STUDIES ON THE DISTRIBUTION AND ABUNDANCE OF FISH EGGS AND LARVAE OFF THE SOUTH-WEST COAST OF INDIA WITH SPECIAL REFERENCE TO SCOMBROIDS

By

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Thesis submitted to the University of Cochin
in partial fulfilment of the requirements
for the degree of Doctor of Philosophy

October 1979

CERTIFICATE

This is to certify that this thesis is an authentic record of the work carried out by Mr.K.C.George, under my supervision at the UNDP/FAO Pelagic Fishery Project, Cochin, and that no part thereof has been presented before for any other degree in any University.

Ernakulam, October, 1979

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1. INTRODUCTION

1.1 Eggs and larval studies of marine fishes in Indian waters

Studies on the natural history of marine fishes in India were pioneered by the erstwhile Madras Presidency Fisheries Department (Hornell, 1910, 1922, Nayudu, 1922, Hornell and Nayudu, 1924). Several contributions to the knowledge of eggs and larvae of different commercial fishes were also made by the above Department in later years (John, 1939, Devanesan and John, 1940, 1941, Devanesan and Varadarajan 1942, Devanesan, 1943, Devanesan and Chacko, 1944, Chidambaram, 1943, Chidambaram and Venkataraman, 1946, Jacob, 1949, Chacko, 1950 a, b, 1954, Chacko and Mathew, 1955, Chacko and Gnanamokhalai, 1963).

Maritime Universities like Madras, Bombay and Travancore (erstwhile) and the Institutes under them also contributed to the studies on fish eggs and larval taxonomy (Aiyar 1935, Jones, 1937, Panikkar and Aiyar, 1939, Panikkar and Nair, 1945, Nair, 1952 b, c, John, 1951, Vijayaraghavan, 1957, 1959, Kuthalingam, 1957, 1958, 1959, a, b, 1960, 1961 a, b, Bal and Pradhan, 1945, 1946, 1947, 1951, Menon, 1945 and Gopinath, 1942, 1946, 1950).

Recent studies at the Department of Marine Sciences, (University of Kerala, Cochin) have resulted in a number of contributions on the fish eggs and larvae of the south-west coast of India (Balakrishnan, 1959, 1961, 1963, 1969, 1971, Balakrishnan and Devi, 1974, Dileep, 1977, Premalatha, 1977, Sreekumari, 1977). Likewise, Andhra and Annamalai Universities also took up similar studies on the east coast (Ganapathi and Raju, 1961 a, b, 1963, Ganapathi and Rao, 1962, Dutt 1966, Rao, 1963, Raju and Ganapathi, 1969, Balasubrahmanyam, 1973, Balasubrahmanyam et al. 1969, Venkataramanujam and Ramamurthi 1974, 1977).

With the establishment of the Central Marine Fisheries and the Central Inland Fisheries Research Institute in 1947, studies on eggs and larvae were taken up as a regular programmes resulting in a number of publications (Jones and Menon 1950 a & b, 1951, 1952, 1953, Pantalu and Jones, 1951, Jones and Pantalu, 1958, Jones, 1958-1967, Jones and Kumaran, 1963, 1964 a, b, Sarojini and Malhotra, 1952, Karamchandani and Motwani, 1952, Balakrishnan, 1957, Kuthalingam, 1960, Bapat and Prasad, 1952, Bapat, 1955, Nair, 1948, 1952 a, 1959, 1961, Nair and Mohammed 1961 a, b, Rao, 1964, Subrahmanyam 1964, 1968, Chandra, 1964, James, 1967, Kotwal, 1967, Balakrishnan and Rao, 1971, Bensam, 1968 a, b, 1969, 1971 a, b, 1973, Gupta, 1972, Achari and Vincent, 1972, Vijayaraghavan, 1973, Girijavallabhan and Gnanamuthu, 1974, Silas and George 1971, Silas, 1974). Eggs, larvae and juveniles of several species like Sardinella longiceps, S. fimbriata, S. gibbosa, Kowala coval, Rastrelliger kanagurta, Scomberomorus spp., Auxis sp., Katsuwonus pelamis, Thunnus albacares, Euthynnus affinis, Xiphias gladius, Istiophorus gladius, Caranx kalla, Gempylus serpens, Stolephorus spp., Myripristis murdjan, Holocentrus sp., Dactyloptena orientalis and the eels have been the subject of studies by the above authors. While these efforts have been localised and generally taxonomy oriented they have resulted in a number of contributions on the life-history and spawning of several commercial species.

Delsman (1922 - '38) in his series of publications on the fish eggs and larvae from the Java sea, contributed a wealth of information on the taxonomy of eggs and larvae of a number of species relevant also to the Indian fish fauna. A concerted effort to collect marine ichthyoplankton from a wider area, particularly off the west coast of India using ocean going research vessels was made since late fifties by the Central Marine Fisheries Research Institute, in collaboration with the erstwhile Indo-Norwegian Project using the research vessels 'Kalava' and 'Varuna' (Jones 1967 a). This has led to the collection of several eggs and larval samples from the shelf waters of the SW coast and the Laccadives archipelago. These materials have been used by and large for qualitative studies and also to indicate the spawning grounds, mainly of tunas, (Jones, 1958 - 1967). Jones and Kumaran (1963, 1964 a) based on Dana Expedition (1928 - 30) material from the Indian ocean gave an account of the distribution of tuna and billfish larvae in the area. Available information on eggs, larvae and juveniles of Indian scombroid fishes have also been compiled by these authors (Jones and Kumaran, 1964 b).

1.2 Quantitative approach to eggs and larval studies

Advanced methods of sampling ichthyoplankton for quantitative studies, eliminating to a great extent, possible errors and better treatment of data have enabled meaningful interpretation of the data for the assessment of stock abundance and prediction of year-class strength.

Of the early quantitative works on the eggs and larvae of marine fishes, the works on the Pacific sardine (*Sardinops caerulea*) initiated in the thirtees deserve special mention (Scofield, 1934 , Sette and Ahlstrom, 1941, Ahlstrom, 1948, 1952, 1954, 1959 a, b). Marak and Colton (1961), Marak *et al* (1962 a, b) and Ahlstrom (1971, 1972) reported on several eggs and larval surveys conducted annually, under the auspices of the U.S. Department of Fish and Wild life Service. Boonprakob (1962) published the results of fish eggs survey in the Gulf of Thailand. In Indian waters, Bal and Pradhan (1945, 1946, 1947) and Panikkar and Nair (1945) reported on the results of investigations on egg and larval collections in Bombay and Madras waters.

During the International Indian Ocean Expedition (IIOE - 1960 - '65) collections of Ichthyoplankton from a wide area of the Indian ocean were made by participating ships with the Indian Ocean Standard Net and used for quantitative studies. These have resulted in the publication of some general accounts of fish eggs and larvae and their distribution in the Indian ocean, (Ahlstrom, 1968, Peter, 1969 a, b, 1974, 1977, Panikkar and Rao, 1973, Shomura, 1970) as well an Atlas on fish eggs and larvae distribution (Panikkar, 1973 ed.).

The IIOE collections have been made on the whole from widely separated stations of the open ocean and shelf water coverage has been rather limited. However, Nellen (1973) made a detailed study on the kinds and abundance of the fish larvae from the cruise of R.V.Meteor in the Arabian Sea and Persian Gulf during 1964 - '65, when some sections covering the shelf waters of the SW coast of India were also worked.

Another recent contribution with a quantitative approach, from areas adjacent to Indian coasts is of Alikhan (1972), who studied the distribution and abundance of fish larvae in the Gulf of Aden and off the coast of west Pakistan based on material collected during 1964 - '67 period, in 9 different cruises.

Silas (1974) described in detail the different larval stages of Indian mackerel and mapped their distribution and abundance off the SW coast of India and the Laccadives sea, based on material from cruises of R.V.Varuna in May '64.

1.3 The utility of eggs and larval studies - objectives of the present study

Several studies of fish eggs and larvae all over the world have contributed to our knowledge of the life-histories of many commercially important species. Apart from this, the fishery oriented objectives of ichthyoplankton studies considered to be of particular value include determination of the spawning areas and seasons, based on distribution of eggs and larvae and forecasting of the year class strength on the basis of the abundance of late larvae. As a fishery independent method, eggs and larval surveys are considered to be reliable for estimating fish stock abundance, in conjunction with other methods of resources evaluation. Several other informat-ion like estimates of biomass of spawning fish population and their fluctuation, ecological conditions and spawning can be derived from such surveys.

The broad objective of the present study was to present a synoptic picture of the distribution and abundance of fish eggs and the important groups of fish larvae obtained off the SW coast of India, so as to delineate the spawning areas and seasons of the fish population, with special reference to the scombroid fishes. An attempt was also made to correlate the occurrence of certain categories of larvae and hydrographical factors like temperature and salinity.

The present effort was a pioneering one in Indian waters, in as much as it involved systematic and seasonally repetitive collection of ichthyoplankton from a large stretch of our seas and mapping of their distribution and abundance.

2. MATERIAL AND METHODS

2.1 The material and its collection

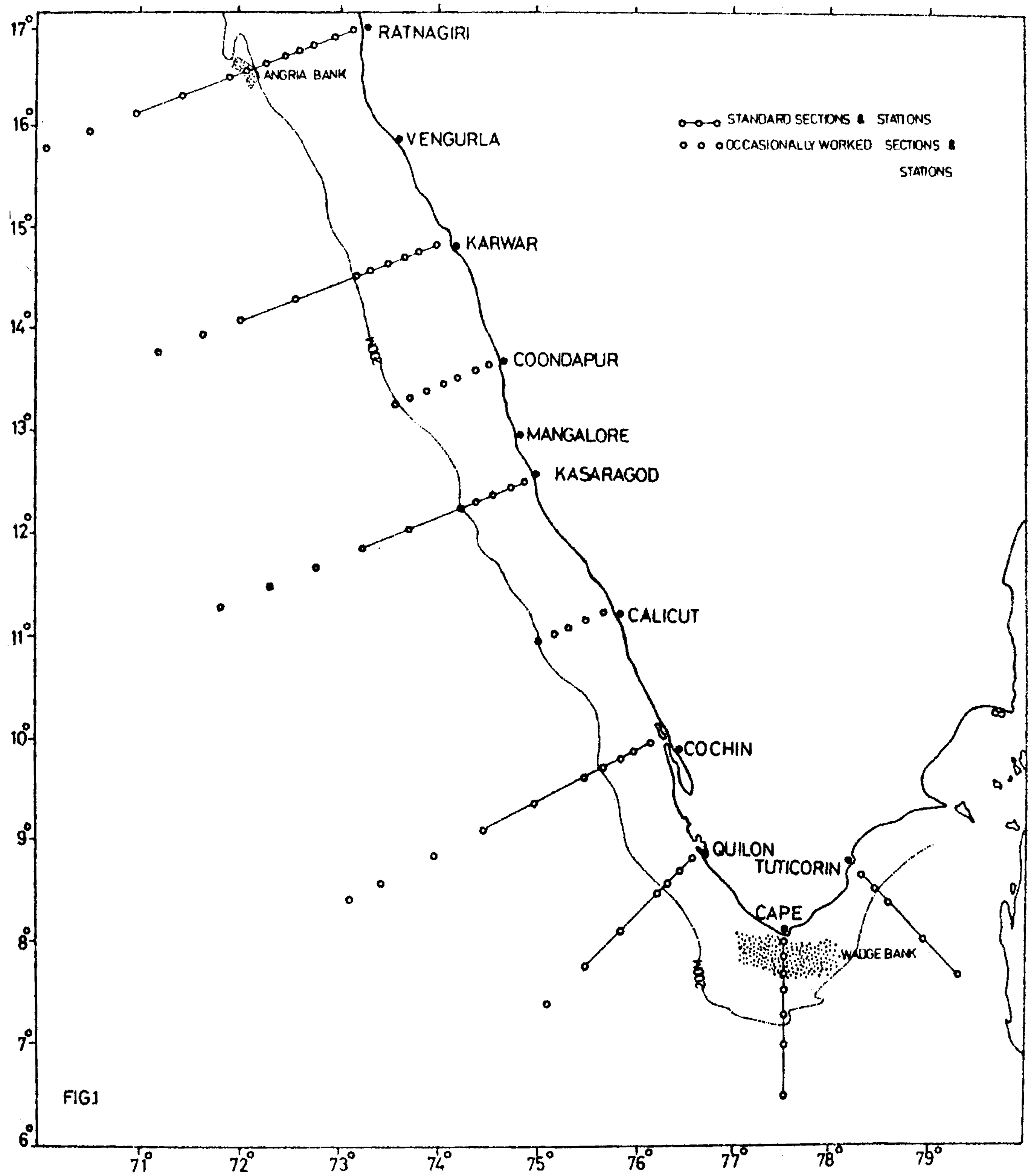
The material dealt with in the present study is part of the ichthyoplankton collections of the UNDP/FAO Pelagic Fishery Project, from the Project area extending from Ratnagiri on the west coast of India (17°N.) to Tuticorin (8°48' N.) on the east coast (Fig. 1) and relates to the period from September 1971 to December 1975. The Project worked 1318 standard stations using Bongo net during the period and collected 2613 samples, almost all duplicate, except a few collected under emergencies with single cone nets (Table - 1).

