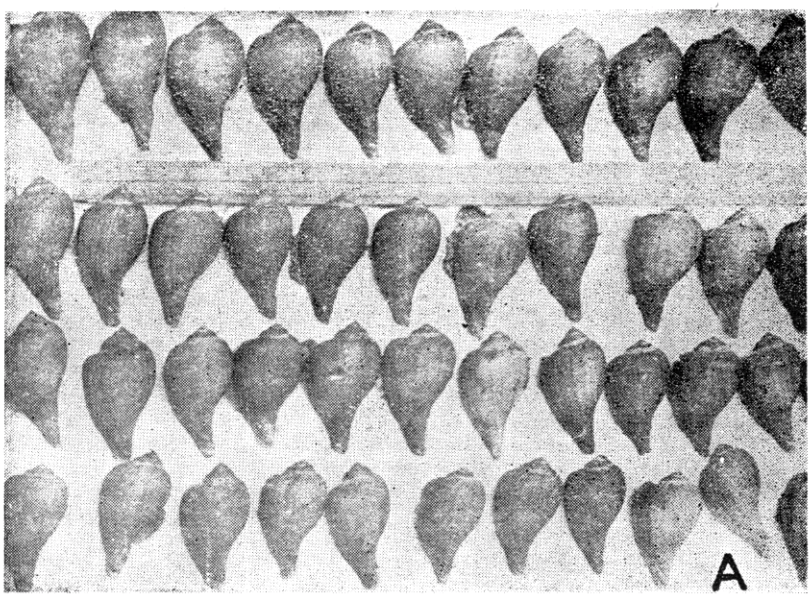


PLATE III

Plate III. The swarming crab *Charybdis* (*Goniohellenus*) *edwardsi* Leene & Buitendijk. A. Dorsal view of male; B. Ventral view of berried female; C. Drift net catch of *Auxis rochei* showing damage caused to it by this crab; D. A basket of 25 kg of males trawled from 180 m; Part of single haul of 3½ tonnes of *C. edwardsi* trawled during R. V. *VARUNA* cruise 71 at 11°34′N 74°51′ E from 142 m. (Photos : E. G. Silas)



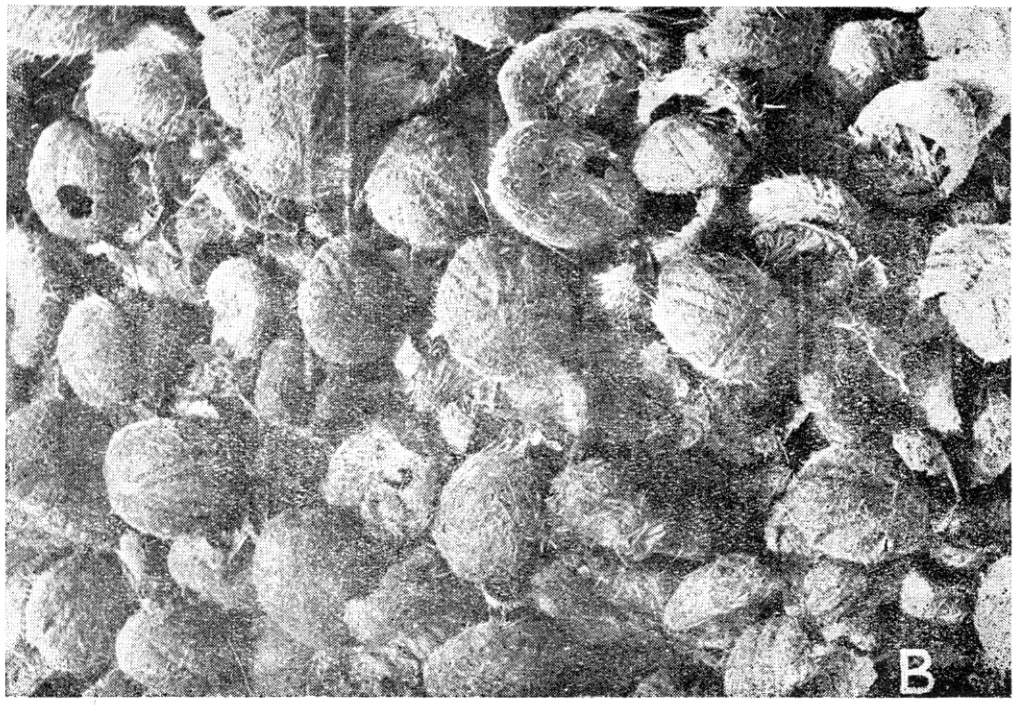


Plate IV. A. *Pirula investigatoris* Alcock trawled from 190 m off Quilon (This has since been reidentified as **P. *sewelli prashad*) B. Part** of a large catch of the echinoid ***Elipneustes denudatus*** **(Koehler)** from 330–350 m at 7°09′N 77°17′E. (Photos: E. G. Silas)

P A R T – II

EXPLORATORY SURVEY OF THE KALAVA FISHING GROUNDS ON THE SOUTH WEST COAST OF INDIA

EXPLORATORY FISHING FOR 'KALAVA'

The word 'Kalava' is used here to denote a heterogenous assemblage of percoid fishes popularly known as rock cods (kalava) and snappers (velameen). Traditional handline fishing for perches 30 to 40 km off the coast has been in vogue along some area off the south-west coast as well as in the Wadge Bank, and Hornell (1916) commented on the fishing grounds in the 25 to 40 fathom depths in the Wadge Bank area. More recently, John (1948) indicated that the depths between 60 and 70 fathoms off Anjengo and Chavara were good for line fishing, and trawling could not be carried out due to the rocky bottom. Gopinath (1954) gave a preliminary account on perch fishery south of Alleppey and of the Wadge Bank. During the cruises of R.V. VARUNA line fishing by indigenous craft has been observed off Alleppey, and in several places south of Quilon and on the Wadge Bank.

From about October 1956, the Indo-Norwegian Project vessels M.F.V. COCHIN (re-christened R.V. KALAVA), M.O. KRISTENSEN, and some of the medium boats were on and off engaged in handline fishing off Cochin (Figure 15B). The most successful and well utilized vessel for this purpose was R.V. KALAVA which in the course of about 200 days of fishing up to December 1966, landed approximately 75,000 kg of perches. Her line fishing activities were mainly concentrated on the 'Kalava' grounds between Ponnani and Alleppey.

Though these early efforts indicated prospects for good line fishing, a systematic exploration of the grounds had not been undertaken. One drawback has been the absence of any information as to the exact location of these grounds in the different areas. The catch data alone may not allow for an estimation of the potential perch resources available in the Kalva grounds. Besides, the 'Kalava' grounds off Kerala Coast are different from the perch fishing grounds on the Wadge Bank where trawling for perches is possible over a large portion of the Bank. Hence the information about the numerical occurrence of the 'Kalava' grounds in the different areas is necessary for any proper assessment. To gather such

and other essential information relating to these 'Kalava' grounds special surveys were carried out during the cruises of R.V. VARUNA.

OBJECTIVES OF THE SURVEY

The major objectives of these surveys were:

1. To locate 'Kalava' grounds and chart out their distribution in relation to bathymetry as well as in space between 8^0N and 14^0N.
2. To study the nature of the grounds as presented by the echograms and assess the extent of particular grounds at random.
3. To carry out handline fishing from the 'Kalava' grounds in different areas to ascertain the species composition and obtain any useful biological data, especially on maturity, fecundity and spawning of the different species.
4. To study the behaviour of these fishes as indicated by the echotraces and fishing results.
5. To conduct intensive fishing on some grounds to see the trends in catch rates and find ways and means of improving the catch returns.
6. To estimate with reasonable accuracy the potential 'Kalava' resources between 8^0N and 14^0N.

METHODS OF SURVEY

Sonar-cum-echo surveys for detecting 'Kalava' grounds were carried out during my participation as Cruise Leader in R.V. VARUNA cruises 71, 72, 75, 84, 85, 86, 90, 92 and 102 (Figures 14 & 15). In addition, echograms taken during the cruises 87,88, 89 and 95 in which I could not participate were also examined through the courtesy of the skippers of the vessel who were specially requested to work the echosounders and ASDIC on some of the cruise tracks over the continental shelf. The 'Kalava' caught during these cruises and brought to Cochin were also examined for species composition and other biological details.

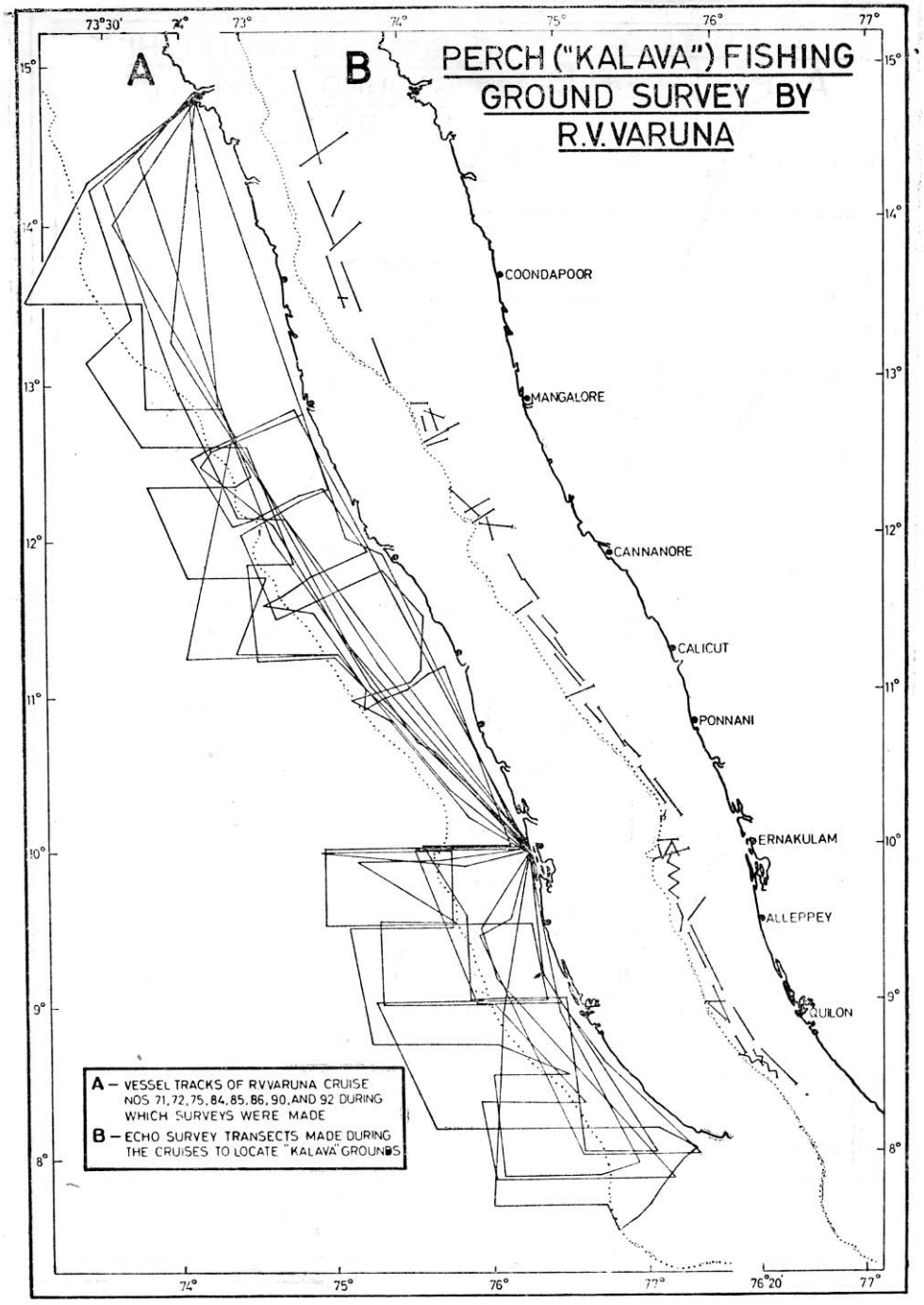


Fig. 14. **'Kalava' fishing ground investigations: A. Trackcharts of R V. *VARUNA* cruises during which echo surveys were carried out for locating 'kalava' grounds. B. Sections of traks showing areas surveyed by sonar cum echo sounders.**

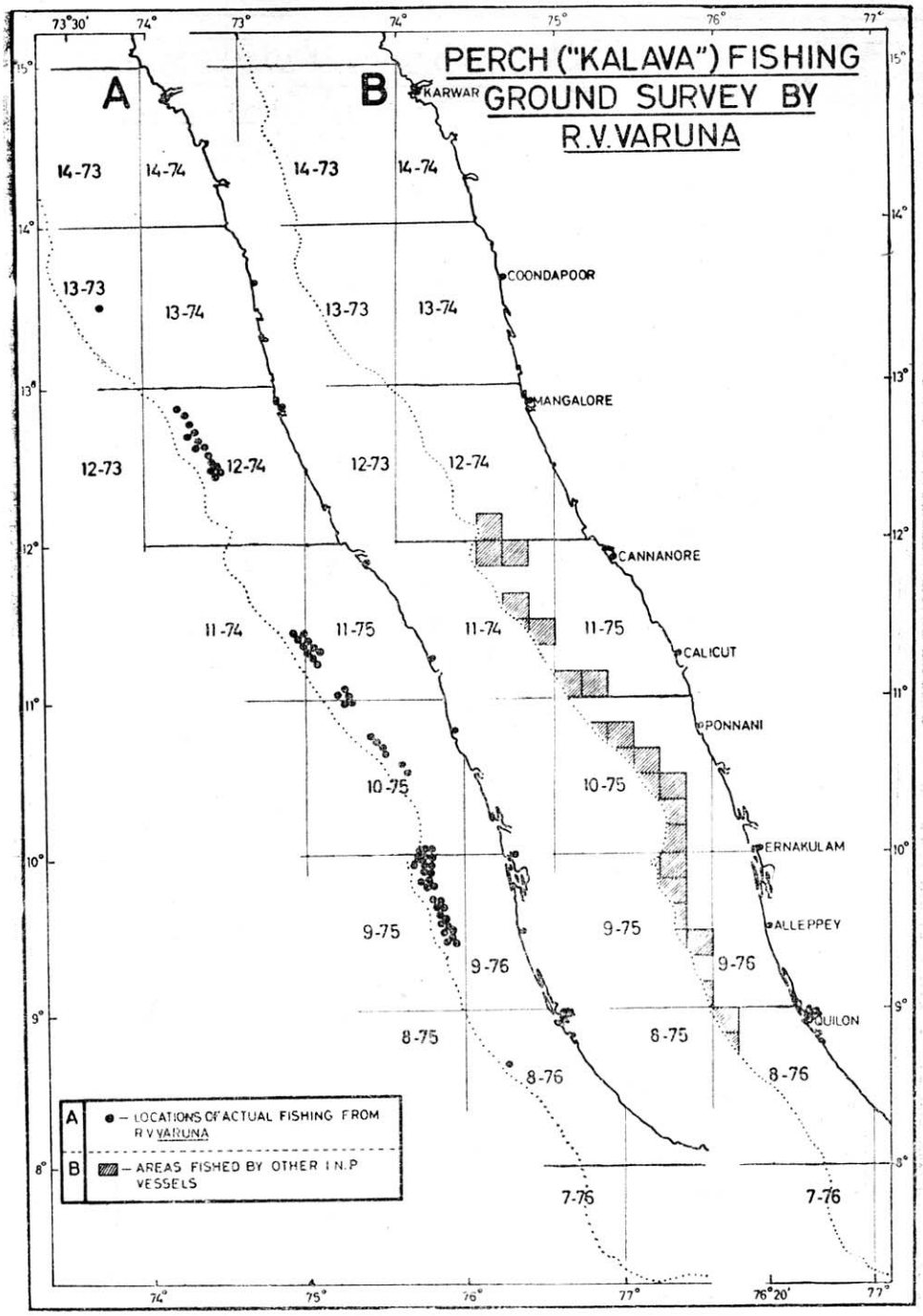


Fig. 15. 'Kalava' fishing ground investigations: A. Locations from where handline fishing for 'kalava' were carried out during R. V. *VARUNA* cruises; B. 10 nautical mile squares within the same depth contours from which 'kalava' fishing was carried out by I. N. P. vessels.

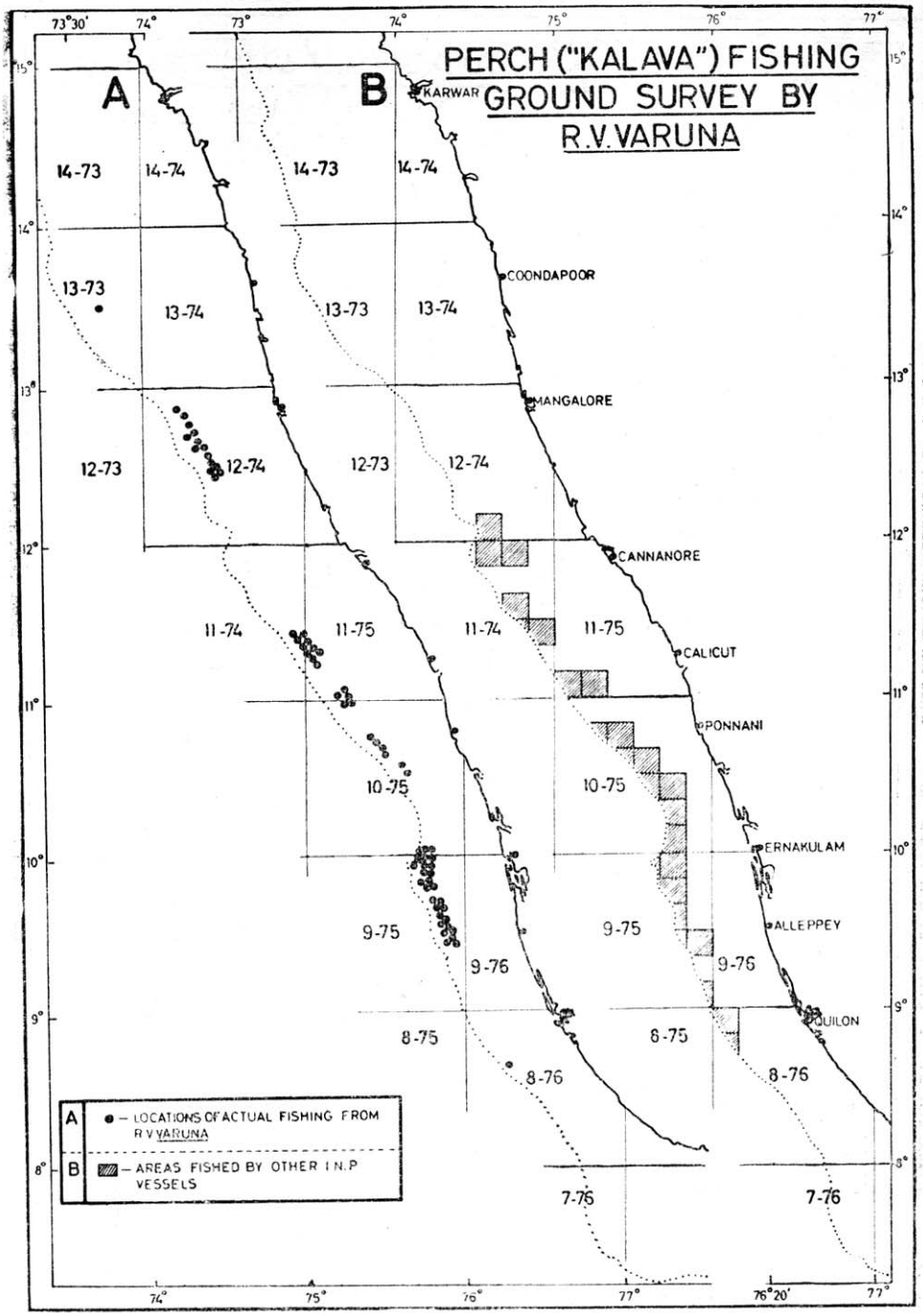


Fig. 15. 'Kalava' fishing ground investigations: A. Locations from where handline fishing for 'kalava' were carried out during R. V. *VARUNA* cruises; B. 10 nautical mile squares within the same depth contours from which 'kalava' fishing was carried out by I. N. P. vessels.

It was felt that use of the echo sounders alone may not help in making a rapid survey as this instrument recorded only the grounds over which the vessel passed. However, the combined use of Sonar (ASDIC) and the echo sounders greatly facilitated this work. The ASDIC on R.V. VARUNA which has a horizontal range of 1500 metres could scan 180^0, from broad on port beam to broad on starboard beam. Once the sonar recorded any elevated formation above the bottom, the course of the vessel was changed to pass over the detected feature and this was then automatically recorded by the echosounder. Unlike traces of the coast line, or submerged reef or ships or boats in the vicinity, or surface or subsurface fish shoals, the traces obtained of 'Kalava' grounds could be told apart by experience. Nevertheless, on each track course, a few of the grounds detected by the sonar were checked by the echosounders for confirmation. It may also be stated that these sonar traces of the 'kalava' grounds could be told apart from traces resulting from interferences from the operation of shipboard equipment, such as echosounders which may be simultaneously working. Plate VII B& C shows an area off Cochin where the grounds are many and closely situated as seen from ASDIC trace. Figure A in the same plate shows the ASDIC recordings as the vessels slowed down and approached the ground. Plates VIII B-C and IX shows echograms (on wet and dry paper) while fishing is in progress.

In the case of the echosounders, air bubbles underneath the ships hull were observed to prevent the efficient propagation of sound impulses. This could cause remarkable falling off in the efficiency of the echosounder. This was very marked when the ship went astern, while trying manouvre against the vessel's drift away from the ground. The use of more than one echo sounder in the vessel at the same time also caused interference marks on the echograms, but these were easily distinguishable. In plates VIII and IX, the gaps in the bottom profile marked 'G' denote to periods when the vessel went astern to prevent drifting away from the ground while fishing was in progress. It will also be seen from the echograms given in plate VIII that the speed of the vessel has to be known correctly in order to get an idea of the width or length of a ground over which the vessel passes.

The method of estimating the number of 'kalava' grounds with the ASDIC was as follows. The horizontal range being 1500 metres, a strip

three kilometers wide can be scanned and if the vessel on a track course covers 10 km this would enable an area of 30 sq.km. to be surveyed in this manner. The position, the track course, time at start, depth, speed of the vessel were noted at commencement of each sonar cum sounding track and depth and time were noted whenever grounds were detected. This gave an idea of the frequency of occurrence of the grounds. When a ground was detected by the sonar on the portside or starboard side or ahead of the vessel, the depth recorded at that time by the echo sounder did not indicate the actual depth where the ground was located. However, this has been checked on several occasions and found to be never more than plus or minus 5 metres. Generally it was one to two metres plus or minus in the depth range of 75 to 100 metres.

In the depth range 75 to 100 metres, the features detected by the Sonar and checked by the echosounder have always turned out to be 'Kalava' grounds. On several occasions, the vessel after passing over the ground has circled it to determine its extent. Often a floating buoy with sinkers tied to a rope to anchor it was thrown out over the ground to mark the place and a few minutes fishing was done to check the results. The methods outlined above indicated clearly the importance of using both sonar and echo sounders for the detection of the grounds and their being surveyed rapidly. The work involved continuous attention to the ASDIC and echo sounders for lengthy periods. Even so nothing would succeed without the close understanding and full cooperation of the skipper of the vessels. In this I was fortunate to work with Captain Sven M. Satrae and Captain Sankarankutty of the I.N.P., without whose help this survey would not have been possible.

NATURE OF 'KALAVA' GROUNDS

Echo surveys of the 75-100 metre depth range showed that hard bottom was characteristic of most places along the south-west coast, especially between 8^0 N and 13^0 N. The 'kalava' grounds here are small areas of hard bottom with shallow ridge-like features or outcrops which rise two to five metres from ground level and have a very irregular profile. This appears to be a peculiar geological feature of the continental shelf off the south-west coast of India. Such outcrops do not form extensive

beds but occur in patches and in some places, such as off Cochin, several of these may appear in one track of the vessel (Plate VIII, B&C). In area too, they show considerable differences some being hardly a few metres across, while good grounds may be more extensive, often a hundred metres or so across. If the ground is small, by the time the first cast is hauled, the vessel may have drifted away from it. The process of getting back on to the ground may often involve circling the ground and echograms taken during such searching have shown that each ground is separated from the adjacent one by 'level hard bottom'. Again, between 8^0 N to 9^0 N the grounds tend to be more in the form of less elevated boulders or boulder-like formations, and their numbers are also relatively more than the disjunct outcrops seen further north. In fact, the grounds seen around 8^0 N are smaller in area and more akin to those seen in the Wadge Bank.

The rock cods and other gregarious fish were found to congregate around such outcrops and detection of 'kalava' grounds would be considerably facilitated if the fishing vessels are equipped with Sonar (ASDIC)and echo sounders. Fortunately, R.V. VARUNA has been ideally equipped to undertake such investigations.

DETAILS OF FISHING OPERATIONS

Three lines were used from the starboard side of R.V. VARUNA (Plate V, A-C) and one kept in reserve and rarely used. The hooks were tied to 8 short snoods placed slightly apart at the end of line which was weighted by a lead weight or an iron piece of approximately 2 kg. The bait used was any trash fish or cut pieces of 'Kalava'. However , fish have been landed even with cotton waste or rags attached to the hooks. The time taken for the line to be reeled out and touch the bottom as well as hauling time have been noted. The former took about 40 to 50 seconds when the depth was around 90 metres. The hauling time varied depending on several factors. When three or more fish were hooked the average time taken for reeling in a line from 90 metre depth was about 2 minutes at the start of fishing and may be as much as three minutes after a couple of hours of good fishing. Thus as hauling in was done manually a uniform level or efficiency could not be expected from the team of two men operating each line. Usually a third man would help to remove the fish from

the hooks and bait the lines.

For the effort expended, the catch could be considerably increased if mechanical haulers could be installed instead of manual reeling of the lines. In regular fishery operations this should not be difficult, especially when a vessel is equipped for 'kalava' fishing. It will be good if each line could have a separate hauler as adjacent lines may sometimes get entangled due to strong undercurrent or the vessel drifting over the lines, in which case this arrangement will not impede the use of other free lines.

Details of fishing from one ground about 100 m in length 45 m in width west of Alleppey from 94m depth, carried out from 0830 to 1830 hours on 12-11-65 during R.V. VARUNA cruise 85 is given in Table XIV. On location of the ground a buoy was used to marks its position.

TABLE – XIV

DETAILS OF 'KALAVA' FISHED FROM ONE GROUND ON 12-11-1965 FROM 94 M OFF ALLEPPEY

SPECIES	Total No.of Specimens	No. of specimens weighed	Total weight in kg. of specimens weighed
Epinephelus chlorostigma	417	38	73.50
Pristipomoides typus	58	36	58.25
Epinephelus diacanthus	14	9	7.50
Epinephelus areolatus	5	5	8.50
Epinephelus prox *morrhua*	3	3	4.75
Epinephelus prox*tauvina*	1	1	9.00
Lutjanus gibbus	1	1	3.00
Argyrops spinifer	1	1	0.75
	510	94	165.25

It will be seen that the average weight of one fish is 1.76 kg and thus the estimated weight of 510 fish, 897.6 kg. which was a catch for a 10-hour period with two hours of rest for the crew in between, i.e., 8 hours of fishing. The catch per hour of actual fishing would be 112.2 kg,

while the catch/line/hour 37.4 kg. The number of fish caught/hr would be 63.75 and number/line/hr 21.25. As eight books have been used/line the catch rate expressed as No. of fish/100 hocks/hr. would be 266, while the catch in kg/ 100/ hooks/hr would be 465.5. The echo sounder was continuously in operation and even at the end of 10 hours no diminution in the intensity of the echo traces over the ground was noticeable. It is presumed that part of the trace could be due to free-swimming shoals of *pristipomoides typus* and juvenile rock cods. Adult rock cods may generally keep close to the bottom and live in crevices in the rocks. Underwater observations in other areas show that adult rock cods of several species evince territorial behaviour.

SPECIES OF PERCHES AND OTHER FISHES CAUGHT BY HANDLINE FROM 'KALAVA' GROUNDS

The species of rock cods, snappers, breams and other fishes caught by handlines from the 'Kalava' grounds on the south-west coast are listed in Table XV (Plates VI and X-C). Part of the catch was always measured and weighed.

TABLE – XV

Name of species	No.of Speci-mens	Length** (mm) Range	Mean	Weight in Kg. Range	Mean
Argyrops spinifer (Forskal)	1	325	325.0	0.75	0.75
Epinephelus areolatus (Forskal)	17	407-557	491.0	0.50-2.50	1.47
Eponephelus chlorostigma (Valenciennes)	112	342-666	502.5	0.25-4.00	1.71
Epinephelus diacanthus (Valenciennes)	19	352-445	412.4	0.25-1.00	0.73
Epinephelus sp. A (prox. *morrhua* (Val.)	16	443-645	568.4	0.75-3.50	2.31
Epinephelus sp. B (prox. *tauvina* (Forskal)	3	765-810	786.3	8.50-9.50	9.00
Pristipomoides typus Bleeker	74	390-685	491.7	0.75-4.00	1.83
Lutjanus gibbus (Forskal)	1	605	605.00	3.00	3.00
Gymnocarinus prox. *griseus* (Schlegel)	1	472	472.0	1.90	1.90
Tachysurus sp.	2	320-355	337.5	0.70-0.71	0.705

** Total length is taken in species with rounded or truncate caudal fin. Fork length is taken for others

As the samples measured and weighed had been caught from different grounds at different times, a fair idea of the average length and weight of the more common species in the catch may be obtained from the data given in Table XIV. This would show that for the species more frequently occurring in the catch (*E. aerolatus, E. chlorostigma, E. diacanthus, E.* prox. *morrhua* and *P. typus*) the average length of a fish in the catch would be 493.3 mm and the average weight 1.61 kg. If all species were taken into consideration the average length would be 499.18 mm and the average weight 2.34 kg.

E. *chlorostigma* was the most common species in the catch occurring in almost all grounds. Next in importance was *Pristipomoides typus* which was found to be predominant in the catch in some grounds especially north of 11^0 N. E. prox. *morrhua,* another large species, which occurred regularly, but in fewer numbers the *E. chlorostigma, E. aerolatus* and *E. diacanthus,* the last mentioned being the smallest of the species of rock cods caught from these grounds.

Some aspects of the biology of the species, especially maturity, fecundity and spawning periodicity, are under study. Investigations on the food of 'kalava' has not been very successful, as the stomachs in most of the fish brought up from depths were everted (Plate V, C) or the contents of the stomach were spewed out when the fish were removed from the hooks. Neverthless, it has been possible to gather some information on the food of these fishes. Briefly stated, the species were found to feed on crustaceans (*Charybdis* (G) *edwardsi, Munidopsis* spp., etc.) and fishes (Scorpaenidae) mainly.

ESTIMATION OF THE NUMBER OF 'KALAVA' GROUNDS

In Figure 14 and 15 the areas surveyed for 'Kalva' grounds are indicated. Details of the echo survey tracks shown in Figure 14B are given below for each 1^0 latitude square. The date, position at start, track course (TC) time (Hrs), distance covered in nautical miles (nm), number of grounds detected, depth ranges (DR)in which the grounds were detected, and the depth range in which scouting was actually done (SR) (if it exceeds the depth range where the grounds were detected) are given below.

1. 8-76:

12-11-65, 8^0 34' N. 76^0 21' E, TC 249^0, 1430-1740 Hrs, 15nm, 37 grounds, DR 82-111m; **3-2-66,** 8^0 41' N, 76^0 21' E, TC 135^0, 1630-1830 Hrs, 15.6 nm, 31 grounds, DR 75-87 m; SR 64-87 m; **5-2-66** 8^0 30' N, 76^0 27' E, TC 350^0 and 28^0 zig zag course, 1910-2200 Hrs, 21 nm, 72 grounds (small), DR 72-108 m: **6-2-66,** 8^0 39'N, 76^0 15' E, TC 337^0, 0750-0849, 7.6 nm, 11 grounds, DR 90-109 m; **6-2-66**, 8^0 50' N, 76^0 10' E, TC 314^0, 0915-1030Hrs, 10.2 nm, 48 grounds, DR 88-108 mm, SR 86-115m.

2. 9-75:

23-2-65, 9^0 26' N, 75^0 54' E, TC 156^0, 2300-0115 Hrs, 17-1 nm, 63 grounds DR 84-95m; **26-4-65,** from 9^0 57' N, 75^0 49' E to 10^0 00' N, 75^0 43' E zig zag course, 1145-1315 Hrs, 6 nm, 38 grounds, DR 84-95 m; **26/27-4-65,** 9^0 37' N**,** 75^0 50'E, TC 149^0 and 180^0 2330-0025 and 0025-0045 Hrs, 9.6 nm, 26 grounds, DR 84-96 m; **14-11-65,** 9^0 36' N, 75^0 47' E TC zig zag course, 0645-0820 and 1830-2030 Hrs, 30 nm, 128 grounds, DR 88-95 m, SR 85-105 m: -, 9^0 40' N, 76^0 00' E, TC 217^0, 0830-1000, 12 nm, 18 grounds, DR 82-98 m, SR 60-104 m; **3-2-66,** 09^0 28' N 75^0 55' E, TC 154^0, 1030-1230 Hrs, 14 nm, 38 grounds, DR 80-91 m: 8-2-66, 09^0 54' N 75^0 40' E, TC 71^0,1445-1645, 15 nm, 26 grounds, DR 82-101m, SR 70-130 m.

3. 9-76:

24-2-65, 09^0 06' N, 03' E TC 156^0, 0220-0420 Hrs, 16.4 nm, 18 grounds, DR 80-92 m, SR 68-92 m; **25-2-65,** 09^0 00' N, 76^0 08' E, TC 250^0, 0800-0900 Hrs, 6.8 nm grounds, DR 83-100 m, SR 60-130m;

3-2-66, 09^0 16' N, 76^0 00' E TC 154^0, 1230-1430, 14.1 nm, 14 grounds, DR 72-80 m.

4. **10-75:**

26-2-65, 10^0 00' N, 75^0 40' E, TC 90^0, 0025-0125 Hrs, 7.5 nm, 6 grounds, DR 80-102 m SR 65-160 m; **26-2-65,** 10^0 10'N, 75^0 50' E, TC 330^0 0845-1045 Hrs, 14.8 nm, 29 grounds, DR 80-99 m, 68-99 m; **26-2-65,** 10^0 34' N 75^0 34' E, TC 320^0, 1215-1320 Hrs, 8.5 nm, 6 grounds, DR 80-110 m, SR 70-180 m: **24-11-65,** 10^0 52'N 75^0 17' E, TC 145^0, 2130-2350 Hrs, 19 nm, 44 grounds, DR 72-95 m: **30-11-65,** 10^0 30'N, 75o 17' E, TC 145^0 0130-0345 Hrs, 16 nm, 39grounds, DR 78-102 m, SR 67-102 m.

5. 11-74:

26-2-65, 11^0 30' N, 74^0 56' E, TC 0140 -0240 Hrs, 6.5 nm, 6 grounds, DR 74-78 m: **27-2-65,** 11^0 35' N 74^0 51'E, TC 230^0, 1145-1245 Hrs, 6 nm, 4 grounds, DR 85-100 m, SR 70-210 m; **25-4-65,** 11^0 29'N, 74^0 52'E TC 140^0, 1030-1430 Hrs, 35.9 nm, 49 grounds, DR 84-114, SR 84-120; **24-11-65,** 11^0 53'N, 74^0 36' E, TC 00^0, 1730-1807 Hrs, 3.5 nm, 6 grounds, DR 86-98 m: **19-12-65,** Off Cannanore, TC 150^0, 7.5 nm, 9 grounds, DR 80-90 m.

6. 11-75:

29-11-65, 110^0 15' N, 75^0 02' E, TC 141^0, 1815-2015 Hrs, 14 nm, 36 grounds, DR 82-95 m; **14-12-65,** Between Calicut and Cannanore, TC 320^0, (1 hr), 7.5nm, 6 grounds, DR 82-93 m; **25-4-66,** 11^0 20' N, 75^0 02' E, TC 147o, 0920-1020, 8.2 nm, 10 grounds, DR 72-98 m.

7.12-74:

28-2-65, 12^0 07' N, 74^0 29' E, TC 50^0, 0005-0105, 7 nm, 4 grounds, DR 82-108 m, SR 70-100 m: **28-2-65,** 12^0 37' N, 74^0 20' E, TC 247^0, 1215-1300 Hrs, 5 nm, 3 grounds, DR 92-102 m, SR 90-140 m; **28-2-65,** 12^0 18' N, 74^0 21' E, TC 135^0, 1845-2045 Hrs, 14 nm, 7 grounds, DR 86-112 m, SR 86-180 m: **20-3-65,** 12^0 05'N, 74o 32' E, TC 99^0 1030-1230 Hrs, 13.2 nm, 7 grounds, DR 84-95 m, SR 75-120 m**: 23-4-65,** 12^0 43' N, 74^0 25' E, TC 239^0, 2300-2345 Hrs, and 0055-0155 Hrs on **24-4-65,** 12.2 nm, 7 grounds,

DR 86-107 m, SR 68-200 m; **24-4-65,** 12^0 07' N, 74^0 25' E TC 55^0 1530-1630 Hrs, 7.2 nm, 4 grounds, DR 88-102 m, SR 84-160 m: 25-11-65, 12^0 40'N, 74^0 12' E, 1135-1155 Hrs, 3 nm, 4 grounds, DR 88-94 m; **25-11-65,** 12^0 40' N, 74^0 15' E, 1300-1400 Hrs, 7.3 nm, 9 grounds, DR 85-101 m; **28-11-65,** 12^0 50' N, 74^0 15' E, 0345-0430 Hrs, 6 nm, 2 grounds, DR 110-115 m; **19-12-65,** S.E. of Mangalore, TC 145^0, (1 Hr), 7.2 nm, 8 grounds, DR 85-93 m.

8. 13-73:

19-3-65, 13^0 43' N, 73^0 38'E TC159^0, 1930-2150 Hrs, 23 nm, 20 grounds, DR 82-93 m; **19/ 20-3-65,** 13^0 16' N, 73^0 52' E, TC 159^0 N, 73^0 38' E, TC 342^0, 1530-1900 Hrs, 22 nm, 9 grounds, DR 90-101 m: **25-11-65,** 13^0 48' N, 73^0 35' E, TC 47^0 1830-2030 Hrs, 14 nm, 3 grounds, DR 99-84 m, SR 99-66 m: **27-11-65,** 13^0 30'N 73^0 40' E 1515-1540 Hrs, 2.5 nm 2 grounds, DR 110 m.