The Plankton collections were made during the regular acoustic survey cruises of the Project vessels by sampling at fixed stations along sections off the coast, in the Project area. Seven sections, namely Ratnagiri, Karwar, Kasaragod, Cochin, Quilon, Cape Comorin and Tuticorin are considered as standard sections in the present study, while data from few others like Vengurla, Coondapur and Calicut, covered only occasionally have also been included in the studies.

From September 1971 to February 1972 only 4 sections namely, Karwar, Kasaragod, Cochin and Quilon were worked. Each section was occupied at an interval of 4 - 6 weeks.

Fig.1

MAP OF THE AREA SURVEYED - SW COAST OF INDIA AND CONTIGUOUS WATERS UPTO TUTICORIN ON THE SE COAST



RATNAGIRI
ANGRIA BANK
VENGURLA
KARWAR
COONDAPUR
MANGALORE
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
WADGE BANK
200M
STANDARD SECTIONS & STATIONS
OCCASIONALLY WORKED SECTIONS & STATIONS
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
71°
72°
73°
74°
75°
76°
77°
78°
79°

FIG 1

Table - 1

Details of the standard (Bongo net) plankton stations and samples collected (Sept. 1971 to Dec. 1975).

Year/ vessel	No.of stations	No.of samples		Total
		Bongo-20	Bongo-60	
1971. Sept-Dec. 'SARDINELLA'	48	96	-	96
1972 'SARDINELLA' and 'VARUNA'	278	438	114	552
1973 'RASTRELLIGER'	377	502	245	747*
1974 'RASTRELLIGER'	344	668	8	676*
1975 'RASTRELLIGER'	271	542	-	542
	1318	2246	367	2613

*Includes few 'single cone net' samples.

The extent of coverage of the sections are presented in Table - 2. The Cochin section is the most covered with 243 stations worked, followed by Ratnagiri, Karwar, Kasaragod, Quilon, Cape Comorin and Tuticorin in that order.

Along each section upto 10 stations were worked. Stations were 10 miles apart on the continental shelf, and 15 or 30 miles apart beyond the shelf. 68% of all stations worked were on the continental shelf. Distribution of the standard stations on the shelf and oceanic region on the basis of sounding depths are presented in Table -3. While material from the standard stations only have been considered for density mapping, those from 91 'special stations' worked on the shelf, between the sections have also been included for computing occurrence indices of certain categories of larvae and correlation with hydrographical factors (The special stations were worked with a single cone net (ring dia. 60 cm) without flow meter).

2.2 Vessels, gear and sampling

In 1971 and 1972 two vessels, R.V.*Sardinella* (Length 16.34 m, (54'), 153, HP) and R.V.*Varuna* (Length 28 m, (91'), 400, HP) were used by the Project for the cruises. From 1973 a larger vessel R.V.*Rastrelliger*

Monthly distribution of the standard plankton stations in different sections (Sept. 1971 - Dec. 1975)

Months/ sections	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Ratnagiri	10	22	19	29	21	18	-	38	10	9	20	20	216
Vengurla	-	5	-	-	-	-	-	-	-	-	-	-	5
Karwar	12	15	30	22	7	16	14	26	9	21	21	14	207
Coondapur	-	7	7	-	-	-	-	-	-	-	-	-	14
Kasaragod	11	15	29	13	11	17	12	25	16	7	18	13	187
Calicut	5	-	-	11	-	10	11	6	6	-	6	-	55
Cochin	22	17	21	25	25	6	25	19	24	23	28	19	254
Quilon	7	16	25	10	15	6	14	12	11	13	19	10	158
Cape Comorin	8	15	18	8	15	13	10	13	-	16	16	8	140
Tuticorin	5	5	14	5	9	5	7	9	-	9	10	4	82
	80	117	163	123	103	91	93	148	76	98	138	88	1318

Table - 3

Distribution of the standard plankton stations on the shelf and oceanic waters according to sounding depths

Depth range (m)	1971	1972	1973	1974	1975	Total
11 - 20	11	50	44	49	40	194
21 - 30	1	6	15	9	8	39
31 - 40	7	27	21	23	19	97
41 - 50	4	24	22	20	15	85
51 - 75	9	58	67	58	37	229
76 - 100	4	26	33	30	23	116
101 - 150	4	30	22	27	21	104
151 - 200	1	7	9	11	7	35
201 +	7	50	144	117	101	419
	48	278	377	344	271	1318

(46.5 m, (152'), 1320 HP) was used.

The Bongo 20 net (Hydrobios type, ring diameter 20 cm) with calibrated flow meter was the principal gear used. The net assembly consists of a pair of net cones of 20 cm ring diameter, connected by a yoke. The yoke bar with the nets can swing in a sleeve connected to the wire rope and take a horizontal position in tow. A heavy (20 kg) hydrodynamically shaped cast metal depressor, shackled to the sleeve helps to keep the equilibrium of the net during the tow. The 90 cm long pair of cones (including 17 cm of canvas collar at the end) of the net are of nylon material of 0.5 mm square mesh. One advantage of this net is that there is no obstruction to water flow into the cones, as there are no bridles connected to the rings for towing the net. The flow meter of the net was centrally mounted at the mouth of one of the cones. The relatively large mesh of the nets normally allowed only the zooplankton to be retained and as such reference to plankton here means zooplankton. A special plastic collared Bongo 20 net (BCF Bongo) with 1.58 m long paired net cones with a TSK flow meter, as well as a Bongo 60 (ring diameter 60 cm, cone length 250 cm) with a 'Hydrobios' digital flow meter were also used for part of the collections. The mesh size of all the nets were 0.5 mm square.

PHOTOGRAPH OF THE BONGO - 20 PLANKTON NET ('HYDROBIOS' TYF
THE PRINCIPAL GEAR EMPLOYED IN THE PRESENT SURVEY. BONGO
NET TOWED AT SLOW SPEEDS IS RECOMMENDED AS THE BEST TYPE
OF SIMPLE GEAR FOR ICHTHYOPLANKTON SURVEYS (SMITH AND
RICHARDSON, 1977)

Since all the nets had periodically calibrated flow meters, the volume of water filtered could be computed for standardisation of the number of eggs and larvae in the collections.

The plankton tows were of the continuous oblique type, made while the ship cruised at a speed of 2 - 3 knots. The pay out and recovery speed of the net was about 20 m per minute. The standard length of wire paid out to reach the depth of tow, compensating for the angle of stray, was 7 m for 5 m depth. This was arrived at after trial measurements of the wire angle under the operating conditions.

At shallow stations the tows were made from near the bottom, after allowing a safe clearance, 10 m being usually the collection depth at the first shore station of each section. During the early part of the work (1971 and 1972) the maximum collection depth was limited to 25 or 50 m but later a standard maximum depth of 100 m was adopted which was increased to 150 m occasionally, to reach deeper thermoclines.

2.3 Treatment of the samples and preliminary analysis

The plankton samples were preserved immediately after collection in 4% formaldehyde solution in sea water.

Wet volumes* of the plankton filtered through a fine gauze and drained on blotting paper were determined by the simple displacement method using a measuring jar containing known volume of the same concentration of preservative-formaldehyde solution.

This method was later improved by using an automatic burette and calibrated 50 ml perspex filtering cylinder which filtered and retained the material. After fixing the filtering cylinder with the filtered material to a rubber washer mounted base, thus making it water tight, the preservative was added from the burette to make up the volume to 50 ml, the capacity of the filtering cylinder. The volume of the filtrate containing cylinder (50 ml) minus the amount of preservative added to fill the cylinder to its calibrated 50 ml level mark gave the volume of the plankton material. This method enabled the volume estimations to be made quicker and relatively more accurately and with less handling of the plankton material. Organisms greater than 2 cm in their longest dimension were excluded during volume determination.

The mean volume from the two cones of the net was the unit considered for biomass calculation. The plankton biomass (ml/m^3 of water filtered) was computed for each station based on the flow meter readings and the cali-

*Volume estimations and general sorting of Icthyoplankton were partly carried out at the National Institute of Oceanography Centre, Cochin.

bration factor and this was taken as the index of abundance of plankton in the different sections at the time of observation.

All the fish eggs and larvae were sorted out of the whole sample. For purposes of standardising the densities of larvae an index of their numbers occurring below one square metre of the surface was computed based on the formula, $\frac{N \times D}{V}$ * where N is the actual number of egg/larvae at the station, V the volume of water filtered in m^3 and D, the depth of the tow (Dragesund, 1970). The eggs were dealt with on an unclassified basis except those of the oil sardine, when observed in significant numbers.

The larvae of major families like Clupeidae, Scombridae, Carangidae, Myctophidae, Gonostomatidae, Synodontidae, Bregmacerotidae and the flat fishes formed the bulk of the easily identifiable material were initially sorted out from the samples and the residual groups preserved without further qualitative studies. Among clupeidae, the larvae of sardines (*Sardinella* spp.) and white-baits (*Stolephorus* spp.) and among Scombridae the mackerel and tunas have been further sorted out for detailed studies.

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* In the present case N is the mean No. caught in the two net cones of the Bongo Net.

For sorting and general classification of larval material, the descriptions and illustrations of Delsman (1922 - 1938), John (1951), Jones (1958 - 1965), Matsumoto (1958, 1959 & 1962), Matsumoto *et al* (1972), Matsui (1970), Nair (1952), Nellen (1973), Peter (1969 a), Vatanachai (1974) and Silas (1974) have been particularly consulted, along with several other literature cited in the reference list.

3. SURVEY AREA AND ITS FEATURES

3.1 The geographical extent and the topography of the shelf

The geographical area covered in the present studies include the SW coast of India, from Ratnagiri (17°N.) to Tuticorin (08°48'N.) on the SE coast. Approximately 1350 km of the coasts of Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu are encompassed (Fig. 1). Seawards, the survey covered the continental shelf and a further distance of about 60 miles on an average from the shelf edge along the standard sections.

The continental shelf of the SW coast of India is narrow in the south and relatively wide in the north. Off Ratnagiri, the 200 metre depth line is about 80 nautical miles from the coast, whereas off Quilon it is only about 30 miles. The well known Wadge Bank, off Cape Comorin, the Quilon Bank, south west of Quilon and the Angria Bank, off Ratnagiri are some of the shallow offshore patches in the area.

The sea bottom is, by and large hard or rocky, south Quilon, whereas north of this the inshore belt is generally having a sandy and muddy bottom with a chain of rocky out-growths in deeper waters around 100 m depth in these areas. Some rocky stretches of shore line are seen north of Calicut and off Ratnagiri.

3.2 Fishes and Fisheries of the area

Before dealing with the eggs and larvae it is felt appropriate to give briefly the background information on the fishes and fisheries of the area. The SW coast of India is known for the major pelagic fisheries of India, sustained by the oil sardine, *Sardinella longiceps* and the Indian mackerel, *Rastrelliger kanagurta*. The lesser sardines mainly *Sardinella fimbriata* and *S. albella* also contribute to significant fisheries in the north and south sectors of the area. The anchovies (*Thrissa* spp.), white-baits (*Stolephorus* spp.), the cat-fishes (*Tachysurus* spp.) the horse-mackerel (*Megalaspis cordyla*) the scads (*Decapterus* spp.) and the ribbon-fishes (*Trichiurus* spp.) are the other major resources of shoaling species. The frigate mackerels (*Auxis thazard* and *A. rochei*), the oriental bonito (*Sarda orientalis*) and little tuna (*Euthynnus affinis*) are the other coastal scombroids occurring seasonally in small or medium sized schools. The skipjack (*Katsuwonus pelamis*) occurs in the Laccadives sea in significant quantities. The northern bluefin

(*Thunnus tonggol*) are caught along the west coast as well as the SE coast. Larger tunas like the yellowfin (*Thunnus albacares*) and the marlins, (*Makaira* sp.) and sailfish, (*Istiophorus gladius*) form a small percentage of the catch in the Laccadives. The seerfishes (*Scomberomorus* spp.) and the pomfrets (*Stromateus* spp.) are also common in the area. The anchovies *Spratelloides gracilis* and *S.delicatlus* are found in the Laccadives sea.

Several small carangids other than horse-mackerel and scads occur in the area, important among them being the golden scad (*Caranx kalla*), found in shallow waters, along with silver bellies (*Leiognathus* and *Gazza* spp.), whitebaits (*Stolephorus* spp.), glass-perches (*Ambassis* spp.) and miscellaneous shallow water species.