9. 14-73:

19-3-65, 14^0 32' N, 73o 42' E, TC 235^0, 1230-1445 Hrs, 22 nm 2 grounds, DR 105-108 m, SR 66-111 m: **19-3-65,** 14^0 14' N, 72^0 26' E TC 15^0, 1545-1830 Hrs, 27 nm, 13 grounds, DR 100-110 m, SR 96-126 m: 14^0 57' N, 73^0 21' E, TC 166^0, 1630-1945 Hrs, 27 nm, 1 ground Dr 85-95 m: **26-11-65,** 14^0 02' N, 73^0 36' E, TC 24^0, 2335-0035 Hrs, 7.2 nm, No grounds, DR 86-99 m.

It is felt that these data would give a fair idea of the pattern of distribution of the grounds in the different areas. On the basis of this the estimated number of 'kalava' grounds in the 75-100 metre depth zone for 1^0 latitudes squares north of 8^0 N is shown in Figure 16 B and details given in Table XVI. The grounds are more numerous in the squares, 8-76, 9-75, and 10-75, but as earlier mentioned, those in 8-76 are relatively smaller. Naturally, the 'kalava' biomass of each ground would vary subject to the size of the ground and other factors. The average size of a fish from the 'kalava' ground is found to be about 1.75kg.

TABLE - XVI

ESTIMATED NUMBER OF "KALAVA" GROUND AND POTENTIAL YIELD

Location 1^0 square	Hrs. of scouting (echo-Survey)	Depth range investi-gated (m)	Depth range of occurren-ce of 'kala-va' grounds	Area sur-veyed in sq. km.	No. of grounds detec-ted	Total area in the 75-100 m depth range in sq. km	Estimated No. of 'kalva' grounds	No.of groun-ds/100 sq. km.
1. 14-73	9.25	66-126	85-108	463	16	3252	146	4
2. 13-73 & 13-74	9.17	66-110	82-110	431	61	2709	385	14
3. 12-74	11.58	68-180	82-112	456	55	1985	240	12
4. 11-74	7.61	70-120	74-114	330	74	1405	315	22
5. 11-75	4.00	72-95	72-95	165	52	385	121	32
6. 10-75	9.75	65-180	72-110	460	171	1181	439	37
7. 9-76	5.00	68-130	72-100	207	37	114	26	18
8. 9-75	13.08	64-130	80-101	521	337	1030	667	65
9. 8-76	9.58	64-115	72-111	297	199	1810	1213	67
Total	79.02	64-180	72-114	3330	1002	13871	3552	30

AREA ABUNDANCE OF 'KALAVA' ON THE SOUTH WEST COAST

Existing data is insufficient to give a reliable picture of the relative abundance of 'kalava' from area to area. The available data (Table XVII) consists of assessments based on the R.V. VARUNA cruises discussed earlier and some information recently published for the Indo-Norwegian Project vessels by Menon and Joseph (1969). It will be necessary to carry out a survey based on extended line fishing operations to cover other areas to find out the total abundance and the component abundance of 'kalava' species-wise for the different areas. As more than one year class of a species may be caught from a single ground, the weight of the specimens of the same species in the catch differs markedly. In view of this, the catch rates expressed as number of fish/hr of fishing, or number/line/hr of fishing may not be very helpful. A more reliable picture of abundance in terms of 'kalava' biomass may be the expression of catch rates as catch in kg/100 hooks/hour. The effort in fishing hours and total catch in kg. for all the vessels for 1^0 latitudes squares more often fished are as follows.

1^0 Lat. Square	Fishing effort in Hrs.	Total weight in Kg.
8-76	21.00	1502
9-75	618.25	40840
10-75	535.80	36546
11-74	58.75	5955
11-75	45.08	4931
12-74	14.00	545

Based on average values of catch of all vessels, it will be seen from Table XVII that in1^0 lat. squares 8-76, 9-75 and 11-74 the catch in kg/100 hooks/hr is between 200 and 300 kg which may be considered high. It is between 180 and 190 kg/100 hooks/hr for 10-75 and 11-75. The data on fishing effort and catch given above would show that these catch rates are fairly representative. In perch fishery, initial high catch rates may be expected when virgin grounds are fished. Hence, a systematic exploration of the grounds will have to be made to see whether they are uniformly productive and to what levels fishing pressure could be maintained.

TABLE- XVII

RELATIVE ABUNDANCE OF 'KALAVA' FROM DIFFERENT AREAS

Area in 1^0 squares	R.V. VARUNA DATA					Data retabulated from Menon & Joseph (1969)		Average* C/100 H/hr
	Fishing effort (Hrs)	C(Kg)	C(hr)	C/L/hr	C/100 H /hr	C/L/hr	C/100 H/hr	
7-76	-	-	-	-	-	1.25	15.63	(insufficient)
8-76	0.75	50	66.6	22.2	277.50	14.34	179.25	228.75
9-75	15.00	1480	98.6	32.9	441.25	10.75	134.38	287.81
10-75	27.80	1385	50.4	16.8	210.00	12.39	154.88	182.44
11-74	1.00	40	40.0	13.3	162.50	29.22	365.25	263.87
11-75	9.08	150	16.6	5.5	68.75	24.67	308.38	168.5
12-74	8.0	215	26.8	8.9	111.25	11.17	139.63	125.44
13-73	1.0	40	40.0	13.3	162.50	-	-	(insufficient)

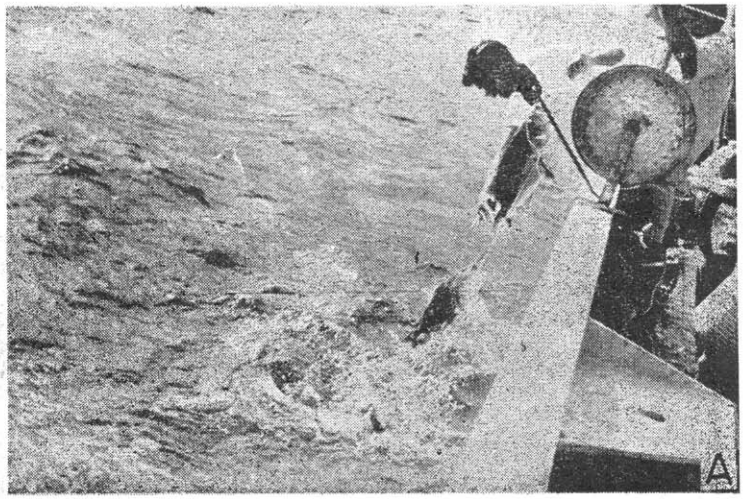
Estimation of the potential sustainable yield of 'kalava'is rather difficult. We have at present no information about recruitment, age, growth rates etc., for the different species.

Larvae of 'kalava' have been collected during the cruises of R.V. VARUNA and are being studied. Juveniles of 'kalava' have been taken in trawls from shallower depths (30 to 60 m) as also from deeper waters (100 to 160 m). The greatest depth from which young 'kalava' were caught by trawl net was 160 metres at 9^0 33' N, 75^0 41' E on 8-6-66 when 10 kg of young *E.diacanthus* of average size 21.8cm were caught. Thus available information is incomplete in many respects.

There is a great need for studying the behaviour of 'kalava'. Unless this is done it will be hard to find answers to such questions as why during fishing 'kalava' should stop biting after dusk. Since direct underwater observations at such depths are not feasible in the near future, and as echograms may not throw light on several similar problems, use of other methods should be explored. One very promising tool which could be used is the baited camera which has been successfully used to study the behaviour of fish, shrimps and other organisms in the deep waters off the California coast by scientists of the Scripps Institution of Oceanography.

*R.V. VARUNA data plus that given by Menon and Joseph (1969).

C= catch in Kg.; L = Line (with 8 hooks): 100 H = 100 hooks.



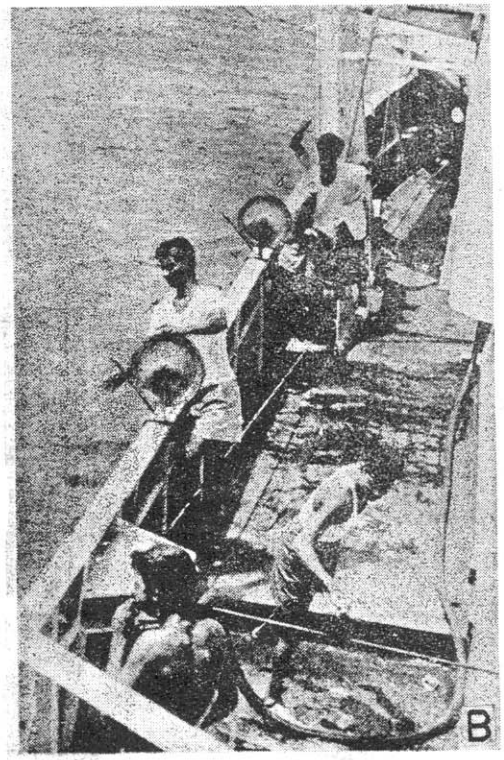


Plate V. 'Kalava' fishing with handlines during R. V. *VARUNA* cruise from 90 m depth off Cochin. (S - F. *chlorostigma* with everted stomach projecting out of the mouth) (Photos: E G. Silas)

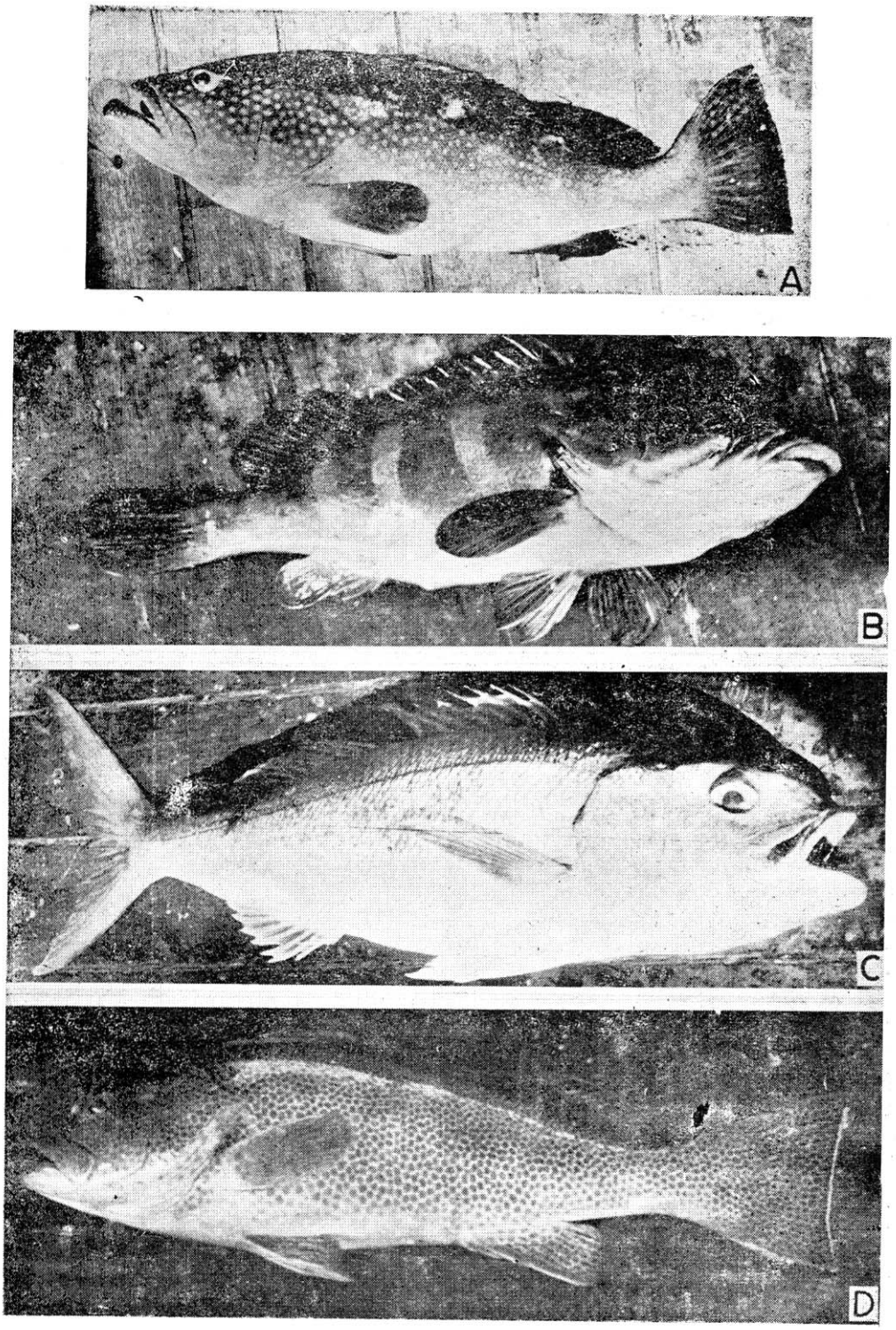


Plate VI Common perches (kalava) caught by handline during R. V. *VARUNA* cruises A. *Epinephelus areolatus* (Forskal); B *E. diacanthus* (Valenciennes); C *Pristipomoides typus* Bleeker; and D. E *chlorostigma* Valenciennes. (Photos: E. G. Silas)

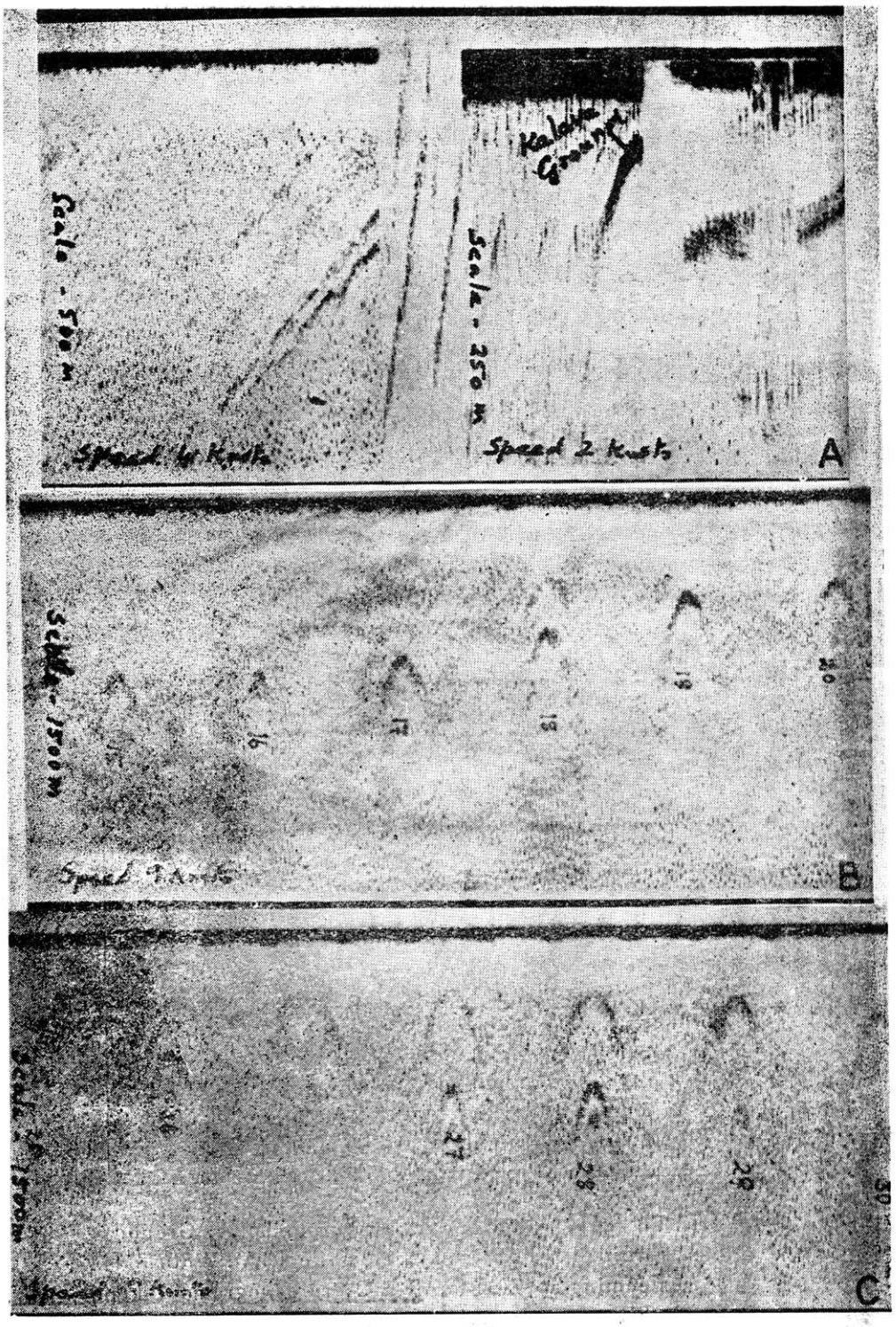


Plate VII. 'Kalava' ground explorations: A-C. Sonar (ASDIC) traces showing A. ASDIC trace at different pulse and range frequencies as the vessel approches 'kalava' ground; B. & C. Numbers indicate 'kalava' grounds in 87 to 90 m depth.

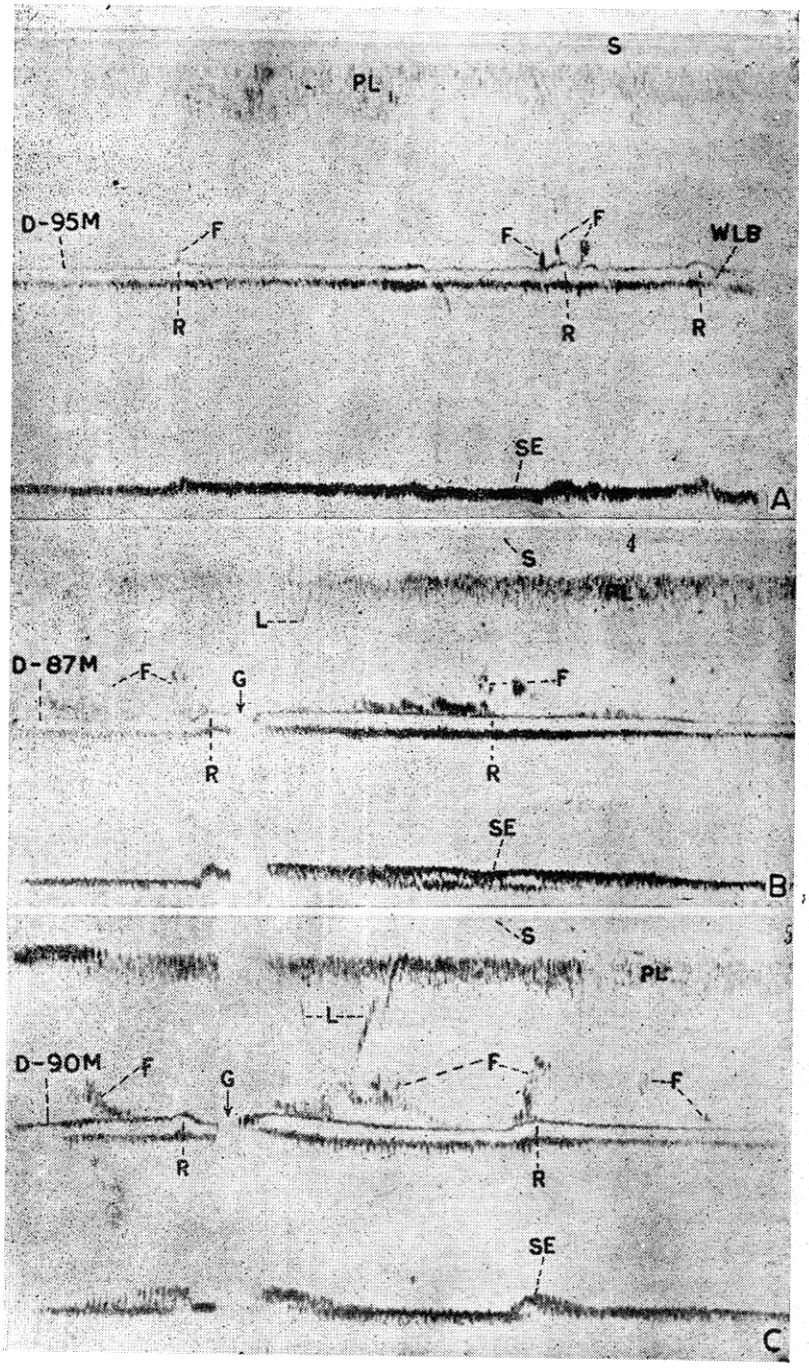


Plate VIII Echograms showing 'kalava' grounds. A. Grounds recorded by echosounder while R. V. *VARUNA* is steaming at 7 knots; B & C are echograms taken while fishing on the grounds.

(D—M = Depth in metres; G = Gap marking period of interference when vessel went astern; F = Fish and probably also other organisms; L = lines fishing; PL = Surface layer of plankton; R = outcrops on hard bottom; S = Surface; SE = Second trace of hard bottom; WLB = White line bottom)

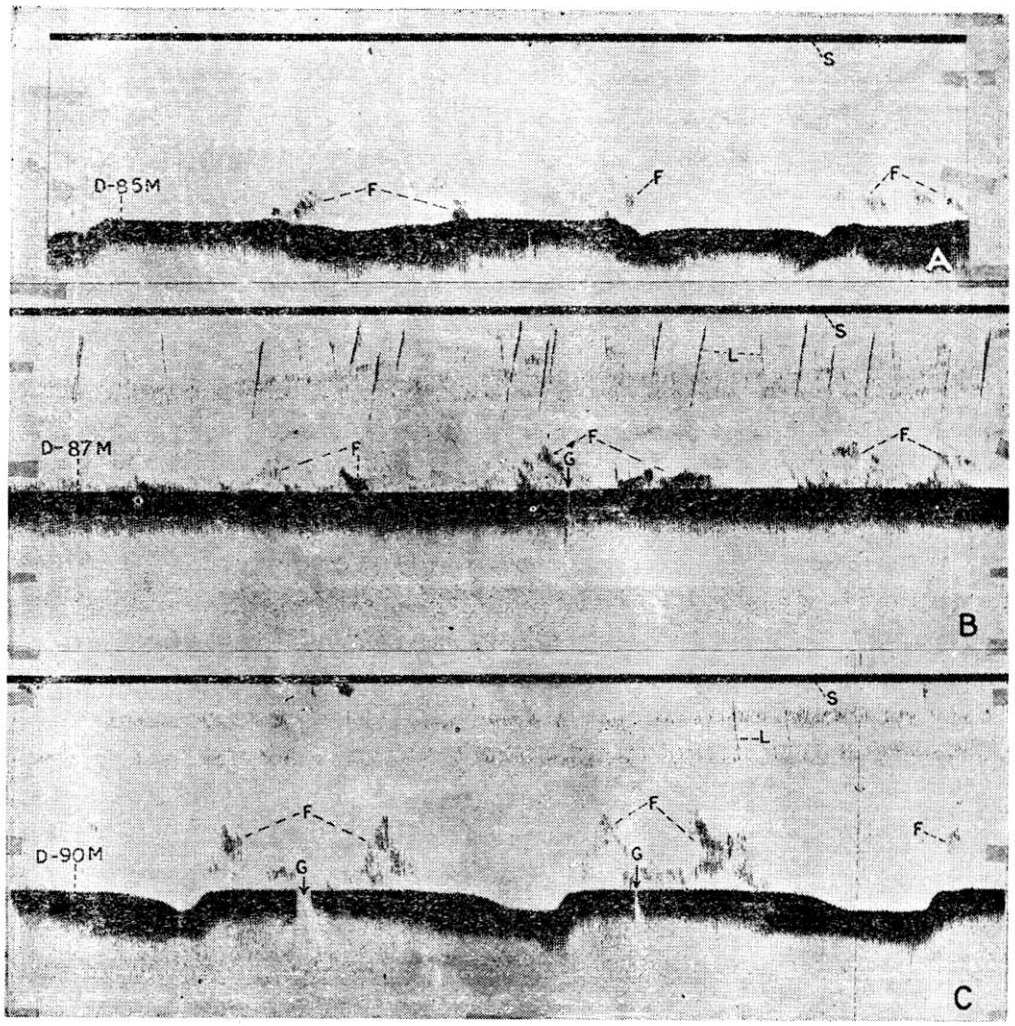


Plate IX. Echograms of 'kalava' grounds when fishing was in progress. A-C. The partly smooth botom profile being due to the recordings on dry echogram paper made while the vessel was staying on the ground (Legend as under plate VIII)

P A R T – III

EXPLORATORY SURVEYS OF THE PELAGIC AND OCEANIC FISHERIES OF THE EASTERN PART OF THE ARABIAN SEA AND THE LACCADIVE SEA

PELAGIC AND OCEANIC FISHERIES

Most of our investigations on pelagic fishes of the Indian Seas deal with studies on the mackerel and sardine which come under the neritic-pelagic complex. Hardly any exploratory surveys have been conducted in our offshore and oceanic waters for fishes and other animals which come under the oceanic-pelagic-complex. The importance of tunas and related fishes, marlins, sailfish and swordfish and their availability in our waters have been drawn attention to (Jones and Kumaran, 1959; Jones and Silas, 1964; Silas, 1967: Silas and Rajagopalan 1967). It is well known that Japanese tuna longlines are regularly operating in the oceanic waters around India. But longlining only taps a small portion of the wast potential fishery resources of the high seas. Exploratory surveys aimed at discovering new resources or areas of abundance, finding out the suitability of gears which would improve catches and understanding the environmental factors effecting the concerned fisheries are essential for developing our oceanic fisheries.

During the cruises of R.V. VARUNA it was possible to plan out different types of exploratory fishing in the offshore and oceanic areas of which two, namely the drift net fishing and purse-seining, need special mention. Surface trolling and longlining (Norwegian type) were tried on only a few occasions and hence are not discussed here. Drift net fishing was started in January 1965 and continued as and when possible up to the end of January 1968. Purse-seining for tuna was tried by R.V. VARUNA as well as by M.V. TUNA which worked in association with the research vessel. During the cruises scouting for tuna with the sonar (ASDIC) (horizontal range 1500 metres) and echosounders were tried and though positive results were obtained it was found that visual scouting was even more effective, when aided by flocks of birds, diving or following tuna shoals, which could be spotted at a distance of several miles. The characteristic sonic spires in the Deep Scattering layer between 300 and 450 meters have been recorded and it is presumed that these could be caused by large tuna, namely the yellowfin or the big eye. The data

from these exploratory surveys are being processed. In the meantime, some of the details of the exploratory surveys are dealt with under appropriate headings.

EXPLORATORY DRIFT-NET FISHING

A number of units of the drift-net made of nylon was used at a time, each unit being 25.85 metres long and 6.10 metres broad. In a single unit the mesh size was the same and units with mesh sizes 2.5, 5.5, 10.0, 12.5 and 17.0 cm were used. The smaller mesh sizes were selected specially for obtaining information about juvenile pelagic fishes of which we know very little. The station position, the number of units used for each operation, the catch and other details are given in Table XXI. A summary of the details is given below:

No. of fishing operations	86
Total soaking time inclusive of shooting and hauling of net)	794.50 Hours
Total catch	2,522.00 kg.
Mean No. of hrs/fishing operation	9.24 Hours.
Average catch/fishing operation	29.33 kg.
Number of positive operations	72

The number of units of nets used varied from 14 to 45. Drift nets were operated in the Laccadive Sea as well as on the continental shelf off the south-west coast. The maximum soaking time of the net for a single operation was 15.00 hrs and the minimum 4 hrs 10 mts. It took approximately 30 to 45 minutes to shoot 45 units and about 45 minutes to haul the same. Mostly hauling was done manually (Plate X,C). But on a few cruises, the line hauler on portside was used connected to a drum which would be rotating and thereby helping in hauling. The effective fishing depth was from surface to between four and five metres. Consequently, very little or no fish were caught on the three or four days close to the full moon. During some months, in some of the areas the net became conspicuous by the attachment of luminous planktonic organisms on such occasions, the catch was invariably very meager.

In Table XVIII a list of the species caught by drift net is given. As the nets were operated in neritic as well as oceanic waters, the areas of occurrence of the species are also included.

TABLE – XVIII
SPECIES OF FISHES AND INVERTEBRATES CAUGHT BY DRIFT NET

Name of species (Genera alphabetically listed)	Shelf area	Oceanic area
FISHES:		
Ablennes hians (Valenciennes)	X	X
Acanthocybium solandri (Cuvier)	-	X
Auxis rochei (Rissc)	X	X
Auxis thazard (Lacepede)	X	X
Caranx sp.	X	-
Carcharhinus longipinnis (Smith)	-	X
Carcharhiuns sp.	-	X
Chirocentrus dorab (Forskal)	X	-
Chorinemus lysan (Forskal)	X	-
Chorinemus tol Cuvier	X	-
Coryphaena equisetis (Linnaeus)	-	X
Coryphaena hippurus (Linnaeus)	-	X
Cypsilurus comatus (Mitchell)	-	X
Cypsilurus cyanopterus (Valenciennes)	-	X
Cypsilurus oligolepis (Bleeker)	-	X
Decapterus spp.	X	X
Echeneis naucrates Linnaeus	X	X
Elagatis bipinnulatus (Quoy & Gaimard)	-	X
Eulamia melanopterus (Quoy & Gaimard)	X	X
Euthynnus a. affinis (Cantor)	X	X
Gempylus serpens Cuvier	-	X
Istiophorus platypterus (Shaw & Nodder)	-	X
Katsuwonus pelamis (Linnaeus)	X	X
Kishinoella tonggol (Bleeker)	X	-
Lobotes surinamensis (Bloch)	-	X
Makaira sp. (Juvenile)	X	-
Megalaspis cordyla (Linnaeus)	X	-
Naucrates ductor (Linnaeus)	X	X
Netuma x *halassinus* (Ruppell)	X	-
Netuma sp.	X	-
Parastromateus niger (Bloch)	X	-
Phtheirichthys lineatus (Menzies)	-	X
Platax teira (Forskal)	-	X
Pristis cuspidatus Latham	X	-
Psenes cyanophrys Valenciennes	-	X
Rachicentron canadus (Linnaeus)	X	X
Rastrelliger kanagurta (Cuvier)	X	-
Sarda orientalis (Temminck & SchleGEL)	X	-
Scoliodon sorrakowah (Cuvier)	X	-
Scomberomorus guttatus (Bloch & Schneider)	X	-
Scomberomorus lineolatus (Cuvier)	X	-
Sphyrna zygaena (Linnaeus)	X	-
Sphyraena jello Cuvier	X	-
Tylosurus crocodilus (Le Sueur)	X	-
Trichiurus lepturus Linnaeus	X	-
Thunnus albacares macropterus (Temminck&Schlegel)	-	X
CRUSTACEANS:		
Charybdis (Goniohellenus) edwardsi Leene & Buiyendijk	X	X
MOLLUSCA: *Symplectoteuthis oulaniensis* (Lesson)	X	X

The size range and average weights of tunas in the drift net catch are given in Table XIX

TABLE – XIX

Species	No. of specimens	Fork length Range in mm	Average weight in kg
Auxis rochei	141	191-290	0.168
Auxis thazard	153	201-510	0.750
Euthynnus a.affinis	238	281-620	2.232
Sarda orientalis	21	281-520	1.309
Katsuwonus pelamis	38	421-650	3.347
Kishinoella tonggol	1	447	-
Thunnus albacares macropterus	7	500-650	3.500

Aspects of the biology of these tunas and other fishes caught in the drift net are under investigation.

TABLE – XX

FECUNDITY OF TUNAS FROM DRIFT NET CATCH**

Species	No. of ovaries examined for counts	Estimated number of ova	
		Range	Mean (Rounded to nearest hundred)
Auxis rochei	4	31236-102902	52000
Auxis thazard	9	197223-1056468	601400
Euthynnus a. affinis	7	493617-1393882	866900
Sarda orientalis	4	268930-403603	354100
Katsuwonus pelamis	1	268373	268400

** Data after Silas and Thomas (MS).

The sampling distribution and occurrence of the species of tunas in the drift net catch are shown in Figure 17, along with details of length frequency and weight. In Figure 18 the areas of occurrence and abundance of the oceanic squid *Symplectoteuthis oualaniensis* are given. Plates X and XI B show some of the species of fishes frequently caught by drift-net.

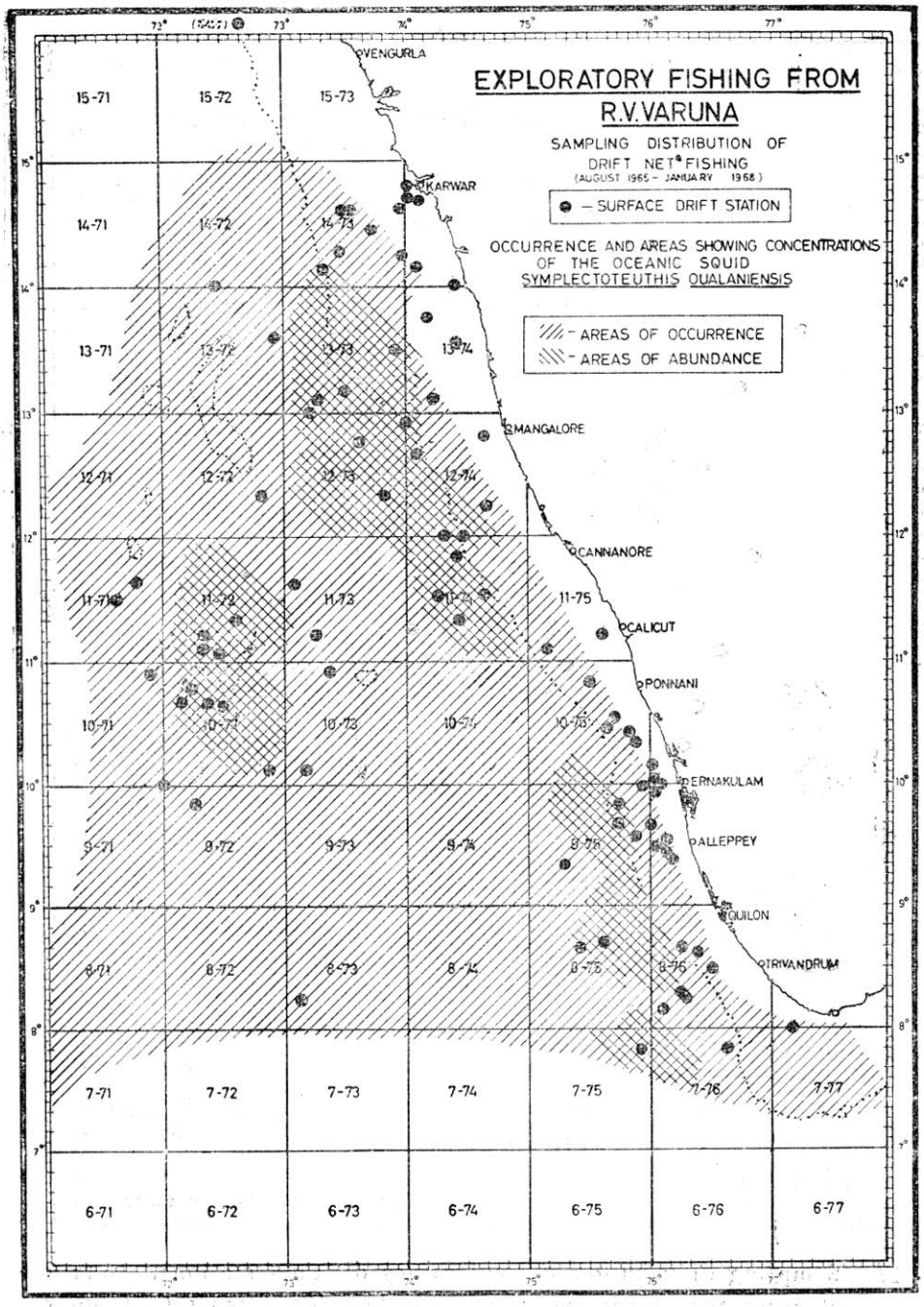


Fig. 18. Sampling distribution of exploratory drift net stations showing also areas of abundance of the oceanic squid ***Symplectoteuthis oualaniensis*** Lesson.

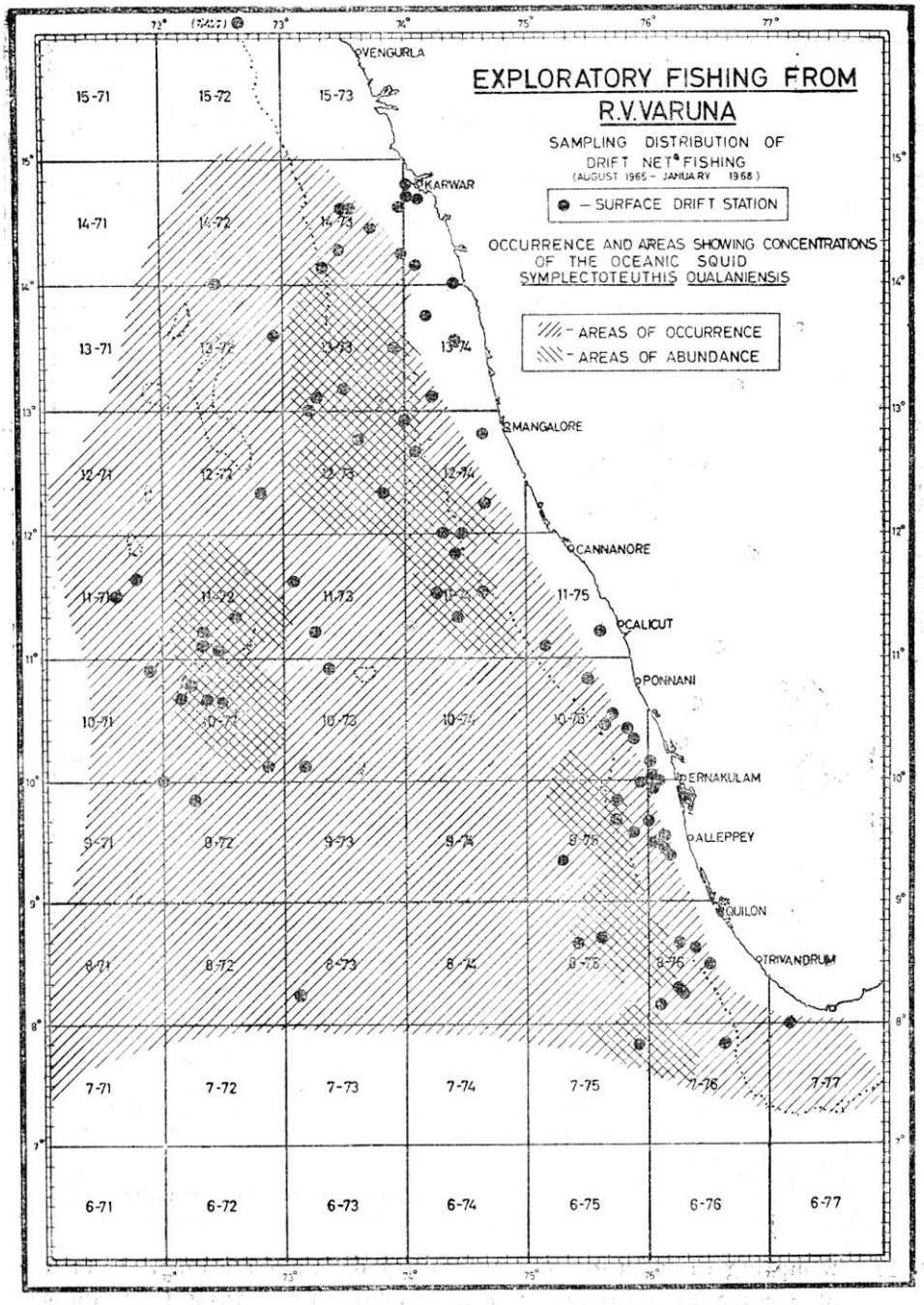


Fig. 18. Sampling distribution of exploratory drift net stations showing also areas of abundance of the oceanic squid ***Symplectoteuthis oualaniensis*** Lesson.