Among the major demersal fishes may be mentioned the malabar sole (*Cynoglossus semifasciatus*), the threadfin bream (*Nemipterus japonicus*), the sciaenids (*Pseudosciaena* spp. and *Otolithus* spp.). The big jawed jumper (*Lactarius lactarius*), flat-heads (*Platycephalus* spp.) and the lizard fishes (*Saurida* spp. and *Saurus* spp.)

On the outer shelf, several demersal, meso-pelagic and bathy-pelagic species are caught. These include mainly the large perches (*Epinephelus* spp., *Lutianus* spp.

and *Pristipomoides* sp.). Trawl catches in deeper areas beyond 70 m depth bring in mostly *Priacanthus* spp., *Holocentrum* spp., *Emmelichthys* sp., *Parascolopsis* sp., and large resources of *Clubiceps natalensis*, *Centropristis* sp., *Champsodon* sp., *Polymyxia* sp. and *Psenes* sp. Deeper on the shelf and slopes are available *Chlorophthalmus* spp., the snake-mackerels (*Epinnula* sp. and *Rexea* sp.), boar fishes (*Antigonia* spp.), the deep sea flat-fish (*Chascanopsetta lugubris*), *Trigla* spp., and *Peristedion* spp.

Large quantities of file-fishes (Balistidae) mainly *Odonus niger* and *Sufflamen capistratus*, the puffers (*Diodon* spp.) tobys (*Canthigaster* spp.) are met with seasonally in the area. Light-fishes (*Gonostomatidae*) and lantern-fishes (Myctophidae), though not exploited commercially are caught now and then on the outer shelf in large quantities.

In addition to the above mentioned species, either found significantly in the exploited fisheries or found by exploratory fishing as potential resources, there are several others of lesser significance in the fish fauna of the seas off the SW coast of India.

The annual average catch of marine fish in India during 1971 - '75 period is estimated to be 1.2 million tonnes (source CMFRI Reports), of which about 50% are landed in the area covered by the present survey. It is natural to expect that the eggs and larval material collected from the area will to a great extent reflect qualitatively and quantitatively the fish fauna of the area. Table - 4 shows the relative importance of the exploited fish resources in the area, based on average annual figures for the 1971 - '75 period. It is seen that the oil-sardine is the single largest exploited fish resource followed by the mackerel. Several other clupeoids like white-baits, other sardines and anchovies form a significant component of the fish catches. Ribbon-fish, cat-fish and sciaenids are the other important groups contributing to the catches. However, the acoustic surveys by the Pelagic Fishery Project (Anon, 1976 a) have indicated that the resources like sardine, mackerel, white-baits, ribbon-fish and horse-mackerel are quite under-exploited and the potential resources are much higher than reflected in the landed catches. The crustaceans and among the fishes, the elasmobranchs and the cat-fish, all of which together form nearly 25% of the landings of the area are not relevant in the eggs and larval survey conducted now, as their spawning habits are either quite different from the other species or their spawn products are not available from the sea at all stages.

Table - 4

Annual average fish catches (1971 - '75) in the area of investigation and the contribution of the major categories of fish*

	Average annual catch (t) from the surveyed area.	Proportionate contribution of different categories. %
Total	632676	
Oil-sardine	152,303	24.07
Other clupeiods	66,754	10.55
Mackerel	83,477	13.19
Other scombroids	13,306	1.79
Ribbon-fish	31,083	4.91
Cat-fish	30,478	4.82
Sciaenids	19,232	3.04
Carangidae	13,422	2.12
Silver-bellies	16,574	2.62
Elasmobranchs	16,766	2.65
Perches	12,696	2.01
Flat-fishes	9,382	1.48
Lizard-fishes	5,292	0.84
Crustaceans	102,671	16.23
Others	61,240	9.68

* Source - CMFRI fish landing data.

3.3 The oceanographical and biological environment of the area.

The oceanographical conditions and biological production of the SW coast of India are largely influenced by the monsoons, particularly, the SW monsoon, the associated currents and upwelling phenomenon. The seasonal reversal of the surface current system along the coast to the north and south directions is a characteristic feature.

The oceanography and biology of the area south of Quilon are influenced also by the NE monsoon and Bay of Bengal conditions, while the area north of it is more governed by the SW monsoon and north Arabian Sea and the influence of the Red sea water.

Several contributions to the oceanography of the area are published; important among them being those of Sewell, 1937, Ramasastry and Myrland, 1959, Banse, 1959, 1968, Ramamrutham and Jayaraman, 1960, Ramamrutham and Patil, 1966, Murthy, 1965, Sharma, 1966, 1967, Darbyshire, 1967, Wooster et al. 1967, Wyrtki, 1973, Currie et al. 1973, Rao et al. 1973 and Reddy and Sankaranarayanan, 1968.

Very recently, the UNDP/FAO Pelagic Fishery Project, worked intensively along the SW coast and published technical reports on the oceanography of the region (Anon, 1973 a, 1976 c).

Based on the above literature, the oceanographical conditions of the area could be summed up as follows:

Temperature:

Surface temperature conditions along the SW coast show a double oscillation during the year with primary maximum in April and a secondary one in November. Corresponding minima are observed during July/August and December/January (Sharma, 1967). In general, the low temperatures are spread over a longer period in the northern areas than in the south. There is a greater seasonal amplitude of temperature in the area north of Kasaragod (12° 30' N.) than south of it.

The vertical thermal structure shows a layer of nearly isothermal, well aerated 'mixed layer' of small temperature range. This layer is of varying thickness, its lower boundary being the thermocline. The temperature at the top of the thermocline depths ranges from 26° to 29° C during the monsoon season and the range is slightly less during winter and slightly more during summer (Murthy, 1965).

The thermocline depths in the area do not exceed 150 m in any month of the year and is deepest in the winter months (Sharma, 1967, Anon, 1973 a) and is shallowest during monsoon months, due to upwelled water reaching near surface levels.

<u>Salinity</u>:

During the SW monsoon, very low salinities of less than 30‰ are observed from Cochin and northwards in the surface layer, due to discharge of large amounts of fresh water, while off Cape Comorin and Tuticorin, at this time, surface salinity is only slightly less than 34‰ (Anon, 1976 e). Salinity and its seasonal amplitude increase north of Kasaragod.

<u>Oxygen</u>:

The shelf waters of the area are generally well aerated during most part of the year, with 4 - 5 ml/L of dissolved oxygen at the surface, except during the SW monsoon upwelling period. Dissolved oxygen values show an increase in seasonal amplitude from south to north. There is a slow decrease in oxygen content towards and during the SW monsoon season, with an abrupt rise afterwards.

<u>Currents</u>:

The coastal surface current of the west coast of India is set towards the south from February, until late

October or November and reversed during remainder of the year. The resultant speed of the current, calculated for 2 degree square is more than 20 km per day for the coast south of Bombay, during the SW monsoon (Warners, 1952, Banse, 1968).

From November to January, a northward flowing surface current is observed. This slow NE monsoon drift appears to be rather shallow and seems to have little influence on the waters below the thermocline (Wyrtki, 1973).

Water masses:

According to Darbyshire (1967) 3 major water masses are present on the SW coast shelf, the 'Indian ocean equatorial water' with temperature less than 17° C and salinity with a minimum of 34.9‰. This water is present only at the deeper levels on the continental slope. Above this is the 'Arabian sea water' defined by temperatures between 17° to 27° C, associated with a maximum salinity between 35.5 - 36.3‰. Above the Arabian sea water is the 'Equatorial surface water' characterised by small temperature range (27° - 30° C) and a wide salinity range between 30 - 40‰ (Anon, 1976 c). Banse (1968) suggested that a water mass is formed on the shelf at the end of the SW monsoon period by the mixing of the low salinity surface water and the upwelled more saline cool water.

The upwelling phenomenon:

The upwelling phenomenon is observed seasonally along the SW coast of India, its effect in nearshore surface waters being felt with the onset of the SW monsoon. During this process the sub-surface, cool, nutrient laden, but less oxygenated water from the deeper shelf moves upwards and get well mixed and oxygenated in the shallow euphotic zone initiating high primary production.

Effects of upwelling are first evident in the south and move progressively to the north. Upwelling is noticed to be more intense in the south. The upwelled water lingers for a longer period on the northern shelf areas than in the south. There is less upwelling south of Quilon (Anon, 1976 c).

Primary production:

Nair et al (1973) calculated an average value of 1.19 gc/m^2 day, equivalent to an annual gross production of 434 gc/m^2 for the west coast of India, within 50 m depth. The above figure is quite high compared to several other areas of the world. It has been observed that the level of production is more towards the coast. Beyond 50 m to the edge of the shelf the mean value of primary production is found to be 0.43 gc/m^2 / day.

Phytoplankton production:

Subrahmanyan (1959, 1965) observed that the maximum production of phytoplankton on the SW coast based on standing crop is during the SW monsoon months (May - August). A secondary peak of production has been observed during the NE monsoon (November - December).

Zooplankton production:

The general pattern in the plankton density and distribution along the SW coast shelf shows that the zooplankton biomass is low on the shelf from January to April. April to June is a period of moderate densities. Afterwards there is an increase which reaches a peak some time during July - September period, following the upwelling on the shelf. A small secondary peak is discernable in the November - December period, the time of the NE monsoon (Menon and George, 1977).

To sum up, it may be stated that an oceanographical environment influenced by the seasonal monsoons, mainly the SW monsoon, the reversing coastal surface currents and upwelling, congenial for high organic production is obtained in the area. The mean surface temperature and salinity values are low during the SW monsoon months, but gradually rise soon after to reach high values during the winter months, particularly of salinity. The primary maximum for temperature and salinity are however observed during the pre-monsoon period from March onwards.

4. DISTRIBUTION AND ABUNDANCE OF FISH EGGS AND LARVAE

Till recently studies on the quantitative aspects of fish eggs and larvae in the Indian seas were limited to studies on their seasonal abundance based on material from the inshore plankton and post-larval fish collections from restricted localities.

Gopinath (1942) stated that larval and post-larval stages of marine fishes made their appearance in large numbers along the Trivandrum coast from the beginning of November and continued to be present till the middle of March and that towards the close of March the larvae diminished in numbers upto April, when post-larvae alone constituted the catches. It was also mentioned that maximum abundance of the larvae was usually recorded in February and March. Subsequently, Gopinath (1946) analysed collections from the same area for two years and observed that the maximum number of species of post-larvae was observed during December and that a preponderance of clupeids and scopelids were observed in January. Altogether, post-larvae of 24 species were isolated by him from the catches obtained in tow nets and other close meshed nets used in the 'Nonnavu' fishery, an exclusive fishery for post-larval fishes practised along the Trivandrum coast. He found that the post-larvae of Stolephorus commersonii, Engraulis mystax, Saurus spp. and Saurida tumbil appeared in large swarms. Further he commented that "from November onwards, the NE monsoon drift, sweeping up the coast of Ceylon creeps up the west coast of Ceylon and India (Sewell, 1937) and forms a strong coastal current in a northerly direction along the Trivandrum coast. Hence in all probability, the larval and post-larval stages arrive along this coast in the course of their migration with the drift from a spawning ground situated somewhere to the south and away from this coast. The annual migration ofthese larval and post-larval forms to these coastal waters and the enormous quantities obtained in collections tend to indicate that probably this coast is a good nursery".

Menon (1945) stated that fish eggs and larvae were most common off the Trivandrum coast during September to November and May to July.

Nair (1952 a) found white sardine (Kowala coval) eggs in large numbers in the coastal waters off West Hill, Calicut, particularly during November - January period.

George (1953) in his studies on the plankton of the coastal waters of Calicut, observed that fish eggs and larvae were numerically small in the plankton. Eggs and larvae were scarce during the monsoon months but started appearing in the plankton from September. Appreciable numbers of fish eggs and larvae, mostly of carangids and clupeoids were observed by him in October and November, with moderate numbers occurring till February. Eggs of Caranx sp. were common from September, Anchoviella sp. during December to January and Kowala sp. during September to November. Eggs of Sardinella longiceps were collected by him in August.

Mukundan (1971) from his studies on the inshore plankton at Calicut from two stations, the deeper one at 40 m, found significant abundance of eggs and larvae from August to December. He found a large number, but fewer types of fish eggs and larvae in these collections, consisting mostly of carangids, clupeoids and soles. Sardine and mackerel eggs were not met with. Menon et al (1977) studied the inshore plankton off Mangalore from April 1975 to March 1976 and found fish eggs in 'reasonably high' numbers during April, November, January and March, but on the whole, poorly represented in the plankton. Fish larvae were rare, but few were collected during October to January period.