Table- XXI

R.V. VARUNA SUFACE DRIFTNET STATION DETAILS

Serial No.	Cruise No.	Date	Position		Sonic depth (m)	Duration	No. of units of netused	Weight of catch (Kg)
			Latitude	Longitude				
1	2	3	4		5	6	7	8
1	V-68	20/21-1-65	Off Karwar		25	1830-0900	25	3
2	“	21/22-1-65	Off karwar		20	1700-0800	25	5
3	“	22-1-65	Off karwar		60	1200-1600	25	nil
4	“	22/23-1-65	Bet.Karwar& Mangalore		60	1900-0900	25	5
5	“	23/24-1-65	Off Mangalore		50	1900-0900	25	5
6	V-81	4/5-8-65	$07^0$50’N	$76^0$38’E	975	2000-0830	25	nil
7	V-82	18/19-8-65	11^o20’N	74^o25’E	1200	2110-0800	25	nil
8	“	23/24-8-65	$14^0$37’N	$73^0$30’E	150	2100-0750	25	50
9	Sp. Fi. Cruise	23/24-9-65	$14^0$37’N	$73^0$30’E	150	2100-0730	25	15
10	“	24/25-9-65	$13^0$10’N	$73^0$30’E	800	2230-0800	25	45
11	“	25/26-9-65	$12^0$00’N	$74^0$10’E	300	2300-0800	25	nil
12	“	26/27-9-65	$10^0$28’N	$75^0$37’E	200	2300-0800	25	150
13	V-83	12-10-65	$09^0$50’N	$75^0$44’E	100	0005-0800	25	11
14	“	13/14-10-65	$08^0$40’N	$75^0$25’E	1300	1900-0700	25	17
15	“	15/16-10-65	$07^0$50’N	$75^0$55’E	1400	1900-0600	25	5
16	V-84	21/22-10-65	$11^0$51’N	$74^0$25’E	240	2245-0745	25	14
17	“	22/23-10-65	$14^0$27’N	$73^0$43’E	70	2200-0730	25	370
18	“	23/24-10-65	$13^0$37’N	$13^0$17’E	200	2300-0610	25	10
19	“	25-10-65	$13^0$07’N	$74^0$13’E	100	0005-0415	25	3
20	“	25-10-65	$13^0$00’N	$73^0$13’E	100	0445-1015	25	4
21	“	25/26-10-65	11^o32’N	$74^0$15’E	1600+	2300-0800	25	6
22	“	26/27-10-65	$10^0$50’N	$75^0$30’E	50	2300-0500	25	50
23	V-85	11-11-65	$08^0$30’N	$76^0$30’E	78	0100-0630	25	10
24	“	11/12-11-65	$08^0$10’N	$76^0$05’E	1400	2330-0700	25	3
25	“	13-11-65	$08^0$43’N	$75^0$38’E	450	0005-0630	25	nil
26	“	14-11-65	$09^0$35’N	$75^0$51’E	64	0130-0630	25	3

1	2	3	4		5	6	7	8
27	V-86	24/25-11-65	$12^0$15'N	$74^0$40'E	58	2130-0630	45	25
28	"	25/26-11-65	$14^0$09'N	$74^0$40'E	50	2230-0630	45	25
29	V-88	15/16-12-65	w. of Karwar		120	2200-0700	45	15
30	V-89	5/6-1-66	$14^0$09'N	$73^0$20'E	50	2300-0800	25	31
31	"	6/7-1-66	$13^0$35'N	$75^0$55'E	1900	2300-0800	25	30
32	"	7/8-1-66	$12^0$55'N	$74^0$00'E	190	2030-0700	25	5
33	V-90	3-2-66	$09^0$40'N	$76^0$00'E	50	0045-0810	25	28
34	"	3/4-2-66	$08^0$38'N	$76^0$22'E	80	2230-0710	25	4
35	"	5/6-2-66	$08^0$40'N	$76^0$15'N	85	2200-0730	25	3
36	"	7/8-2-66	$09^0$40'N	$75^0$44'E	200	1845-0015	25	6
37	V-91	15/16-2-66	$10^0$07'N	$75^0$52'E	1900	2000-0645	45	62
38	"	16/17-2-66	$10^0$40'N	$72^0$22'E	1750	2145-0630	45	31
39	"	17/18-2-66	$11^0$20'N	$72^0$36'E	1600	2145-0630	45	54
40	"	18/19-2-66	$11^0$13'N	$73^0$16'E	1960	2145-0730	45	137
41	V-92	21/22-4-66	$12^0$00'N	$74^0$28'E	215	2230-0730	25	32
42	"	22/23-4-66	$12^0$46'N	$73^0$37'E	900	2200-0730	25	94
43	V-94	23/24-5-66	13 Km. W. of Calicut-			2100-0645	25	24
44	Sp.Fi. Cruise	31/1-5/6-66	22 Kn. W. of Alleppey		45	2000-0730	25	@100
45	"	1/2 6-66	Off Cochin		45	2030-0630	25	nil
46	"	15/16-6-66	$09^0$59'N	$76^0$03'E	25	2005-0700	25	35
47	"	16/17-6-66	$09^0$31'N	$76^0$09'E	25	2100-0645	25	40
48	V-96	20/21-6-66	$10^0$32'N	$75^0$41'E	25	1800-0700	25	20
49	V-98	18/19-7-66	$10^0$25'N	$75^0$50'E	30	2000-0700	25	10
50	V-99	12-8-66	$10^0$20'N	$75^0$52'E	29	0015-0615	25	68
51	Sp.Fi. Cruise	16/17-8-66	Off Alleppey		45	2000-0630	-	75
52	"	18/19-8-66	Off Cochin		30	2000-0600	-	45
53	"	19-8-66	Off Cherai		30	-	-	20
54	V-100	22/23-8-66	$14^0$00'N	$74^0$26'E	35	1930-0630	25	60
55	"	26/27-8-66	@ 16 Km N.W. of Cochin		30	1800-0600	25	287
56	V-101	5/6-9-66	@ 16 Km. W. of Alleppey		45	1900-0700	25	75

1	2	3	4		5	6	7	8
57	V-101	6/7-9-66	$08^0$00'N	$77^0$11'E	60	1900-0700	25	40
58	"	9/10-9-66	$09^0$58'N	$76^0$00'E	70	2030-0630	25	6
59	V-102	7/8-11-66	$16^0$30'N	$73^0$40'E	230	2210-0700	35	4
60	V-103	6/7-12-66	$12^0$20'N	$73^0$50'E	1250	2220-0635	25	10
61	"	8/9-12-66	$11^0$13'N	$72^0$20'E	1700	2130-0730	25	40
62	"	10/11-12-66	$11^0$06'N	$72^0$20'E	1700	2040-0630	25	10
63	V-104	17/18-12-66	$14^0$15'N	$73^0$28'E	35	2200-0630	25	11
64	V-105	9/10-2-67	$11^0$38'N	$71^0$47'E	1450	2200-0900	28	nil
65	"	10/11-2-67	$10^0$54'N	$71^0$54'E	1700	2145-0845	26	nil
66	"	11/12-2-67	$11^0$37'N	$73^0$05'E	2020	2205-0730	26	2
67	"	12/13-2-67	$10^0$55'N	$73^0$22'E	1720	2300-0730	26	12
68	"	13/14-2-67	$10^0$00'N	$72^0$00'E	2400	2200-0740	26	9
69	"	14/15-2-67	$10^0$07'N	$73^0$10'E	1600	2300-0745	26	2
70	V-106	22/23-2-67	$11^0$32'N	$74^0$38'E	190	2200-0645	25	nil
71	"	23/24-2-67	$13^0$30'N	$73^0$55'E	68	2130-0700	25	nil
72	"	25/26-2-67	$14^0$45'N	$74^0$01'E	33	2200-0700	25	nil
73	V-107	7-3-67	Off cochin		-	0030-0700	25	nil
74	"	10-3-67	$08^0$55'N	$75^0$12'E	1800	0005-0600	25	nil
75	V-108	29/30-3-67	Off Minicoy Id.		1600	2300-0630	40	4
76	"	31/1-3/4-67	Off Agathi Id.		1500	2200-0700	40	5
77	"	1/2-4-67	Off Agathi Id.		1500	2030-0630	40	1
78	"	2/3-4-67	Off Pitti Id.		1600	2230-0715	40	3
79	V-109	15-4-67	$12^0$20'N	$72^0$50'E	2000	0005-0600	25	10
80	"	16-4-67	$11^0$30'N	$71^0$38'E	1500	0005-0645	25	3
81	"	16/17-4-67	$11^0$09'N	$72^0$27'E	1700	2200-0645	25	10
82	"	19-4-67	$09^0$50'N	$72^0$13'E	1700	0005-0645	25	11
83	V-110	28/29-4-67	$13^0$30'N	$74^0$25'E	38	2330-0900	25	15
84	V-120	8/9-10-67	$12^0$40'N	$74^0$05'E	450	2100-0600	14	85
85	V-121	4/5-11-67	$09^0$20'N	$75^0$18'E	2200	2100-0630	20	4
86	V-123	12/13-1-68	$08^0$17'N	$76^0$17;E	1100	2230-0630	20	nil

PURSE SEINE FISHING FOR TUNAS

Purse seine fishing for tunas in the Laccadive Sea was first carried out by R.V. VARUNA in February 1966, but was not successful. In March 1967, purse seining was again tried in the Laccadive Sea, this time by M.V. TUNA (earlier known as M.V. HESSATRAL), with R.V. VARUNA going along to scout for tuna shoals and carry out other investigations. The net used had the following dimension: Length 540 metrers; width 67 metres; mesh size 10 cm. The net had not been properly weighted and when shot was not sinking fast as desired. The skipjack shoals which were completely encircled sounded much faster and not a single fish was caught. To be more effective in the high seas, the net has to be of larger diemensions, the length to be increased by at least another 250 metres and the depth doubled. The same purse seine net was successfully operated on the shelf area when good catches were obtained, the maximum exceeding ten tonnes in a single operation. Details of the areas fished, the lengths and weights of tunas caught, etc., are shown in Figure 19. The catch was mainly composed of schools of *Euthynnus a. affinis* and *Auxis thazard.* On three or four occasions the catch consisted of mixed schools of the two species. Surface schools of tuna (skipjack shoals) are shown in plates XII and XIII.

Of a total number of 38 purse seine operations carried out by R.V. VARUNA and M.V. TUNA, the number of positive stations with tuna were only 10 for which the effort expended in hours was 39.50. The total catch amounted to 19,436 kg. The average duration of the positive operations being 3.95 hours, the average catch in kg/positive fishing operation was 1943.8 kg. In other words, the catch/hour (for positive hauls) worked out to about 494 kg of tunas. Since a training programme was undertaken to familiarize the crew with the use of the net, which also resulted in several negative hauls, these were not considered in the above estimation. These investigations have proven beyond doubt that in the coastal waters, nets of the type used could be successfully operated and much higher catch rates could be expected. The greatest problem in this fishery is marketing the catch. Canning tuna meat would be one answer, but the meat of the coastal species being red, this may not have an export market. However, its utility towards manufacture of fish paste, or fish

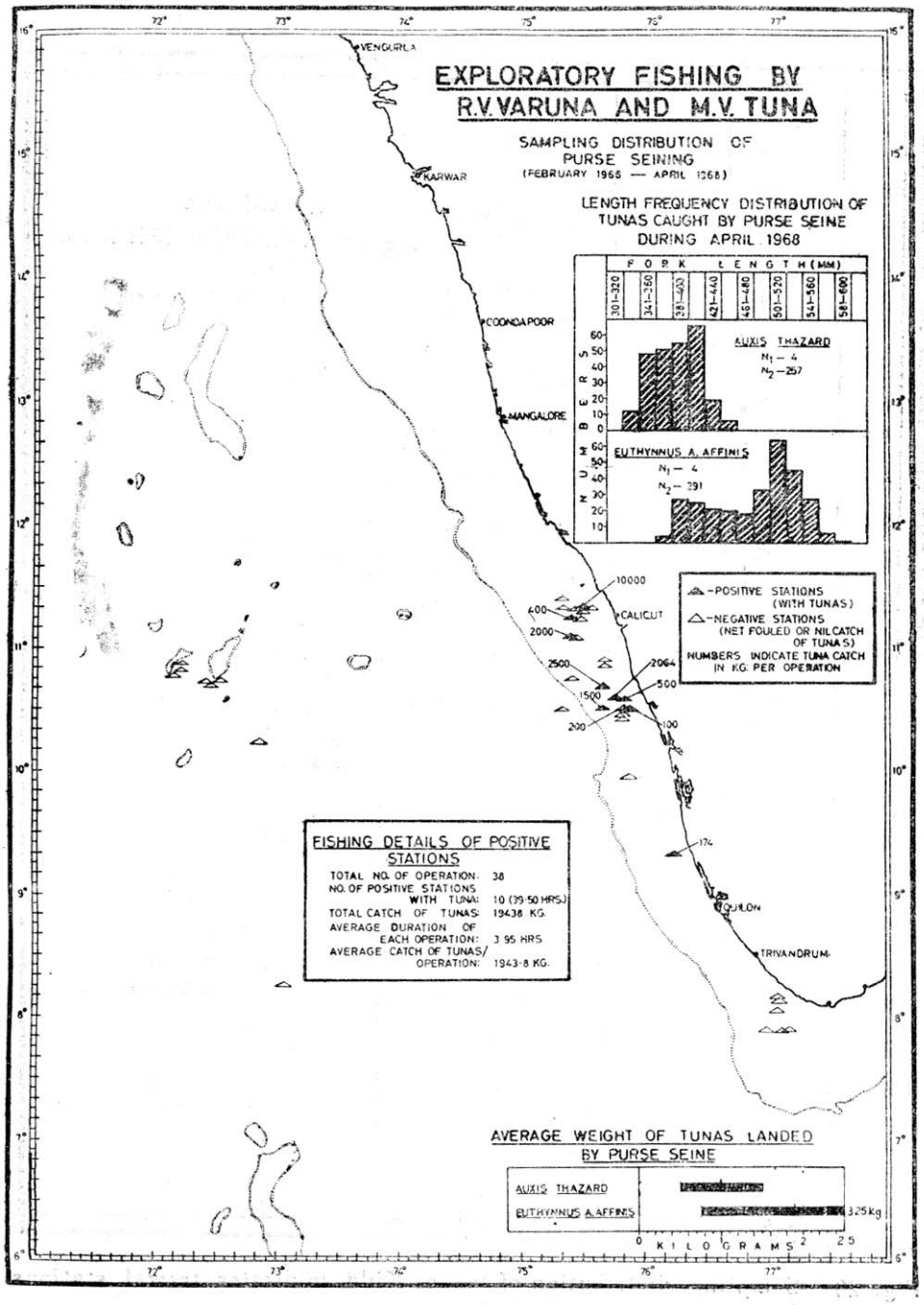


Fig. 19. Exploratory purse seining for tunas from the south west coast and the Laccadive Sea carried out by R. V. *VARUNA* and M. V. *TUNA*. Details of length and weight of the tunas caught as well as catch in kg/operation are also indicated.

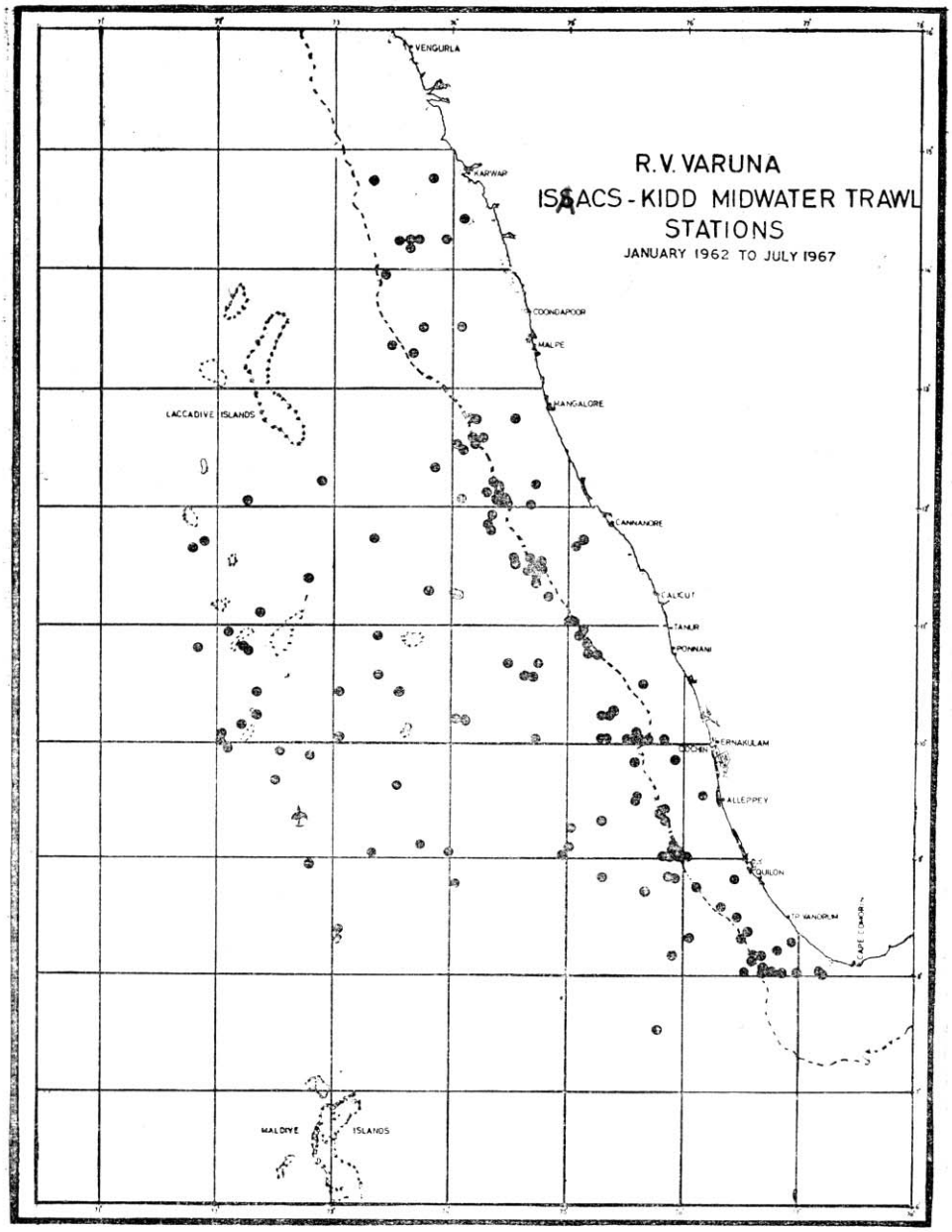


Fig. 20. Sampling distribution of Isaacs-Kidd midwater trawal stations (January 1962 to July 1967).

powder could be explored. While investing in large scale purse seining these factors may also be given due consideration.

In purse seine operations scouting for surface or subsurface shoals takes up a lot of the time. Fortunately in some areas, especially in the central and northern parts of the Laccadive Sea the behaviour of oceanic birds have helped considerably in the visual scouting for the shoals. Watson et. al (1963) have given a list of the birds occurring in the Laccadive Sea. Of these, two species of terns, the sooty tern *Sterna fuscata* and the Noddy tern *Anous stolidus* (Plate XI A) were found to be most common and known to breed on some of the remote islands, especially cherbaniani and Pitti. As practically nothing is known about the breeding habits of these birds, Pitt Islands was visited by me on a few occasions to conduct field studies. In this connection I wish to extend my thanks to Mr. K.M. Vergheese, Fisheries Officer, Laccadive Administration for all help given, during one of the cruises touching pitti Island.

MIDWATER TRAWLING AND DEEP SCATTERING LAYER INVESTIGATIONS

While planning the exploratory fishing programme it was felt that mere fishing alone would not answer many of the questions that may arise therefrom. Very little attention has been given in our fisheries investigations to behaviour studies. One among several of the investigations undertaken was the study on the availability of forage organisms of pelagic fishes such as tunas, bill fishes and pelagic sharks. In order to obtain information on these, a 10 foot (3 metres) Isaacs Kidd midwater trawl was used, especially from November 1963 (Table-XXII), (Figure 20). Collections were taken from 150 stations and some of the constituents in the collection such as the Euphausiacea, and cephalopods which form important items in the food of oceanic fishes have been partly studied (Silas, 1968; Silas and Mathew, 1967 and MS). Several of the midwater trawl hauls were taken with special reference to the upper sonic scattering layers as the trawl could be operated only up to a depth of 350 metres (warp length 800 metres).

In Figure, 21, the R.V. VARUNA stations were Deep Scattering Layer (DSL) studies were carried out are shown. Plate XIV shows echograms taken off Aghati and Androth Islands at dusk or soon after showing the ascent of the sonic scattering layer especially off Androth; (Plate XV shows echograms taken) off Minicoy Islands and Suheli Par in which the descent of the sonic scattering layers at dawn can be seen. A detailed report on these investigations will be published elsewhere.

One of the reasons for paying special attention to the DSL was the possibility that it has an important role to play as regards the congregation of several planktonic organisms which also form forage of pelagic fishes. In addition to this, characteristic spire-like echotraces have been obtained from the DSL which is presumed to be that of fish, possibly tunas such as the yellowfin or bigeye tuna. These investigations will be continued as and when possible.

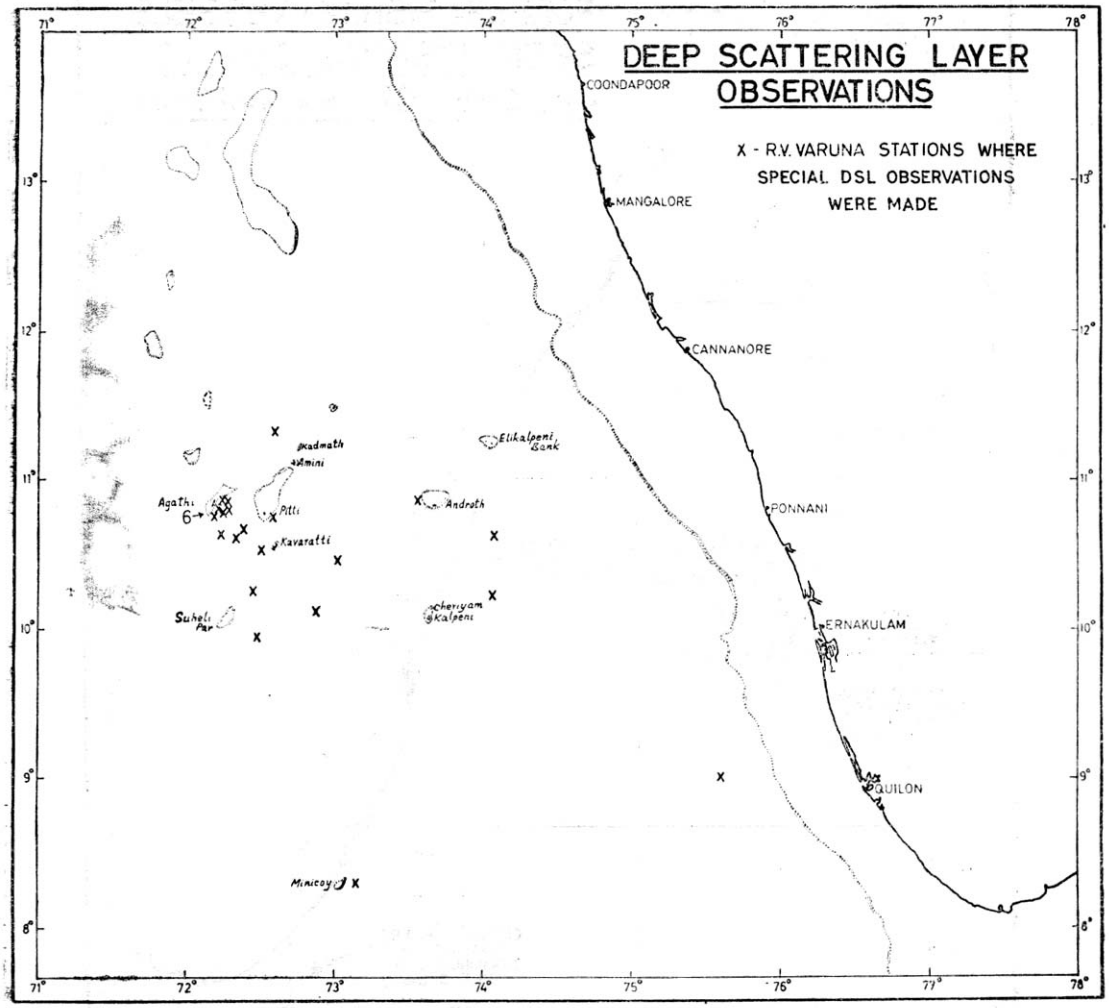


Fig. 21. R. V. *VARUNA* stations from where studies of the Deep Scattering Layers were carried out.

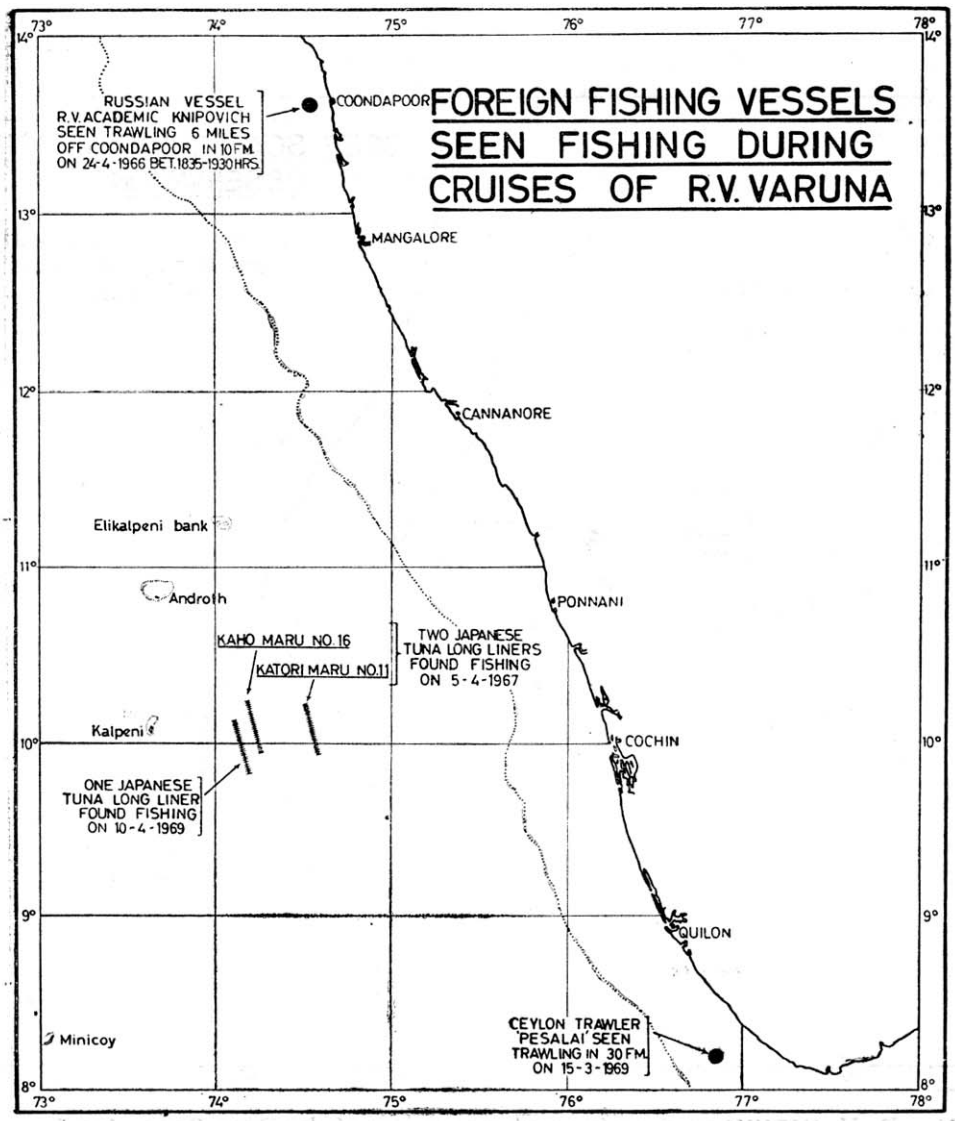


Fig. 22. Map showing the locations from where foreign fishing vessels were seen fishing during the cruises of R. V. *VARUNA*.

Table - XXII

R.V. VARUNA –ISAACS-KID MIDWATER TRAWL STATIONS

Serial No.	Cruise No.	Date	Position		Sonic Depth (m)	Depth of haul (m)	Duration (Hrs.)
			Latitude	Longitude			
1	2	3	4		5	6	7
1	V-5	25-2-62	09^{0}33’N	76^{0}10’E	20	15	1000-1145
2	V-6	2-3-62	08^{0}50’N	76^{0}35’E	25	-	1645-1715
3	“	4-3-67	08^{0}17’N	76^{0}57’E	30	-	0705-0745
4	V-16	7-9-62	09^{0}50’N	75^{0}34’E	160	-	0915-2000
5	V-28	20-4-63	08^{0}08’N	76^{0}36’E	250	30	1830-1915
6	V-40	20-10-63	09^{0}38’N	73^{0}33’E	2000	55	1010-1040
7	“	21-10-63	12^{0}04’N	72^{0}15’E	1800	65	0645-0745
8	V-41	3-11-63	08^{0}22’N	76^{0}34’E	110	40	2015-2300
9	“	4-11-63	08^{0}30’N	76^{0}28’E	70	40	0020-0050
10	“	4-11-63	09^{0}00’N	75^{0}58’E	220	60	0940-1020
11	“	4-11-63	09^{0}00’N	75^{0}58’E	2000	300	1940-2045
12	“	5-11-63	09^{0}04’N	74^{0}00’E	2800	400	0605-0715
13	“	5-11-63	09^{0}06’N	73^{0}48’E	2340	120	1230-1310
14	“	5-11-63	09^{0}03’N	73^{0}20’E	1700	400	1745-1845
15	V-46	5-3-64	07^{0}32’N	75^{0}47’E	1800	-	1100-1200
16	V-47	18-3-64	Off Vizhingam		38	20	0700-0745
17	“	18-3-64	08^{0}00’N	77^{0}11’E	48	20	1215-1245
18	V-48	25-3-64	11^{0}00’N	75^{0}01’E	69	30	0015-0100
19	“	25-3-64	10^{0}50’N	75^{0}10’E	250	-	0245-0315
20	“	25-3-64	10^{0}45’N	75^{0}15’E	200	-	0340-0415
21	V-49	6-4-64	08^{0}10’N	75^{0}55’E	1375	100	2355-0035
22	“	6-4-64	08^{0}10’N	76^{0}33’E	200	-	0525-0605
23	“	6-4-64	08^{0}10’N	76^{0}41’E	100	-	0650-0725
24	“	8-4-64	10^{0}00’N	75^{0}20’E	1800	-	1615-1720
25	“	9-4-64	10^{0}04’N	74^{0}43’E	2000	-	0600-0635
26	V-50	18-4-64	08^{0}00’N	77^{0}12’E	54	30	0945-1040
27	“	18-4-64	08^{0}00’N	77^{0}00’E	60	30	1128-1210

1	2	3	4		5	6	7
28	V-50	18-4-64	$08^0$00’N	$76^0$51’E	90	30	1425-1510
29	“	18-4-64	$08^0$0’N	$76^0$42’E	190	30	1715-1745
30	“	19-4-64	$09^0$00’N	$75^0$50’E	350	75	0635-0735
31	“	20-4-64	$19^0$00’N	$75^0$50’E	50	15	0250-0310
32	“	20-4-64	$10^0$00’N	$75^0$38’E	180	-	0625-0645
33	“	20-4-64	$11^0$00’N	$75^0$03’E	65	25	1900-1920
34	V-51	26-4-64	$12^0$34’N	$74^0$14’E	120	-	2300-2350
35	“	27-4-64	$11^0$54’N	$74^0$18’E	750	-	0800-0830
36	“	27-4-64	$12^0$00’N	$74^0$40’E	80-90	-	1300-1400
37	V-52	4-5-64	$10^0$40’N	$74^0$30’E	2000	-	1650-1740
38	“	5-5-64	$10^0$00’N	$75^0$20’E	1900	-	0840-0920
39	“	11-5-64	$08^0$50’N	$75^0$54’E	325	-	0020-0015
40	“	12-5-64	$09^0$30’N	$75^0$35’E	700	-	2345-0155
41	V-53	19-5-64	$08^0$33’N	$76^0$20’E	170-180	-	1900-1945
42	“	20-5-64	$10^0$28’N	$75^0$38’E	160-180	-	2200-2245
43	V-54	26-5-64	$12^0$02’N	$74^0$26’E	350	-	1920-2020
44	“	26-5-64	$12^0$08’N	$74^0$19’E	750	-	2300-2345
45	“	27-5-64	$12^0$31’N	$74^0$05’E	1000	-	0340-0415
46	“	30-5-64	$11^0$26 ‘N	$74^0$43’E	800	-	0810-0845
47	“	30-5-64	$11^0$15’N	$74^0$0’E	900	-	1135-1235
48	“	7-6-64	$08^0$50’N	$75^0$52’E	350	-	0800-0845
49	“	7-6-64	$10^0$00’N	$75^0$37’E	200	-	1515-1555
50	V-56	2-7-64	$09^0$24’N	$75^0$50’E	200	50	0100-0210
51	V-57	14-7-64	$10^0$00’N	$74^0$43’E	2000	-	1845-1925
52	V-60	26-8-64	$10^0$00’N	$75^0$36’E	350	-	2220-2300
53	“	28-8-64	$12^0$05’N	$74^0$27’E	250	150	0635-0700
54	“	28-8-64	$12^0$35’N	$74^0$10’E	200	-	1900-1930
55	V-61	12-9-64	$09^0$30’N	$75^0$37’E	500	-	0930-1000
56	V-62	23-9-64	$09^0$00’N	$75^0$58’E	200	-	0735-0800
57	“	23-9-64	$10^0$00’N	$75^0$35’E	300	-	1535-1605
58	“	24-9-64	$10^0$57’N	$75^0$08’E	180	-	1535-1630
59	“	24-9-64	$11^0$28’N	$74^0$40’E	300	-	2015-2100
60	“	25-9-64	$12^0$33’N	$74^0$12’E	200	-	1630-1700

1	2	3	4		5	6	7
61	V-62	25-9-65	$12^0$04’N	$74^0$24’E	100	-	1100-1200
62	V-63	10-10-64	$08^0$50’N	$75^0$19’E	140	100	2130-2210
63	V-64	23-10-64	$08^0$00’N	$76^0$42’E	200	-	1600-1620
64	“	23-10-64	$08^0$00’N	$76^0$32’E	950	-	1845-1915
65	“	24-10-64	$09^0$00’N	$75^0$54’E	200	150	0945-1010
66	“	25-10-64	$10^0$00’N	$75^0$33’E	1000	-	0230-0300
67	V-64	25-10-64	$10^0$49’N	$75^0$12’E	400	-	0930-1000
68	“	26-10-64	$11^0$23’N	$74^0$43’E	1200	-	0545-0615
69	“	26-10-64	$11^0$56’N	$74^0$20’E	975	-	1130-1200
70	“	27-10-64	$12^0$31’N	$74^0$02’E	500	-	0645-0720
71	V-71	24-2-65	Off Vizhingam		200	150	0800-0900
72	“	25-2-65	$09^0$00’N	$76^0$00’E	200	100	1015-1110
73	“	25-2-65	$09^0$00’N	$75^0$54’E	360	125	1215-1315
74	“	26-2-65	$10^0$55’N	$75^0$07’E	200	100	1610-1720
75	“	27-2-65	$11^0$42’N	$75^0$07’E	-	50	0630-0645
76	“	1-3-65	$11^0$30’N	$74^0$42’E	250	200	0130-0240
77	V-72	19-3-65	$14^0$10’N	$73^0$37’E	90	75	1620-1710
78	“	19-3-65	$13^0$58’N	$73^0$26’E	160	130	1840-1930
79	“	20-3-65	$13^0$19’N	$73^0$39’E	140	100	0040-0125
80	V-75	25-4-65	$11^0$34’N	$74^0$31’E	900	30	0645-0715
81	“	25-4-65	$11^0$34’N	$74^0$31’E	900	200	0900-1015
82	“	26-4-65	$09^0$44’N	$75^0$40’E	160	50	2230-2310
83	“	27-4-65	$09^0$00’N	$75^0$59’E	180	75	0800-0840
84	V-77	25-5-65	$08^0$00’N	$76^0$43’E	120	-	1305-1345
85	“	26-5-65	$09^0$00’N	$75^0$50’E	270	-	0945-1030
86	V-81	5-8-65	$07^0$50’N	$76^0$04’E	1050	-	1420-1520
87	“	6-8-65	$08^0$20’N	$76^0$03’E	850	-	0050-0200
88	V-103	6-12-66	$12^0$05’N	$75^0$05’E	1100	40	1710-1810
89	“	7-12-66	$12^0$20’N	$73^0$57’E	2000	40	1710-1830
90	“	9-12-66	$10^0$57’N	$72^0$06’E	1600	40	1730-1830
91	“	9-12-66	$11^0$45’N	$73^0$20’E	2000	40	1815-1915
92	“	10-12-66	$10^0$13’N	$72^0$20’E	1700	40	1805-1900
93	“	11-12-66	$09^0$52’N	$72^0$48’E	1800	40	1805-1905
94	“	12-12-66	$10^0$33’N	$74^0$39’E	2050	40	1710-1840