Ramamurthy (1965) met with fish eggs and larvae off Karwar and adjacent areas only rarely. However, some fish larvae were seen in the plankton during the September - November period.

Data from the IIOE (1960 - 65) showed significant abundance of fish larvae off the central part of the west coast of India, with catches upto 1600 larvae per haul, off the Malabar coast (11°00' N. and 74°35' E.) Low values for eggs were observed for most part of the Indian coasts during the south-west monsoon (Panikkar and Rao, 1973). The results as above is based on very limited sampling on the shelf waters.

Peter (1974) stated that fish larvae were present in 93% ofthe IIOE samples from the Arabian sea, but their composition showed that only 17% belonged to economically important groups and that June to August period was the best season for eggs and larvae, the peak being in July.

Ahlstrom (1968) studied 50 representative samples of fish larvae from the IIOE collections, from 19 oceanic, 27 Intermediate and 4 coastal zone stations. Oceanic stations were found to be dominanted by larvae of Myctophidae and Gonostomatidae, accounting for 75% of all the larvae caught.

The intermediate zone was the richest in kinds of fish larvae and contained large numbers of the oceanic families, but in addition, anchovies (12% of the total) and several predominantly demersal families (ca 20% in all) were seen in these samples. In the limited number of coastal stations, anchovies accounted for about 13% of the total and nearly all other identified larvae belonged to bottom living groups (Shomura, 1970).

Nellen (1973) found in the R.V.Meteor samples (December 1964 to April, 1965 cruise in the Arabian sea and Persian Gulf) from the west coast of India, significant numbers of Gonostomatidae and Myctophidae (89% and 91% respectively considering all stations) followed by Bregmacerotidae (75% of all stations). An average of only 42 larvae per m^2 was caught from the west coast of India, whereas from the Gulf of Oman, the vessel caught as high as 695 larvae per m^2.

In the following section, the distribution of all eggs and larvae in the surveyed area from September 1971 to December 1975 are presented, to bring out the seasonal and spatial spawning pattern of the fish population in the area. The year is divided broadly into 3 seasons namely; the pre-monsoon (January to April), the monsoon (May to August) and the post-monsoon (September to December).

For contouring the distribution densities, the average standardised number (no/m^2) of eggs and larvae for each station for all the cruises of a season are plotted on the survey area map, at the respective stations and isodensity lines are drawn, using suitable contour intervals to depict the density levels.

While adopting this method it is assumed that the distribution of eggs and larvae through space and time are continuous and the concentration gradients between the points, linear (Sette and Ahlstrom, 1941). The plankton collections during the present study were started in the post-monsoon season of 1971.

4.1 Distribution and abundance of fish eggs:

1971 post-monsoon season (Fig. 2)

During this season the sampling was carried out by the 54' vessel Sardinella and the coverage was largely limited to the shelf waters, from Karwar to Quilon.

Distribution of fish eggs showed a shore-ward concentration. This concentration has been highest in the area from Calicut to Karwar, where the inshore belt showed more than 200 eggs per m^2, indicating active spawning in this area. The density gradient towards offshore was gradually lighter, with less than 10 eggs/m^2 on the outer shelf, along the entire stretch surveyed.

1972 Pre-monsoon season (Fig. 3)

During this season the coverage was extended further seaward beyond the shelf, as well as to the north, upto Ratnagiri. Except for the pockets of egg concentration in the nearshore areas from Mangalore to Vengurla (13° - 15°50' N.) and to a lesser extend in the Quilon - Cochin region and the small offshore pocket over the Angria Bank; the whole shelf was very poor in the abundance of eggs, with less than 10 eggs per m^2. Not far beyond the shelf, the density index diminished to zero value.

1972 Monsoon season (Fig. 4)

This was the first monsoon time survey during the studies. A nearshore belt from north of Quilon to Coondapur was found to have very moderate numbers of eggs with very dense pockets off Kasaragod, Calicut and Cochin. The mid-shelf was poor in the abundance of eggs except for isolated pockets off Kasaragod and Calicut. The outer shelf had relatively higher density in eggs, with generally more than 10 eggs/m^2. A dense offshore strip (more than 50 eggs/m^2) was observed off the Karwar-Vengurla coast. The dense inshore pocket off Kasaragod was due to the presence of a clean patch of oil sardine eggs.

1972 Post-monsoon season (Fig. 5)

There was an increase in density of eggs towards the shore, in the inner third of the shelf, as seen during similar period in 1971. The coverage during this season was more extensive than in 1971. Dense concentration of eggs (more than 100 eggs/m^2) was noticed in the inshore off Coondapur - Karwar coast and off Quilon. In general, there was decreasing concentration towards the outer shelf. However, an extensive patch of dense offshore concentration was noticed over the shelf, in the Karwar - Ratnagiri area and also an oceanic concentration in the same area.

1973 Pre-monsoon season (Fig. 6)

The trend of egg densities had the same basic pattern as observed in the same period of 1972 with much of the shelf area devoid of any significant spawning activity. During this season, with the arrival of the 152' vessel Rastrelliger two more sections in the south, namely, Cape Comorin and Tuticorin were also covered. The inshore concentration of eggs as noticed in the north between Mangalore and Vengurla in 1972 was found to be more extensive during this season, stretching from north of Calicut to Ratnagiri, with the high core value in the Kasaragod - Karwar area. The limited offshore extension of this high density area covered the whole shelf at its centre point off Coondapur.

The extended southward coverage showed very good spawning activity in the mid-shelf, south of Quilon and the Wadge Bank, where it was most dense. In general, there were decreased values along the major part of the shelf and beyond except the high values at offshore pockets, off Ratnagiri, Quilon and Cape Comorin.

1973 Monsoon season (Fig. 7)

On the whole, very little fish spawning activity was noticed north of Mangalore, over the entire shelf, except for small pockets of moderate concentration of eggs in the inshore and offshore waters, off Ratnagiri. However, south of Mangalore, the concentration of eggs showed very high core values (more than 200 eggs/m^2) on the mid-shelf, off Kasaragod and the shelf slope and oceanic waters, off the Quilon - Cape region. High values of density were seen over the deeper areas of the Wadge Bank. The Cochin - Calicut shelf showed relatively light density of eggs during the period, while the Cape - Tuticorin area showed very high concentration, particularly off Tuticorin.

1973 Post-monsoon season(Fig. 8)

The post-monsoon trend of increasingly higher concentration of eggs towards the shore in the entire area prevailed during the season, with the high core values shifted to outer shelf between Mangalore and Vengurla in the north, and off Quilon in the south. Patches of very high values were observed off Karwar, Kasaragod and Quilon. Relatively low values were observed in the inshore, off the Quilon - Cochin region and off Tuticorin. High density patches were more significant during this season than in the previous two post-monsoon seasons. During the present season the spawning activity in the area appeared relatively more intensive.

1974 Pre-monsoon season (Fig. 9)

The inshore shelf, north of Cochin to Coondapur and almost the entire shelf north of it up to Ratnagiri was very poor in eggs, while the offshore waters in this region showed moderate increase in densities. The off-shore waters south of Cochin showed an extensive area of high values (more than 50 eggs/m^2) upto Tuticorin. The nearshore area off Tuticorin showed still higher concentration of eggs. A dense patch (more than 100 eggs/m^2) of eggs in the Cochin - Quilon region, restricted to the inner half of the shelf with the high core value off Cochin was noticed. An oceanic high density pocket, SW of Quilon was also evident. From the above, it was clear that the major fish spawning during the season was restricted to the southern part of the surveyed area and the intensity of spawning in this region appeared to be more than during the same period of 1973. However, the high value in the northern stretch observed in 1973 was altogether lacking in the picture of 1974.

1974 Monsoon season (Fig. 10)

Distribution of eggs during the season showed moderate to high values, in a wider area, than was observed during the two previous monsoon seasons. High density pockets in the inshore area was not prominent, except off Cape Comorin. An almost continuous, but narrow stretch of higher values (more than 50 eggs/m^2) was noticed from Karwar to Tuticorin in the oceanic waters. Similar densities were noticed over the slope of the shelf, in the area north of Quilon and closer to the shore in the Quilon - Cape sector, with higher core value (more than 100/m^2) in the latter area.

The inshore belt from north of Quilon to Karwar showed uniformly moderate values, while an outer shelf patch of high value was seen in the waters north of Karwar upto Ratnagiri. The density was decreasing seawards with some high value pockets in the north and also off Cape Comorin.

1974 Post-monsoon season (Fig. 11)

The distribution of eggs during this season showed uniformly light density all along the shelf and beyond, compared to similar seasons previously observed. However, the pattern was typical and of the same trend as in 1971 and 1972 but dissimilar to that of 1973 season, when rather high densities of fish eggs were noticed. Moderate value (20 eggs/m^2) appeared uniformly over most part of the shelf. North of Karwar upto Ratnagiri, the denser distribution was deflected to the oceanic waters, the shelf off Ratnagiri having been very poor in concentration. Outside the shelf, in general there was only very light distribution of eggs except the strip mentioned north of Karwar.

1975 Pre-monsoon season (Fig. 12)

The distribution of eggs during this season showed a different pattern from that of similar periods observed previously. (1972, '73 & '74) in that the inshore waters of the northern area, were richer in fish eggs. The inner shelf from Kasaragod to Cochin remained a light zone of density. A high density inshore strip from Cochin to Cape Comorin with values of more than 100 eggs/m^2 and an oceanic belt off the Cochin - Kasaragod coast, with more than 50 eggs/m^2 were observed during the season. In the southern sector, increasing seaward density of eggs was noticed in the oceanic waters. Most part of the Wadge Bank remained poor in fish eggs, except for one small pocket of relatively higher density.

1975 Monsoon season (Fig. 13)

The entire shelf and oceanic waters as far as observations were extended, showed very high densities of fish eggs, except for a narrow inshore strip between Cochin and Mangalore and a wider belt on the shelf from Coondapur to Ratnagiri. The outer edge of the shelf and slope in almost the entire area of investigation showed very high density, with more than 200 eggs/m^2. A similar high density belt with values more than 200 eggs/m^2 was also observed in the oceanic waters outside the Wadge Bank, extending eastwards to near the coast of Sri Lanka. Higher density of eggs than the previous monsoon seasons was seen during the present season.

1975 Post-monsoon season (Fig. 14)

The general trend of increase in the density of fish eggs towards the shore, characteristic of the post-monsoon season was seen, with quite high values compared to the 1974 season. From south of Calicut upto Tuticorin, the high values spilled beyond to oceanic regions. In the north, a poor density area, less than 10 eggs/m^2 was seen over the inner half of the shelf, closer to the shore near Kasaragod and progressively away from shore, north of it. Near the edge of the shelf, off the Kasaragod - Ratnagiri area, a moderately high value narrow belt (more than 50/m^2) of eggs was noticed. The highest density during the season was seen SW of Quilon, in oceanic waters.

The general picture of the distribution of fish eggs showed that during the pre-monsoon season, typically, the indices of abundance of fish eggs were low over the entire SW coast, with some localised concentrations both in the north and south sectors of the area or only in the southern sector.

During the monsoon season high indices of abundance were noticed with consistently high concentrations in the central and southern sectors. Sometimes, dense pockets in nearshore waters or larger high value offshore patches were also met with.

During the post-monsoon season, abundance of fish eggs were generally moderate to high over the shelf, decreasing steadily towards offshore, with pockets or narrow stretches of high concentrations, usually near the shore or over mid-shelf. However, these generalised patterns varied in details in the different years, as seen from the yearly pictures already presented.

The overall picture of abundance of fish eggs of the SW coast of India indicated that the highest fish spawning activity in the area took place during the SW monsoon season and the least during the pre-monsoon season.