1	2	3	4		5	6	7
95	V-103	12-12-66	$10^0$33’N	$74^0$39’E	2050	20	1900-1935
96	V-104	18-12-66	$14^0$15’N	$73^0$38’E	90	50	0850-0950
97	“	19-12-66	$13^0$30’N	$73^0$45’E	78	50	0455-0555
98	“	19-12-66	$12^0$45’N	$74^0$10’E	150	85	1145-1245
99	“	20-12-66	$12^0$12’N	$74^0$21’E	183	3	1415-1515
100	“	20-12-66	$11^0$32’N	$74^0$44’E	175	85	1940-2040
101	V-105	8-2-67	$11^0$51’N	$74^0$19’E	1200	55	1745-1830
102	“	9-2-67	$11^0$41’N	$71^0$52’E	1650	70	1900-1945
103	“	10-2-67	$10^0$48’N	$71^0$50’E	1600	70	1830-1915
104	“	11-12-67	$11^0$23’N	$72^0$46’E	1820	70	1845-1935
105	“	13-2-67	$10^0$08’N	$72^0$11’E	2400	70	1840-1910
106	“	14-2-67	$10^0$02’N	$73^0$03’E	1980	70	1840-1910
107	V-106	22-2-67	$11^0$32’N	$74^0$45’E	100	75	1850-1930
108	“	23-2-67	$12^0$12’N	$74^0$42’E	55	25	1800-1830
109	“	24-2-67	$12^0$4’5N	$74^0$10’E	120	-	1330-1400
110	“	25-2-67	$13^0$30’N	$74^0$04’E	51	28	0820-0850
111	“	25-2-67	$14^0$15’N	$74^0$06’E	45	28	1845-1915
112	“	26-2-67	$14^0$45’N	$73^0$50’E	53	28	1110-1140
113	V-107	8-3-67	$09^0$05’N	$75^0$00’E	2240	75	1500-1530
114	“	8-3-67	$09^0$51’N	$75^0$55’E	880	75	2020-2050
115	“	9-3-67	$09^0$21’N	$75^0$50’E	188	75	1745-1815
116	“	9-3-67	$09^0$21’N	$75^0$17’E	2100	75	1745-1815
117	“	14-3-67	$08^0$42’N	$75^0$40’E	320	75	0855-0925
118	“	14-3-67	$08^0$46’N	$76^0$07’E	180	75	1345-1415
119	V-108	28-3-67	$09^0$16’N	$75^0$00’E	2600	70	2215-2245
120	“	29-3-67	$08^0$47’N	$74^0$01’E	2650	70	0840-0915
121	“	30-3-67	$08^0$24’N	$73^0$04’E	2200	75	0705-0735
122	“	30-3-67	$08^0$58’N	$72^0$49’E	1800	120	2045-2120

1	2	3	4		5	6	7
123	V-108	31-3-67	$09^0$57’N	$72^0$31’E	1650	117	0840-0930
124	“	31-3-67	$10^0$27’N	$72^0$20’E	2060	160	1430-1500
125	“	31-3-67	$10^0$50’N	$72^0$14’E	1000	75	2015-2045
126	“	2-4-67	$10^0$49’N	$72^0$15’E	1200	70	1945-2030
127	“	4-4-67	$10^0$27’N	$73^0$02’E	1850	75	2010-2040
128	“	5-4-67	$10^0$13’N	$74^0$03’E	2300	70	0750-0825
129	“	5-4-67	$10^0$13’N	74^o08’E	2300	300	0840-0940
130	V-109	14-4-67	$12^0$15’N	$72^0$53’E	2000	70	2115-2200
131	“	15-4-67	$11^0$40’N	$71^0$40’E	1600	100	2115-2145
132	“	16-4-67	$11^0$07’N	$72^0$21’E	1740	70	2105-2135
133	“	17-4-67	$11^0$19’N	$73^0$49’E	2080	90	2058-2133
134	“	18-4-67	$10^0$57’N	$73^0$22’E	1800	70	0420-0450
135	“	18-4-67	$10^0$00’N	$72^0$00’E	2400	105	2020-2050
136	“	18-4-67	$10^0$00’N	$72^0$02’E	2300	70	2100-2130
137	“	18-4-67	$09^0$58’N	$72^0$04’E	2100	40	2148-2218
138	“	19-4-67	$09^0$41’N	$72^0$30’E	1850	105	0910-0940
139	“	19-4-67	$10^0$22’N	$73^0$35’E	2100	105	2050-2120
140	“	19-4-67	$10^0$25’N	$73^0$33’E	2100	24	2140-2210
141	“	20-4-67	$10^0$15’N	$75^0$18’E	1200	117	2115-2140
142	“	20-4-67	10015’N	$75^0$20’E	1000	90	2200-2230
143	“	20-4-67	$10^0$15’N	$75^0$22’E	880	25	2245-2315
144	V-110	28-4-67	$15^0$15’N	$73^0$32’E	95	70	1000-1045
145	“	28-4-67	$14^0$15’N	$73^0$58’E	55	25	1500-1530
146	“	29-4-67	$13^0$21’N	$73^0$28’E	120	70	1930-2030
147	“	30-4-67	$12^0$45’N	$74^0$32’E	53	30	0715-0815
148	“	1-5-67	$12^0$12’N	$74^0$22’E	180	70	0015-0115
149	“	1-5-67	$11^0$32’N	$74^0$42’E	180	70	0730-0815
150	V-111	11-5-67	Off Colachel		183	85	1520-1550

CONCLUSIONS

1. The intensive surveys of R.V. VARUNA on the south west coast have very clearly indicated the existence of rich potential resources of certain deep sea fish species (*Chlorophthalmus, Cubiceps, Pseneopsis* etc.) and prawns (*Parapandalus spinipes, Heterocarpus gibbosus, H. wood-masoni* and others) etc. on the upper continental slope about which very little or practically no information was available hitherto, although the occurrence of the deep sea lobster *Puerulus sewelli,* the seep sea prawns *Penaeopsis rectacutus, Aristeus semidentatus,* etc., were earlier recorded from catches by R.V. CONCH and R.V. KALAVA (Kurian, 1963, 1964; Samuel, 1963 George and Vedavyasa Rao, 1966; Tholasilingam *et al.,* 1964). Some of these recent discoveries of prawns and deep sea fishes such as the rhinchimaeroid *Neoharriotta pinnata,* the squaloid sharks *Atractophorus armatus, Echinorhinus brucus* and several other fishes show the inadequacy of our knowledge about the natural distribution of these deep sea forms. The fully equipped and large vessels of the Indo-Norwegian Project viz.,M.V. KLAUS SUNNANA, M.V. VELAMEEN and M.V. TUNA have proved within a short time the feasibility of fishing on a commercial scale in the deep waters of the shelf edge and the upper continental slope. These vessels should be fully utilized for further explorations of the continental slope.

2. The existence of 'kalava' grounds was well known especially through the fairly intensive fishing of some of the grounds off Cochin by R.V. KALAVA. The importance of the present cruises lies in the fact that the surveys carried out by them have proved adequate to give an idea of the pattern of distribution of the 'kalava' grounds on the south west coast. It is for the first time that sonar has been used in our water in conjuction with echosounders with the result that a fuller knowledge of the locations and distribution of the grounds is now available.

3. Traditional fishing of surface shoals of tuna by pole and line using live bait is being rapidly replaced in the Pacific Ocean by countries such as the United States and Japan taking to purse seining with remarkable success. Purse seining for tuna tried in our oceanic waters have failed so far because of the unsuitability of the particular net for

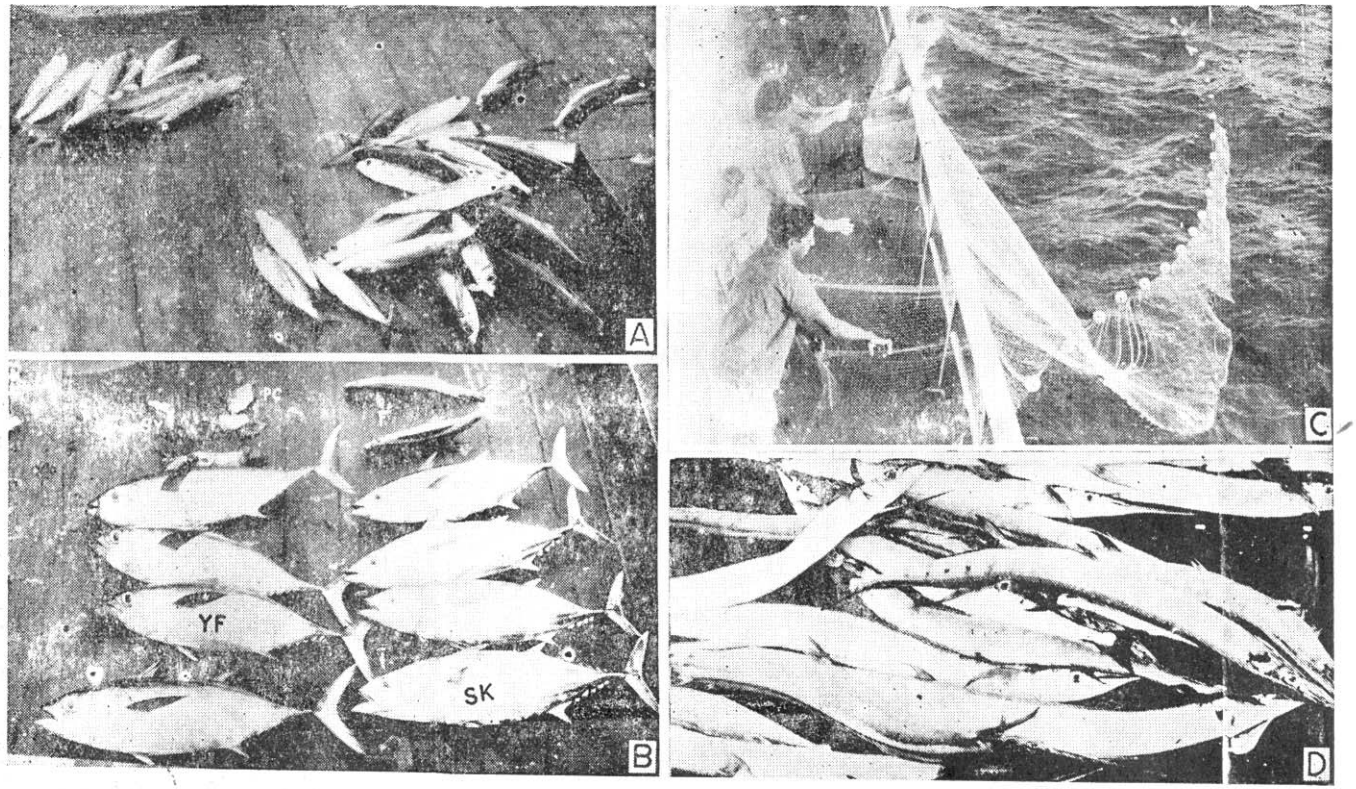


Plate X. A–D. Drift net fishing by R. V. *VARUNA*. A Flying fishes forming part of a catch; B. Tunas and otherfishes and squids from one night's fishing in the Laccadive Sea; C. Drift net being hauled in; D. Part of a catch of *Ablennes hians* caught off Karwar.
(F = Flying fish, *Cypselurus furcatus;* PC = *Psenes cyanophrys;* SK = Skipjack *Katsuwonus pelamis;* SY=Oceanic squid *Symplectoteuthis ouolaniensis*; and YF = yellowfin tuna *Thunnus albacares macropterus*.) (Photos : E. G. Silas)

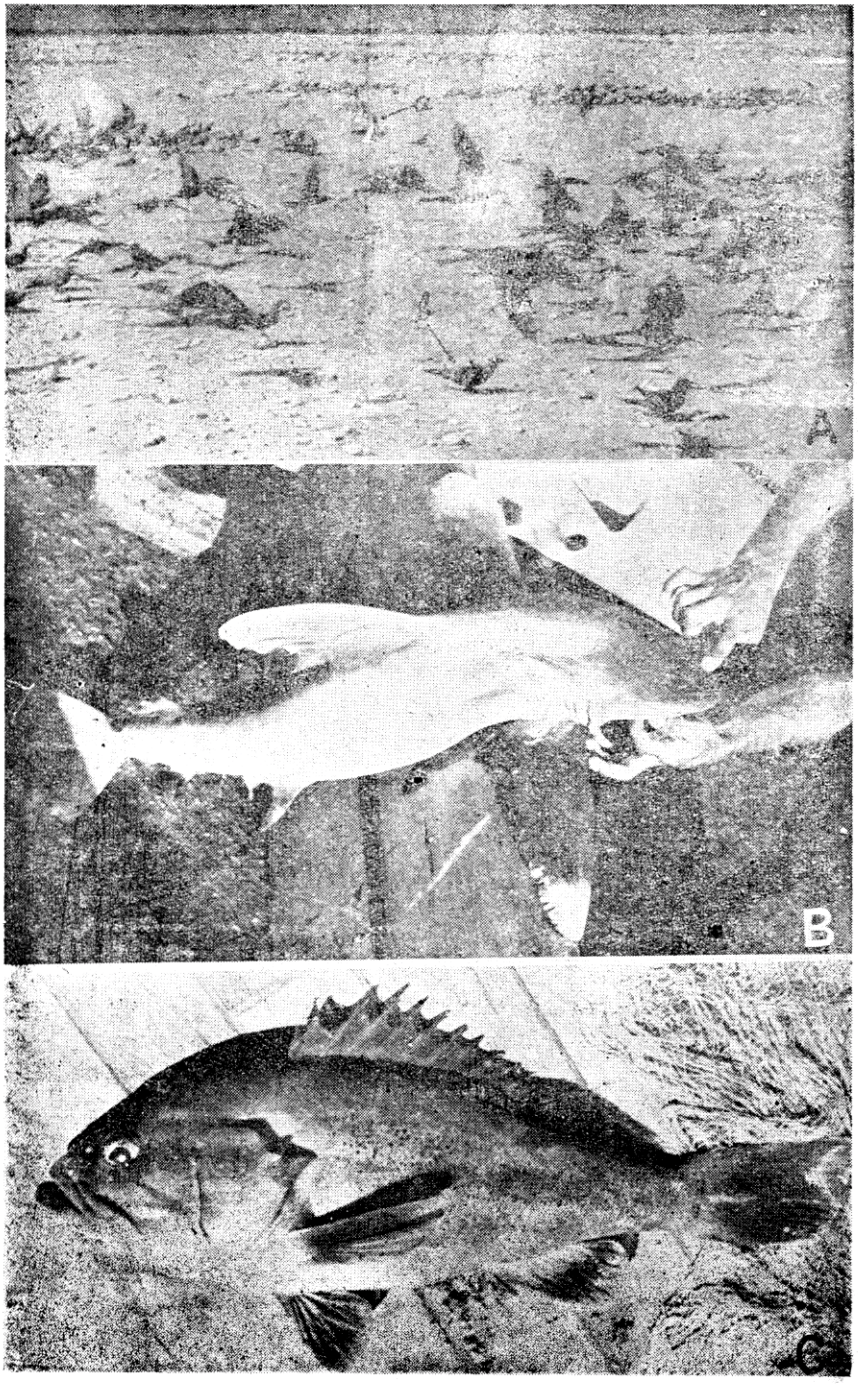


Plate XI. A. Terns on Pitti Island, Laccadive Sea – (a) Sooty tern *Sterna fuscata* and (b) Noddy tern *Anous stolidus;* B. Juvenlie oceanic white tip shark *Pterolamiops longipinnis* from drift net catch in the Laccadive Sea; C *Epinephelus* sp. A (prox. *morruka*) from 'kalava' grounds off Cochin.) (Photos : E. G. Silas)

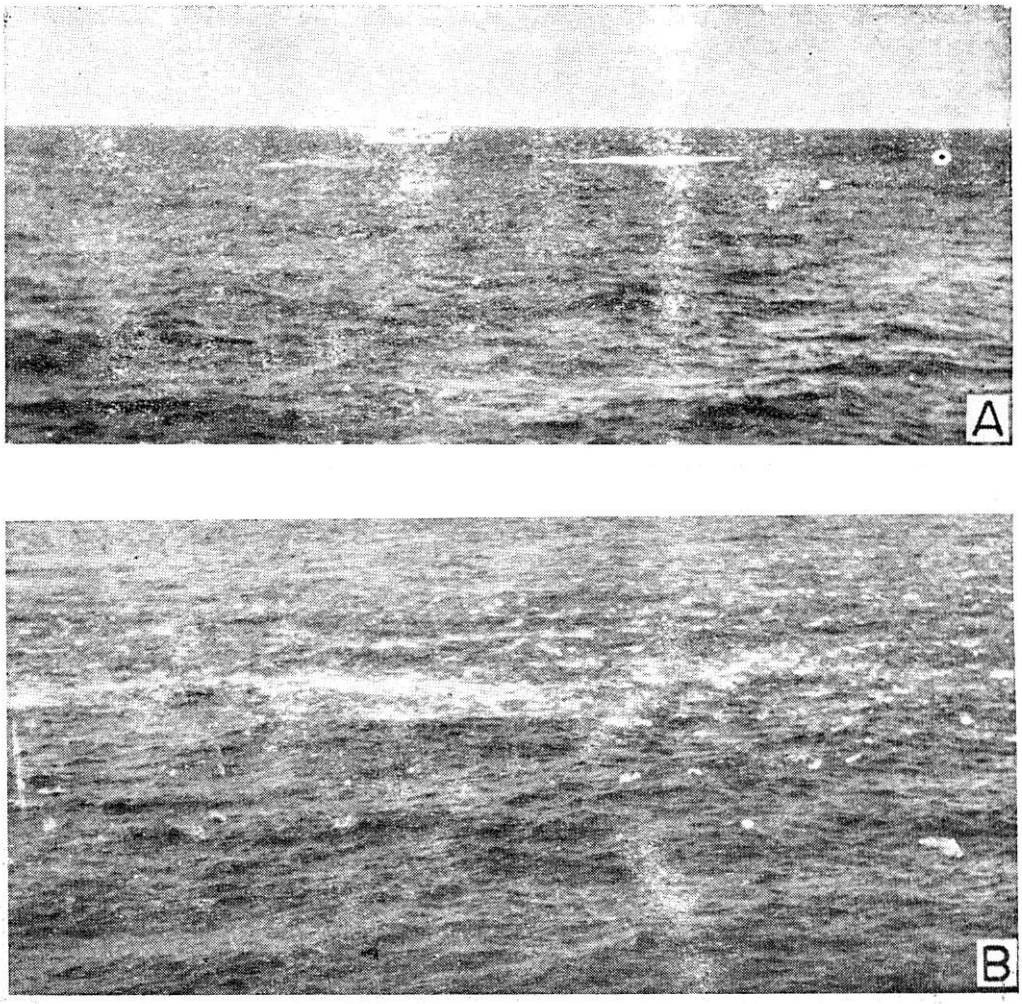
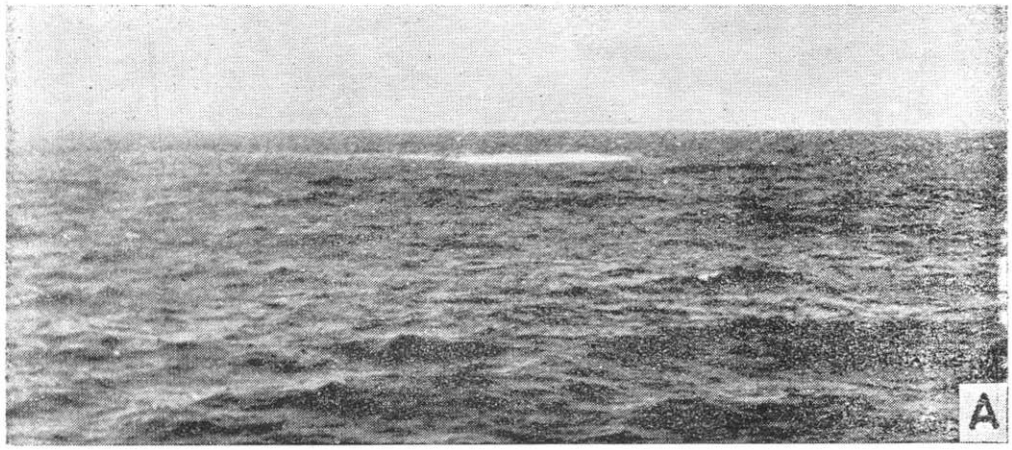


Plate XII. Purse seine fishing and tuna shoals in the Laccadive Sea. A. M.V. *TUNA* seen approaching a skipjack shoal off Pitti Is.; B. Surface agitation caused by fast-moving school of skipjack off Pitti Is.
(Photos : E. G. Silas)



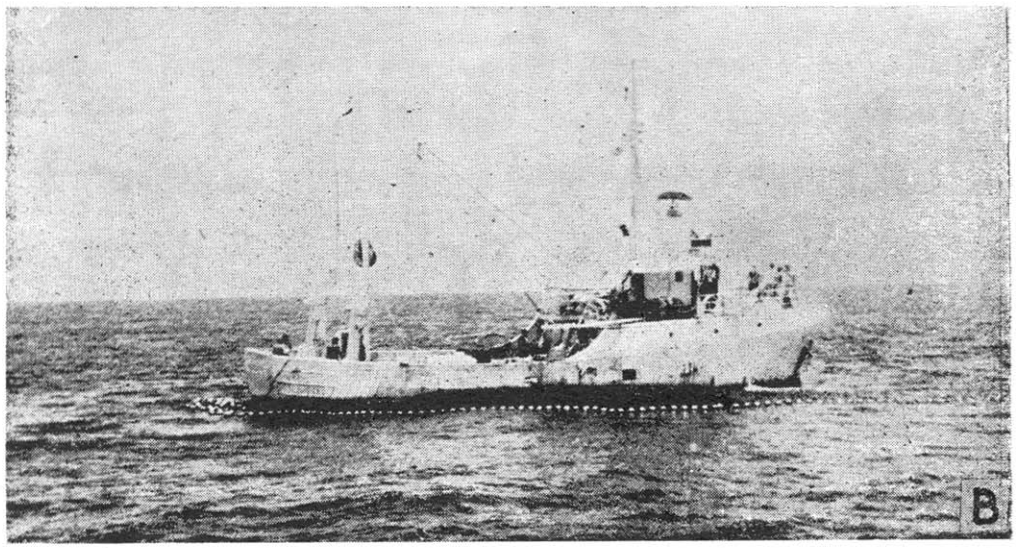


Plate XIII A. Actively moving surface school of skipjack seen as white patch; B. M. V. *TUNA* 'resting' after an unsuccessful purse seine operation off Agathi Island, Laccadive Sea. (Photos: E. G. Silas)

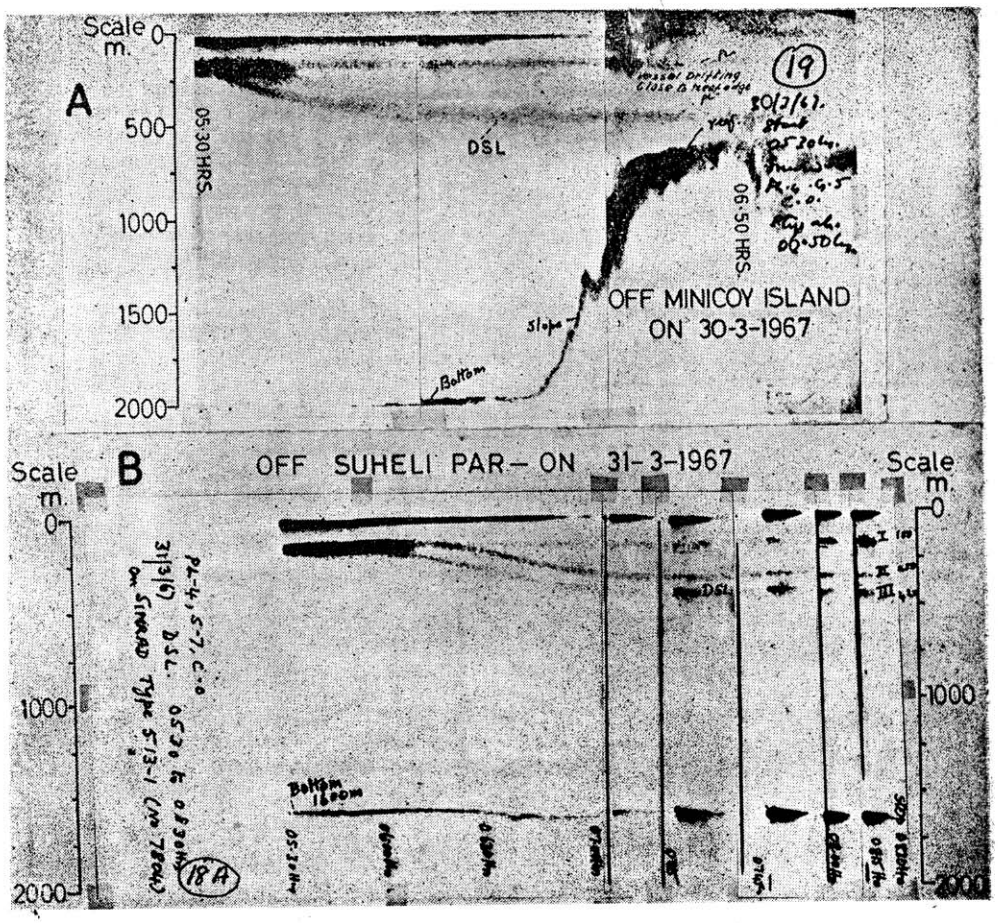


Plate XIV Deep-scattering Layer investigations: A. Precision sonic records off Minicoy Island, Laccadive Sea showing scattering organisms migrating downwards from 0530 to 0650 hours; B. Same phenomena seen off Suheli Parr, Laccadive Sea. (Details marked on figures)

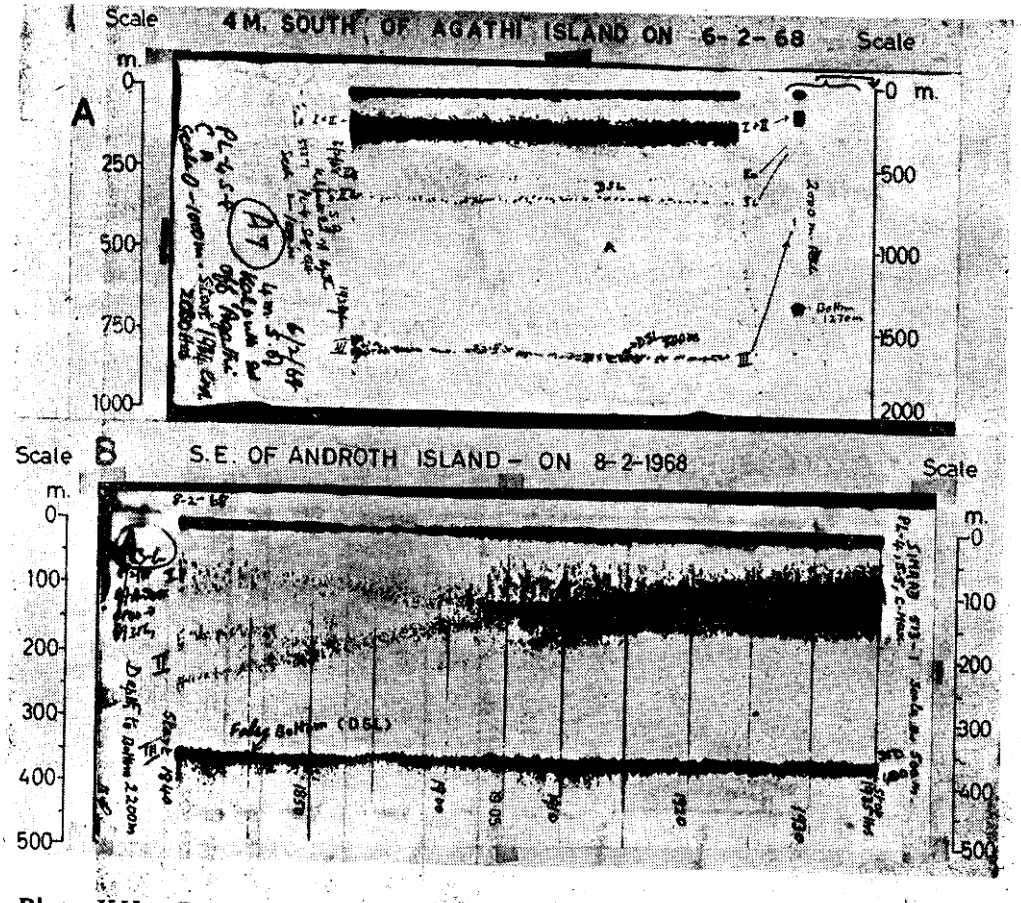


Plate XV. Deep Scattering Layer investigations: Precision sonic records showing scattering organisms migrating upward. A. 4 nautical miles south of Agathi Island between 1934 and 2030 hours; B. S. E. of Androth Island, Laccadive Sea between 1840 and 1930 hours. (Details marked on figures)

successful operation in the oceanic areas as well as the inexperience in using the gear. These being the first attempts at purse seining for tunas in our waters, the failure met with should not deter us from intensifying explorations.

4. Two significant results were obtained by drift-fishing. The frigate mackerel *Auxis thazard* and *A. rochei* were earlier reported to occur sporadically along our coast. By drift net fishing and actual observations during the research cruises it was found that both these species occur in fair abundance in our offshore and oceanic waters, a fact which was little known hitherto."Silent' surface shoals of *A. rochei* were very frequently encountered at dusk over the shelf edge.

Another finding is the abundance of oceanic squids, particularly *Symplectoteuthis oualaniensis* schools of which were invariably attracted by light to the ship's side at night and found to feed on smaller planktonic organisms and fish thus attracted. This is one of the commercially important species fished in the Pacific. There is need for collecting more information on oceanic squids and exploring the possibilities of develpiong a fishery for these.

At the same time, the introduction of monofilament nylon gill nets for tunas on the Laccadive Sea and other areas also need to be considered.

5. The vertical migration of organisms causing sonic scattering has been regularly observed during the cruises of R.V. VARUNA. Tuna occurring in depths may also be detectable by the echo sounder. Very characterstic spire-like echo traces have been recorded from the Deep Scattering Layer between 300 and 450 metres as well as in the subsurface scattering layer generally between 50 and 150 metres during day time. There is a good amount of indirect evidence from the catch composition of Isaacs-Kidd midwater trawl operated in the Deep Scattering Layers, as well as from the information available on the food of oceanic tunas to presume that such spire-like echo traces could possibly represent tunas, especially the larger species such as yellowfin and bigeye tunas or perhaps also billfishes. These investigations need to be intensified in order to understand more about the habits of tunas and billfishes to enable use of suitable gear at proper depths for fishing them.

6. A number of devices are used for detecting and following pelagic fish shoals, the recent innovations being the sonar, and aerial survey by spotter planes and helicopters. However, visual scouting is still relied on by skippers of pole-and-line fishing boats and purse-seiners and in this connection very useful indicators of shoals and their habits are oceanic birds. During the present cruises, positions of surface and even subsurface tuna sholes have been very easily detected at a distance of several miles in the Laccadive Sea by observing the movements and behaviour of bird flocks. Chiefly the sooty tern *Sterna fuscata* and the noddy tern *Anous stolidus,* both known to breed on Pitti Island and Cherbaniani Island in the Laccadives. These birds indirectly help the skippers to avoid unnecessary scouting, thus saving on ship's fuel and time. More attention should be given to the study of the living habits of these birds which breed on some of the uninhabited islands.

7. Foreign vessels have been sighted fishing off our coasts and from the Laccadive Sea, which also indicates the richness of our waters (Figure, 22). In conclusion it may be stated that the indications of the possible existence of very rich fish and prawn resources in the deep water grounds and the continental slope are so strong and the need for stepping up food production to meet the food shortage so imminent that we cannot afford to neglect any longer the urgent need to explore these resources adequarely and exploit them in a satisfactory manner.

REFERENCECS

Anonymous, 1931. A systematic survey of the Madras Deep-sea fishing grounds by S.T."Lady Goschen" 1927-28. Rept. No.3 of 1929: *Madras Fish. Bull.,* No. 23: 153-187.

Anonymous, 1962. Report on a systematic survey of the Madras Deep-Sea fishing grounds by S.T. "Lady Goschen" 1930. *Ibid*., No. 28: 27-95.

Chidambaram, K. 1953. The experimental introduction of powered fishing vessels within India and Ceylon. *Proc. Indo-Pacific. Fish. Coun.,* (ivth meeting, 1952), Sect. 2: 225-233.

George, M.J. and P. Vedavyasa Rao 1966. On some decapod crustaceans from the south west coast of India. *Proc. Symposium on Crustacea,* Part I: 327-346.

Gopinath, K. 1954. Anote on some deep sea fishing experiments off the south western coast of India. *Indian J. Fish.,* 1 (1&2): 163-216.

Hefford, C.F. 1949. Report on the work of "William Carrick". Govt. Press, Bombay.

Hornell, J. 1916. Notes on two exploring cruises in search of trawl grounds off the Indian and Ceylon coasts. *Madras Fish. Bull.,* No.14: 33-70.

John,C.C. 1948. *Progress Report of the Fisheries Development Schemes Central Research Institute, Travancore University Division of Marine Biology and Fisheries,* 1-8.

John, V., P.I. Chacko, R. Venkataraman and A.T. Sherif 1959. Report of fishing experiments in the offshore waters of the Madras State *Fish. Stn. Repts & Year Book,* Dept. Fisheries Govt. of Madras, 106-138.

Jones, S. and M. Kumaran 1959. The fishing industry at Minicoy Island with special reference to the tuna fishery. *Indian J. Fish.,* **6**(1): 30-57.

Jones, S. and E.G. Silas 1964. A systematic review of the scombroid fishes of India. *Symposium on Scombroid Fishes,* MandapamCamp, pt. 1: 1-105.

Kurian, C.V. 1963. Further observations on the deep water lobster *Peurulus sewelli* Ramadan off Kerala Coast. *Bull. Dept. Mar. Biol. Oceanogr. Univ. Kerala,* **1**: 122-127.

Kurian, C.V. 1964. On the occurrence of deep-water prawn *Penaeopsis rectacutus* (Spence Bate) off Kerala coast. *Curr. Sci.,* **33** (7): 216-217.

Kurian, C.V. 1965. Deep water prawns and lobsters off the Keralas Coast. *Fish. Tech.,* **2** (1): 51-53.

Menon, M.D. and K.M. Joseph 1969. Development of kalava (Rock Cod) fishery off south west coast of India-A prospectus. *Seafood Export Journl,* **1** (2): 7-28.

Myrland, Per 1962. Research Vessel VARUNA. *J. mar. Biol. Ass. India,* **4** (2): 224-225.
Rao, K. Virabhadra 1969. Distribution pattern of the major exploited marine fishery resources of India. *Bull. cent. mar. Fish. Res. Inst.,* No.6: 1-69.

Raj, B.S. 1933. Report on a systematic survey of Deep Sea fishing grounds by S.T. "Lady Goschen" for 1928-29. Rept. No.3 of 130: *Madras Fish. Bull.,* No.24: 199-232.

Samuel, C.T. 1963. Bottom fishes collected by R.V. Conch off Kerala Coast. *Bull. Dept. Mar. biol. Oceanogr. Univ. Kerala,*1: 97-121.

Silas, E.G. 1967. Tuna fishery of the Tinnevelly Coast, Gulf of Mannar. *Proc. Symposium on Scombroid Fishes,* Mandapam Camp, pt. 3: 1083-1118.

Silas, E.G. 1968. Cephalopoda of the west coast of India collected during the cruises of the Research Vessel *VARUNA,* with a catalogue of the species known from the indian ocean. *Proc. Symposium on Mollusca,* Pt. 1:27-361.

Silas, E.G. and K.J. Mathew 1967. *Stylocheiron indicus,* a new euphausiid (Crustacea: Euphausiacea) from Indian Seas. *Curr. Sci.,* **36** (7): 196-172.

Silas, E.G. and K.J. Mathew (MS). Euphausiacea of the South Eastern Arabian Sea and the Laccadive Sea from the deepwater plankton and Isaacs-Kidd Midwater Trawl collections made during the cruise of R.V. *VARUNA.*

Silas, E.G. and M.S. Rajagopalan 1967. The sailfish and marlins of the Tuticorin coast. *Proc. Symposium on Scombroid fishes,* Mandapam Camp, pt. 3: 1119-1131.

Silas, E.G., D. Sadananda Rao and C.P. Ramamirtham 1968. Potential demersal fisheries of the upper continental slope and the shelf edge in relation to the hydrological features. *Symposium on the Living Resources of the Seas around India,* CMFRI, Mandapam Camp, Dec. 1968, Abstract, p. 15 (Under publication).

Silas, E.G., G.S.D. Selvaraj and A. Regunathan 1969. Rare chimaeroid and elasmobranch fishes from the continental slope off the west coast of India. *Curr. Sci.,* **38**(5): 105-106.

Silas, E.G. and P.A. Thomas (MS). Maturation, fecundity and spawning of tunas of the south eastern Arabian Sea and the Laccadive Sea.

Sorley, H.T. 1948. The Marine Fisheries of the Bombay Presidency. pp. 1-174.

Tholasilingam, T., G. Venkataraman and K.N. Krishna Kartha 1964. On some bathypelagic fishes taken from the continental slope of the south west coast of India. *J.mar.biol.Ass. India,* **6**(2): 268-284.

Watson, G.E. R.L. Zusi and R.E. Storer 1963. *Preliminary field guide to the birds of the Indian Ocean.* Smithsonian Institution, Washington, pp. i-x, 1-214.