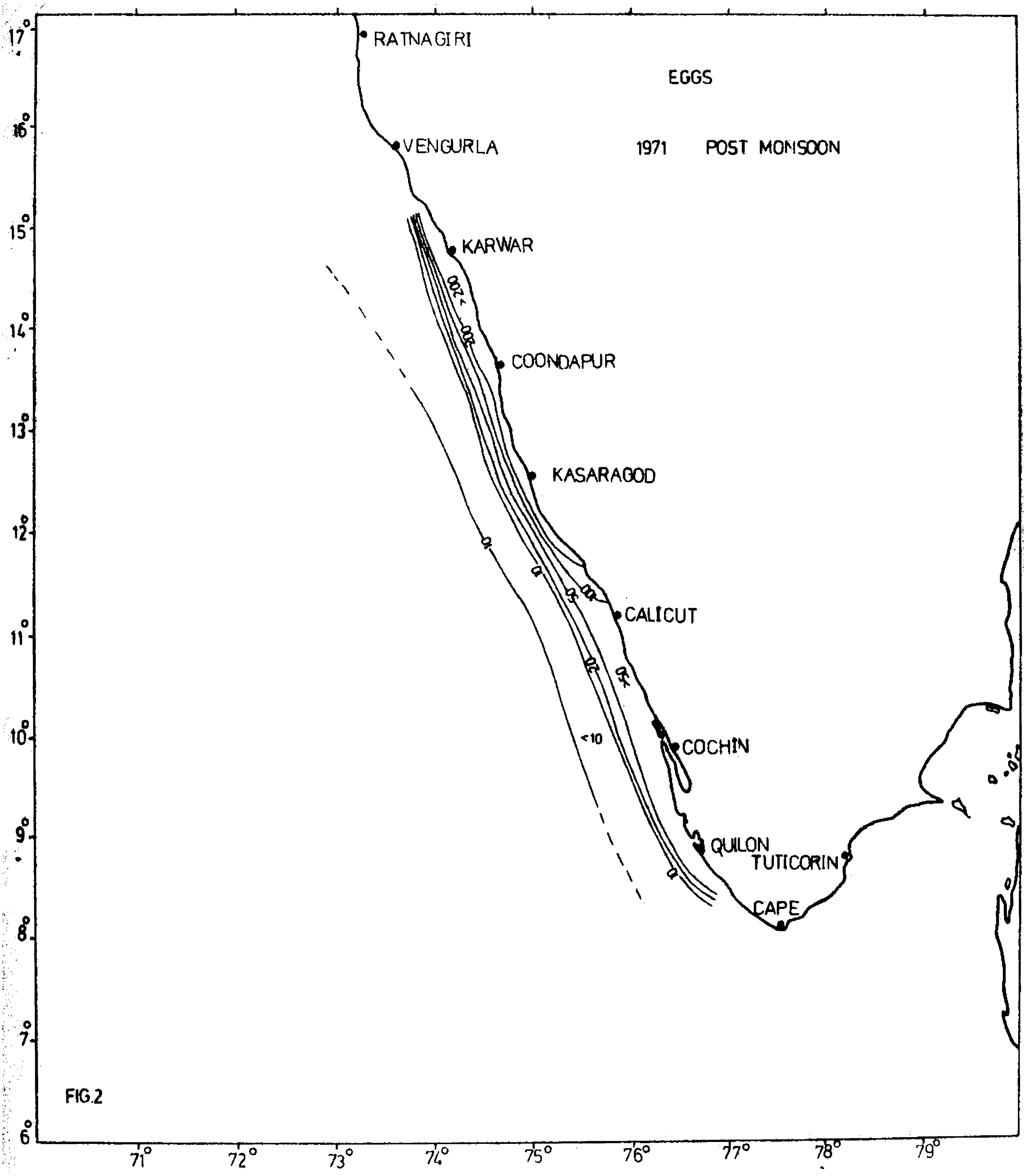
4.2 <u>Distribution and abundance of fish larvae</u>:

The picture of distribution of fish eggs as well as larvae are derived out of the same samples and hence is a simultaneous picture, one supplementing the other.

In tropical waters, most fish eggs are known to hatch out into larvae in about 24 hours and the presence of eggs or young larvae anywhere could be taken as evidence of spawning of the fish in the vicinity. While presence of large numbers of eggs could be taken as proof of congregation of spawners and of a spawning ground there, the high larval densities in an area may not exactly delimit a spawning ground. The drift of the larvae due to prevailing currents could cause translocation of the young larval population to areas away from the spawning ground. A super imposed picture of both eggs and larval population however could help to delimit more clearly the spawning and nursery areas.

Fig. 2 - 14

SEASONAL DISTRIBUTION AND ABUNDANCE OF FISH EGGS - SEPTEMBER, 1971 TO DECEMBER, 1975.



EGGS
1971 POST MONSOON
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
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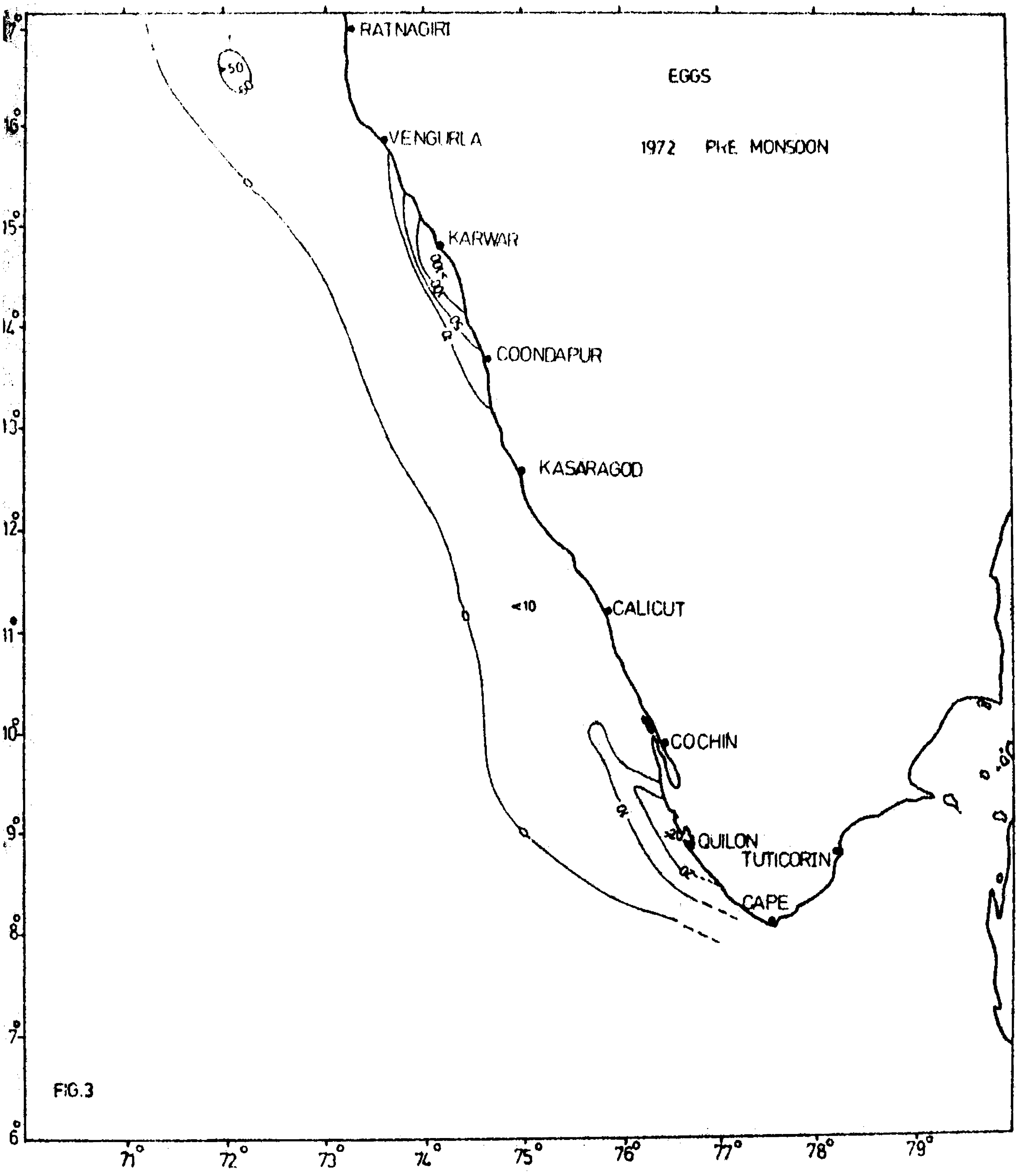
FIG.2



EGGS
1972 PRE MONSOON
RATNAGIRI
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COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
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CAPE
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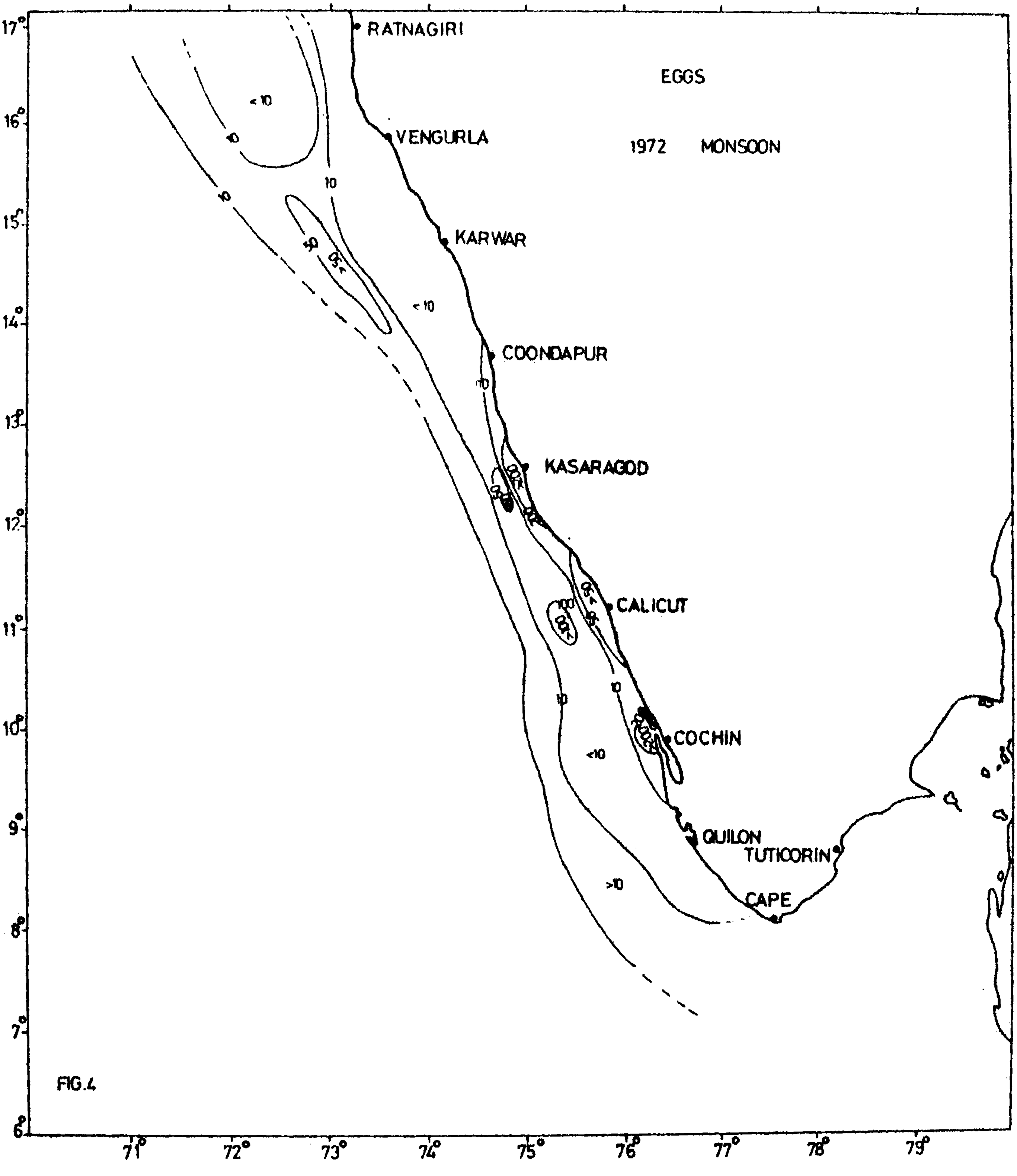
FIG.3


RATNAGIRI
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KASARAGOD
CALICUT
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EGGS
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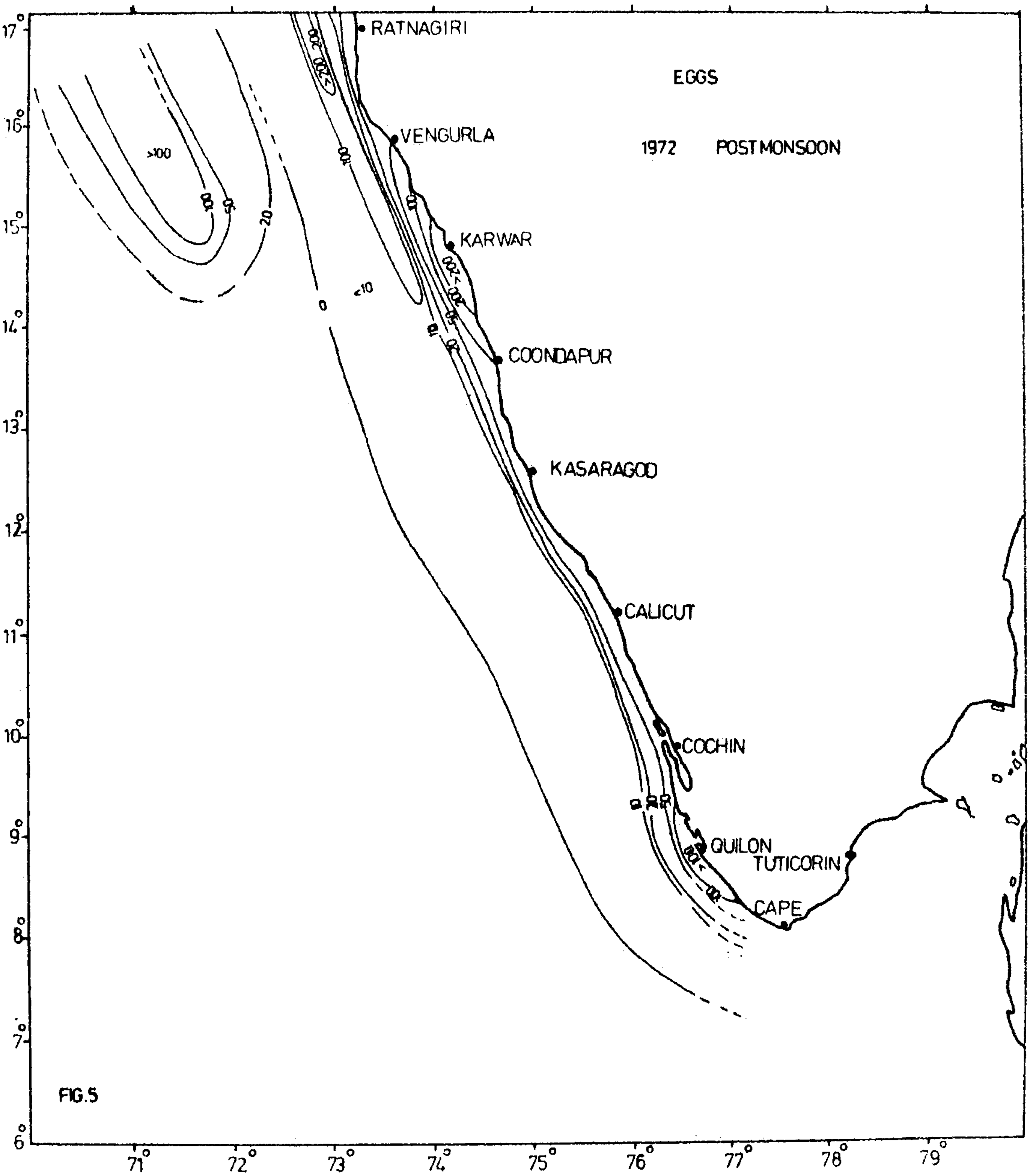
FIG.4



EGGS
1972 POSTMONSOON
RATNAGIRI
VENGURLA
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COONDAPUR
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QUILON
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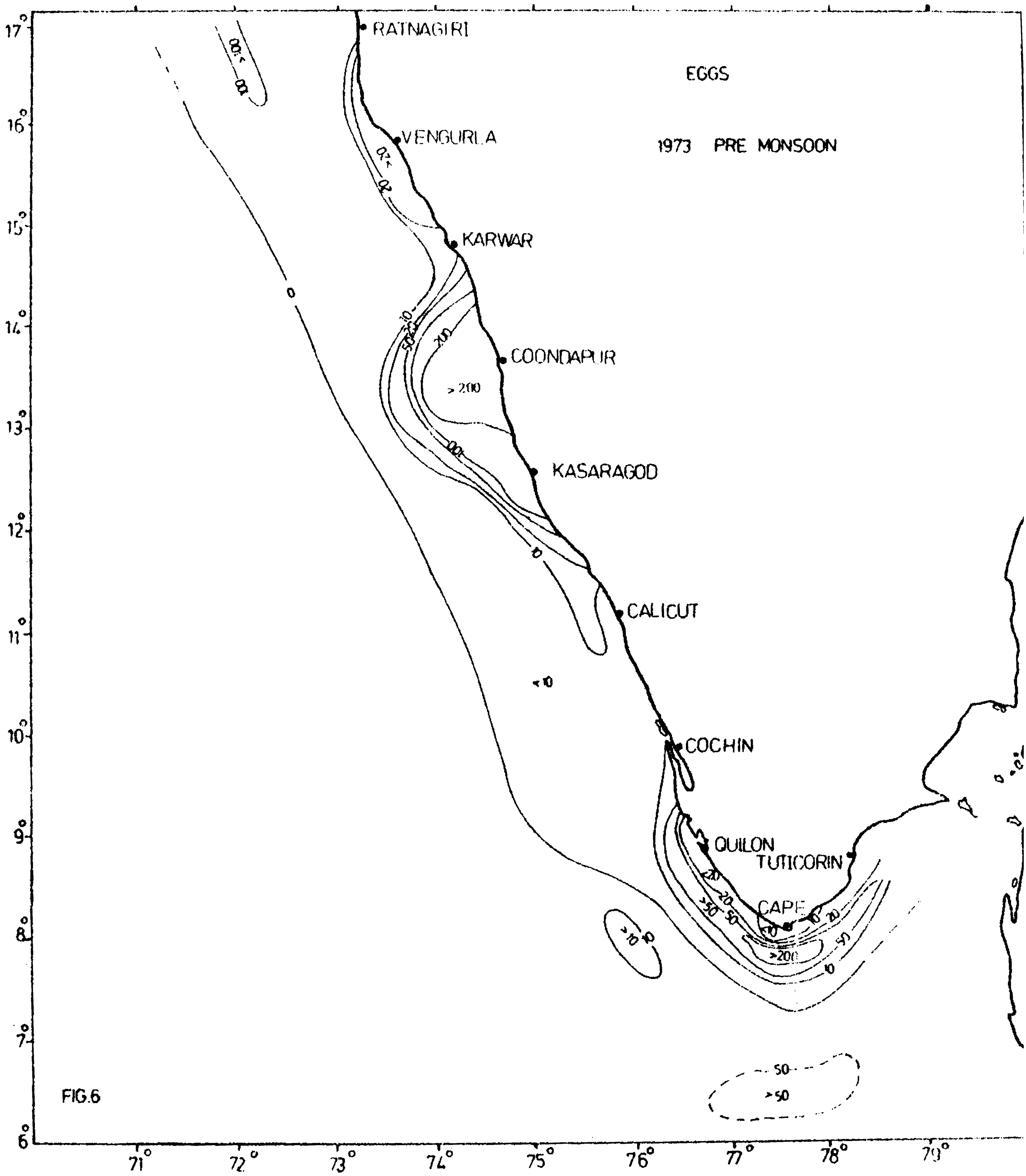
FIG.5


EGGS
1973 PRE MONSOON
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COONDAPUR
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CALICUT
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TUTICORIN
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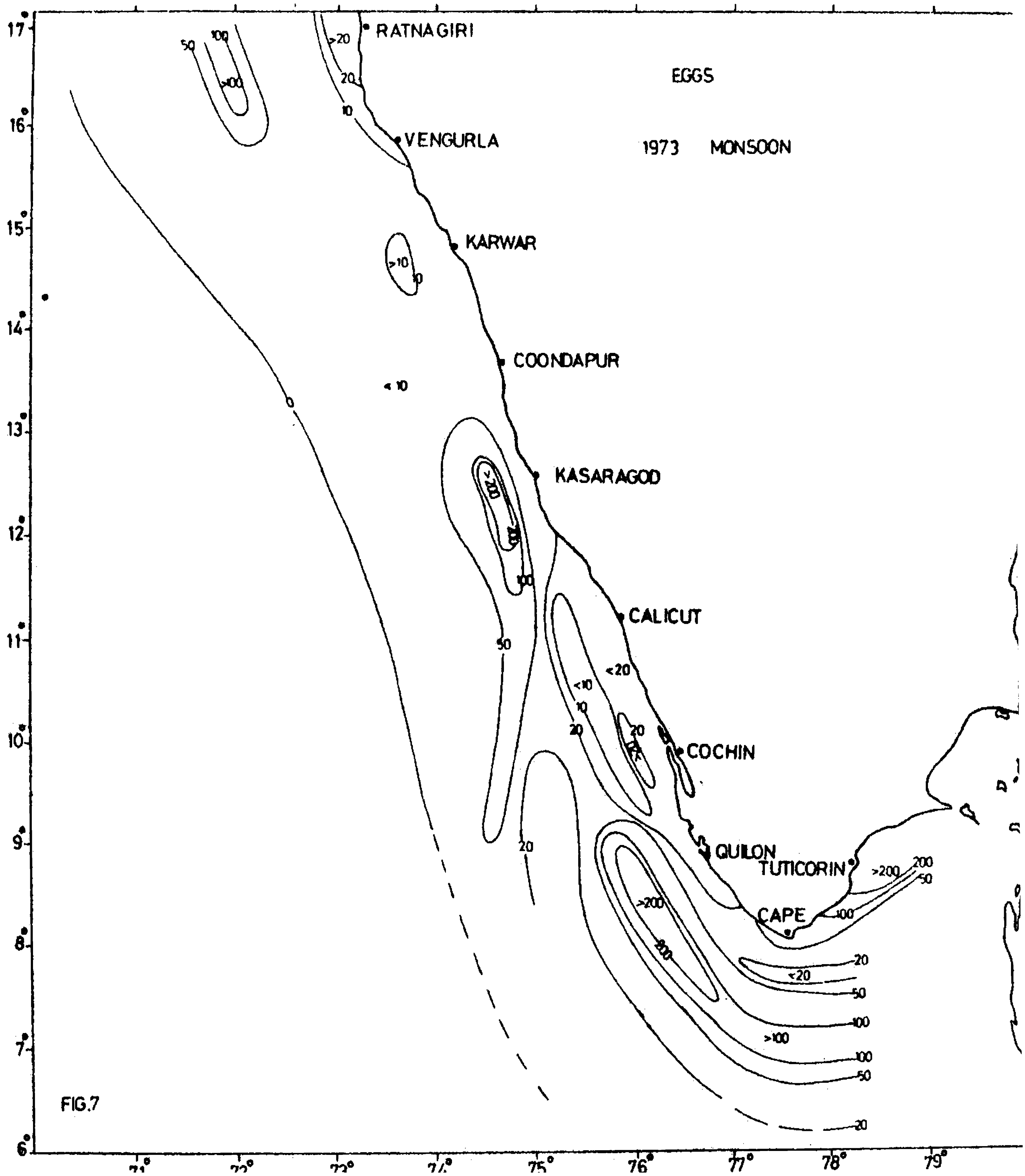
FIG.6


EGGS
1973 MONSOON
RATNAGIRI
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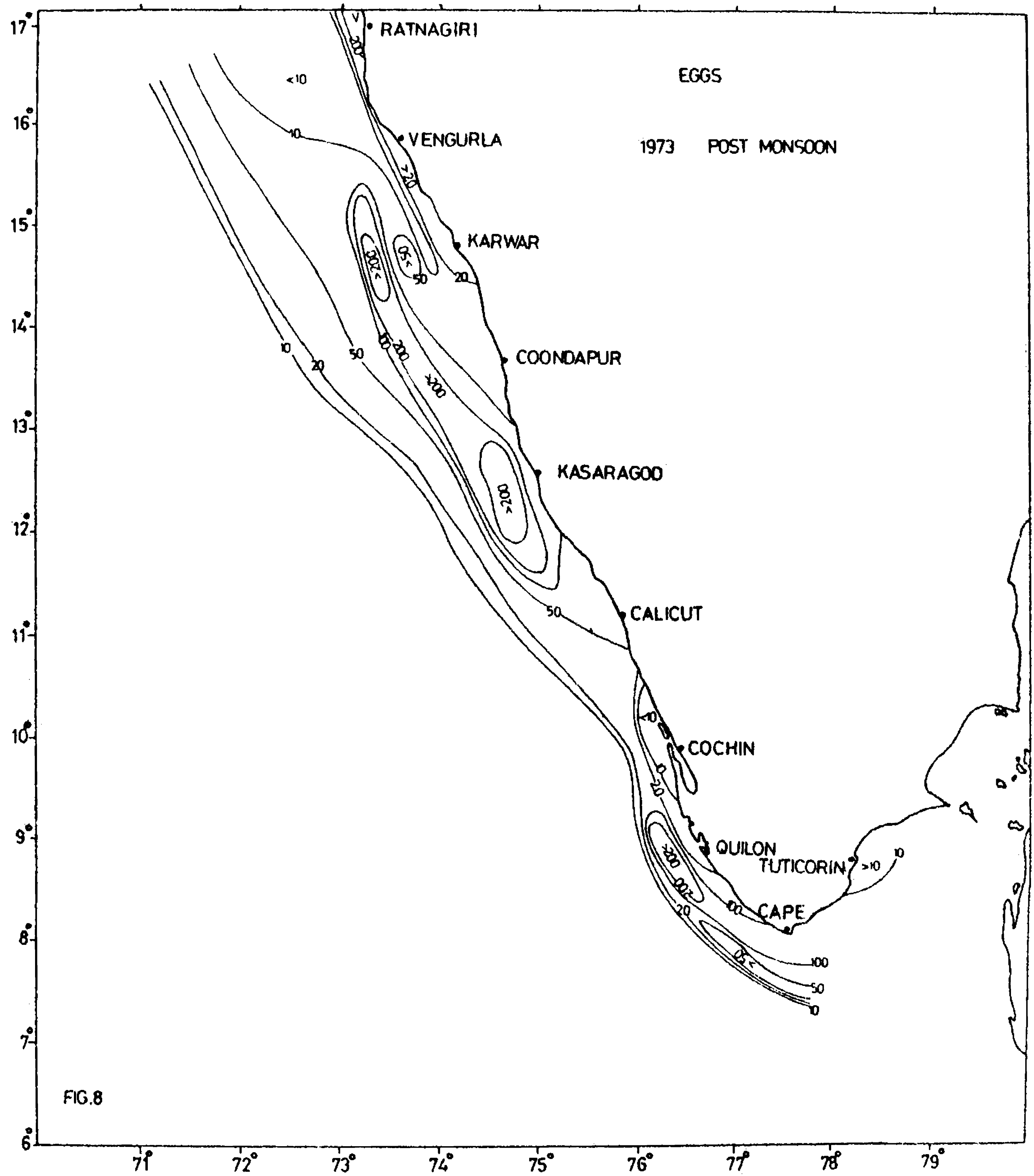
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE

FIG.7


EGGS
1973 POST MONSOON
RATNAGIRI
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KARWAR
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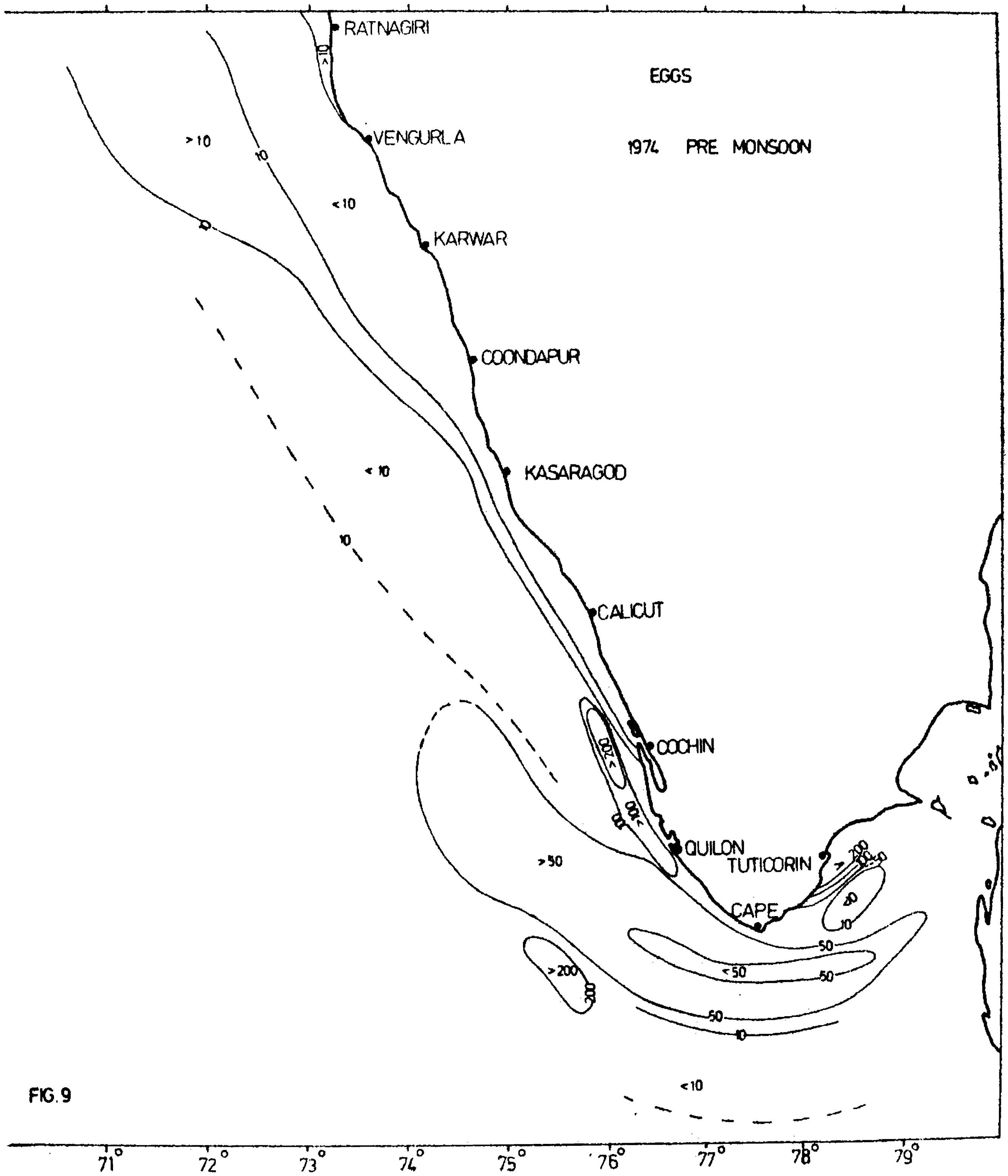
FIG.8



RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
EGGS
1974 PRE MONSOON
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FIG. 9

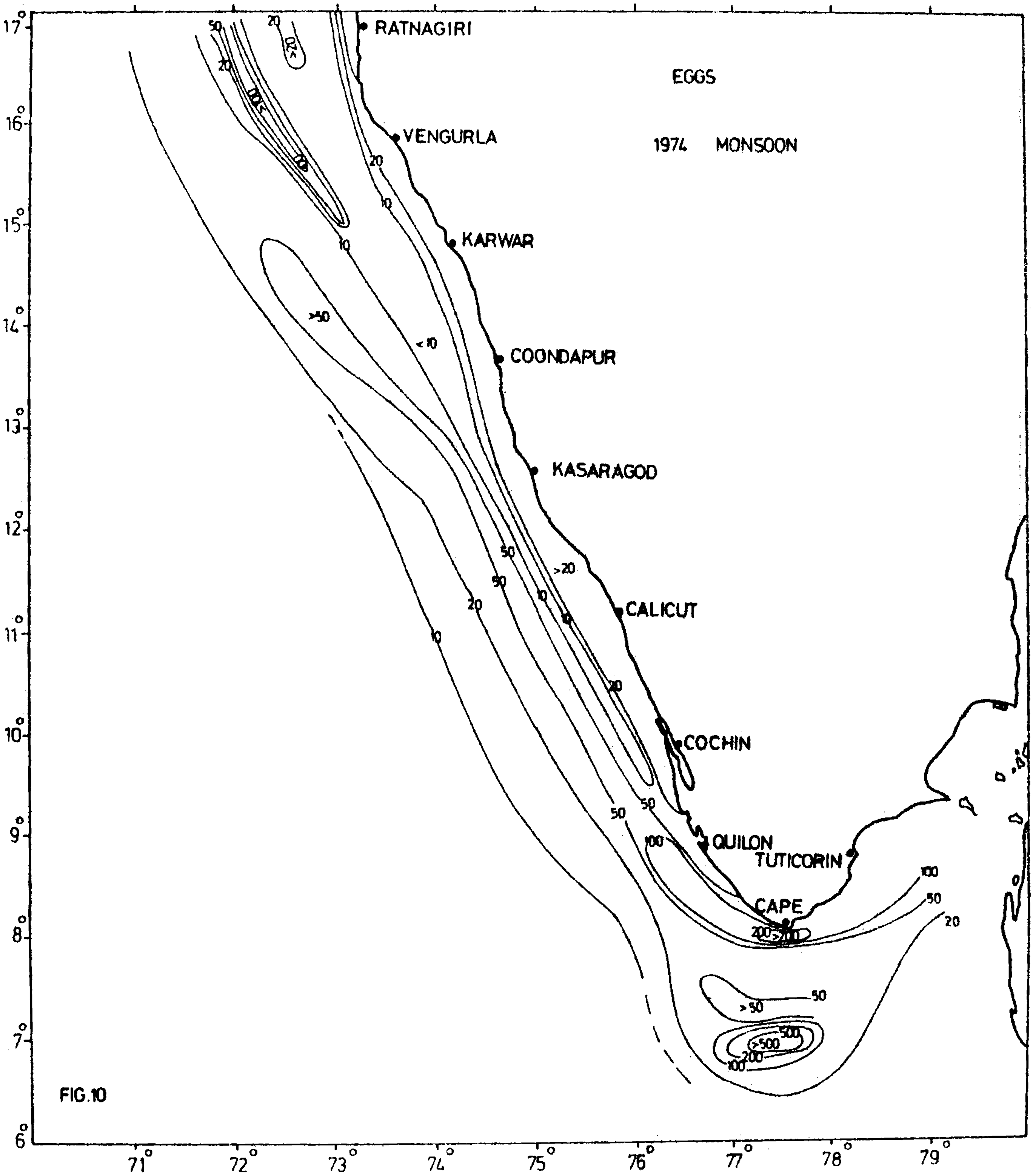
EGGS
1974 MONSOON
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
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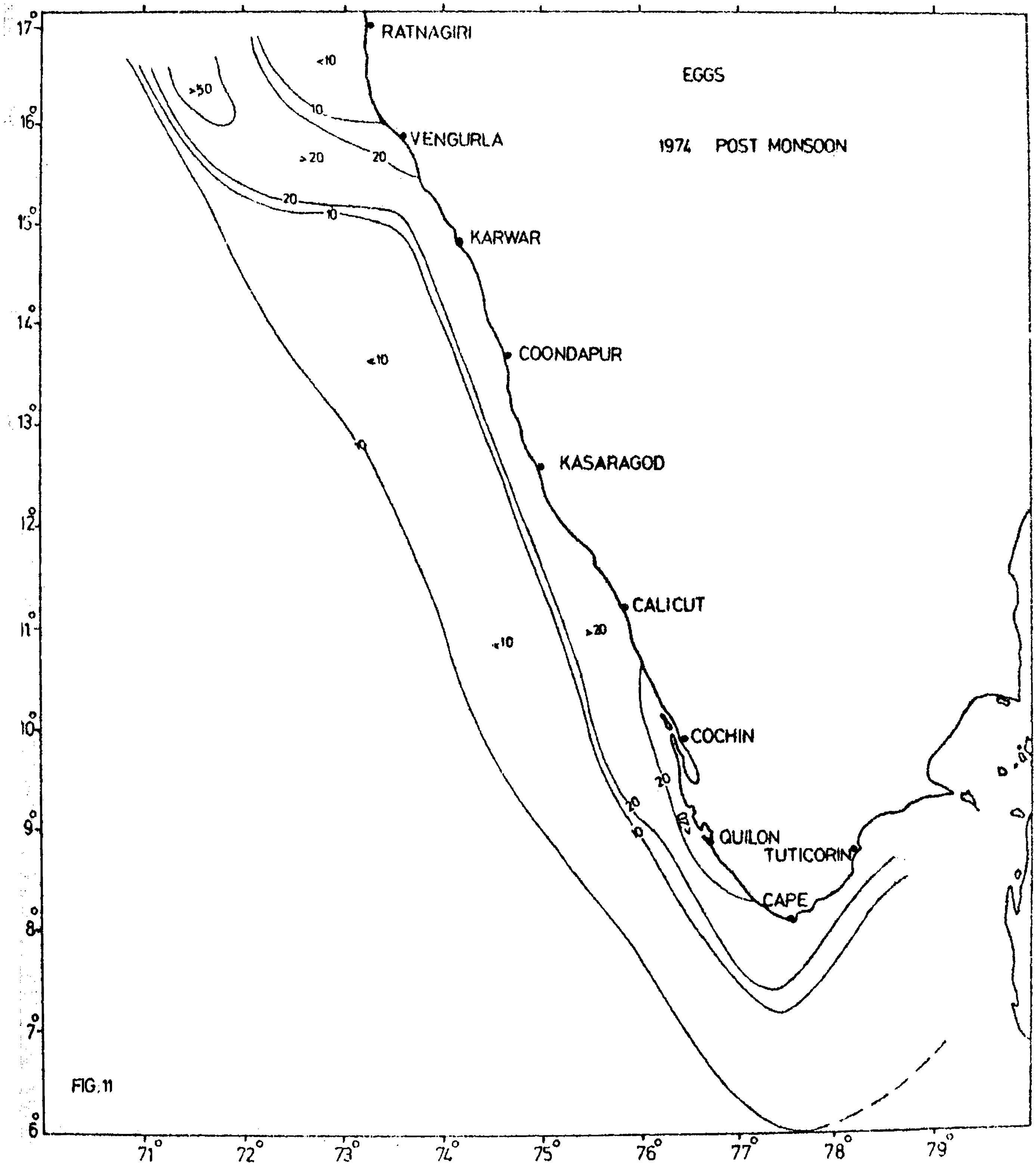
FIG.10



EGGS
1974 POST MONSOON
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
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COCHIN
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FIG. 11

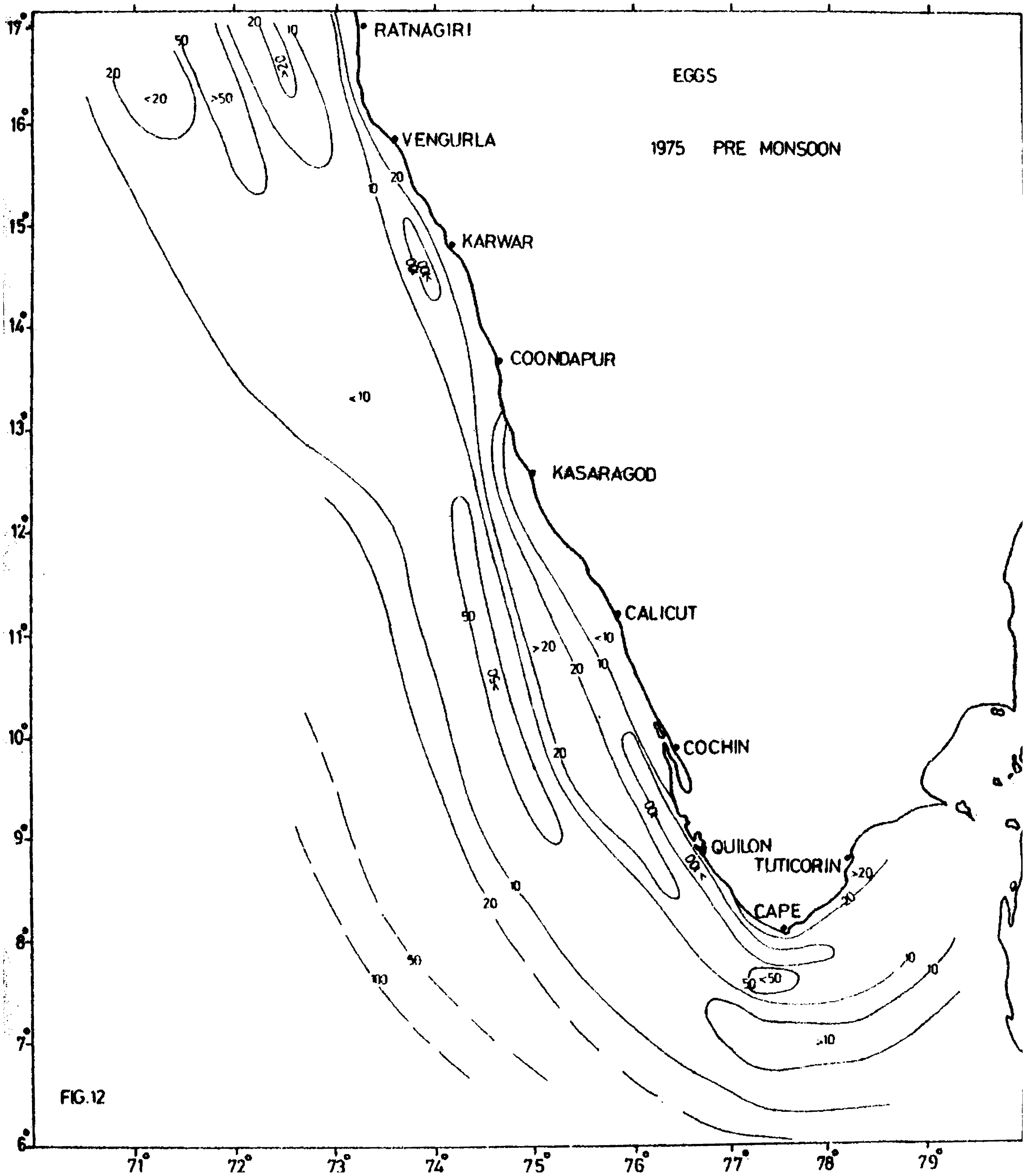
EGGS
1975 PRE MONSOON
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
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FIG.12

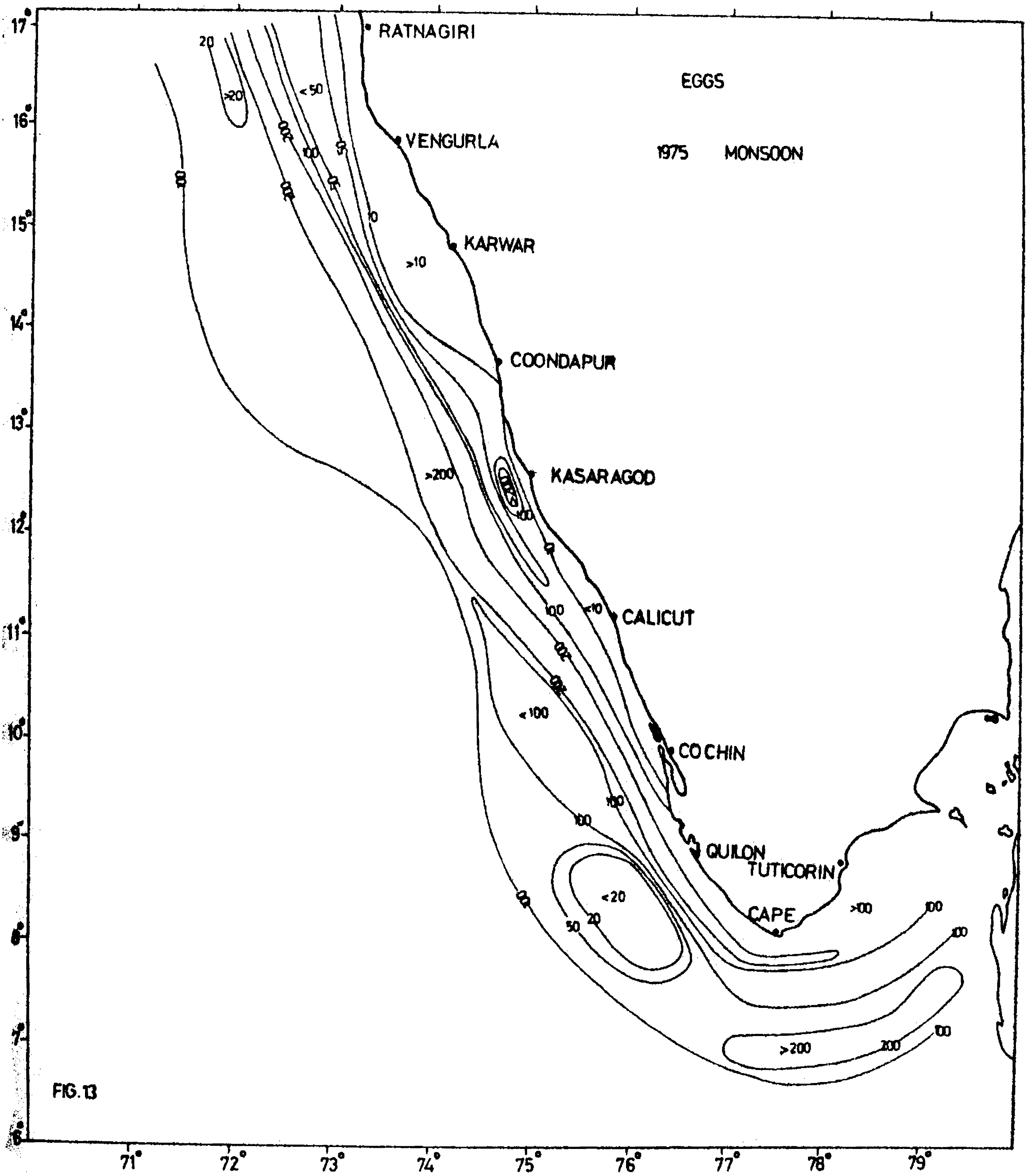
EGGS
1975 MONSOON
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
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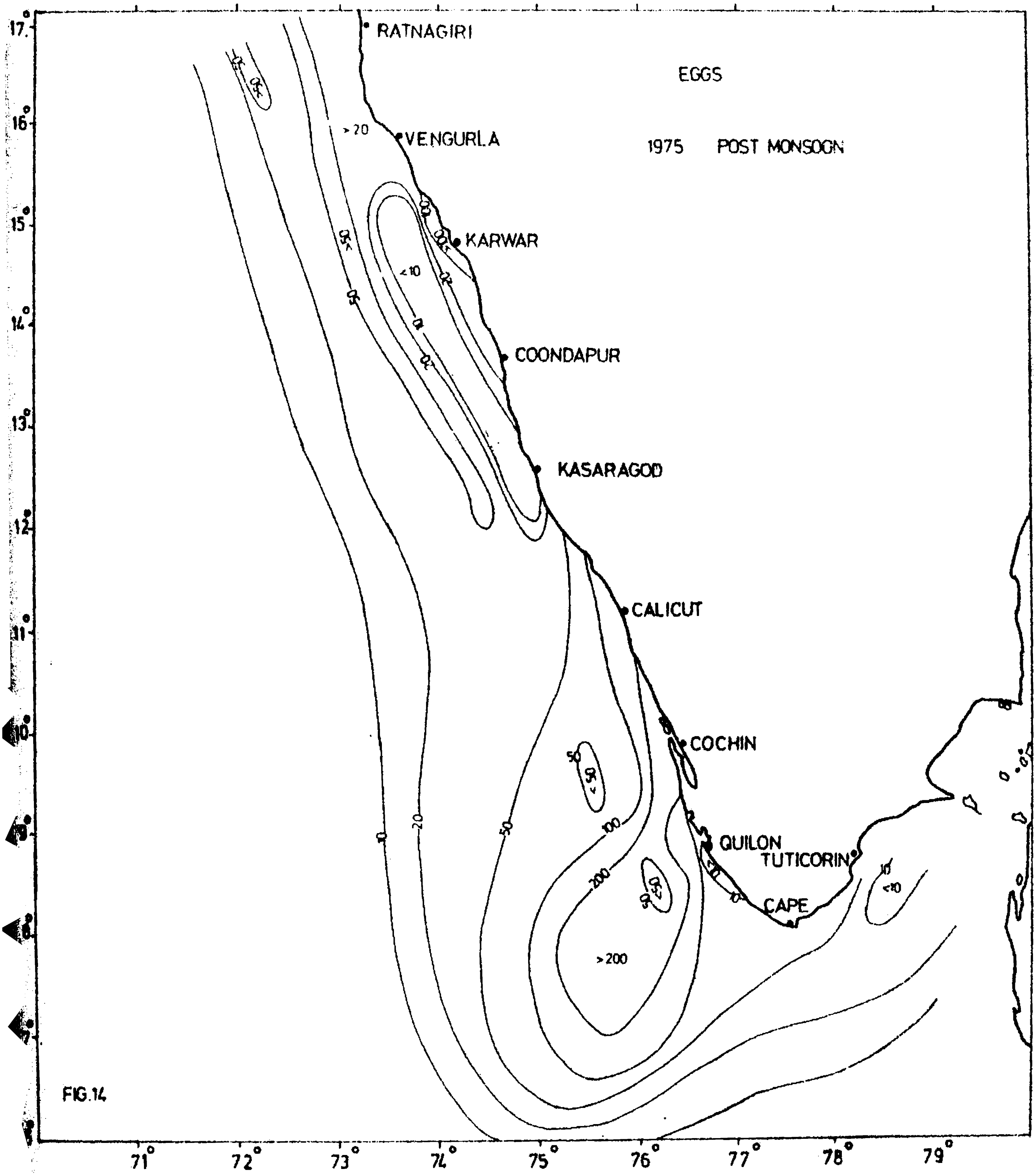
FIG. 13


EGGS
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KASARAGOD
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FIG.14

1971 Post-monso n season (Fig. 15)

The distribution of fish larvae during the period showed concentrations away from the shore, whereas fish eggs were observed closer to the shore. The indices of larval abundance have been lower than those of eggs. A wide belt of moderate value on the outer shelf and off-shore waters with more than 20 larvae per m^2, was seen between 9°30'N and 15°N with its high core value (50 larvae/m^2) between 10°30' and 13° N. The values decreased towards the oceanic region. Both at the northern and southern ends of the surveyed area, the larval concentrations were less widespread than at the central areas. An inshore belt of an average width of 10 miles was observed to have low index of larval abundance (less than 10 numbers /m^2). The relatively offshore distribution of the larvae and the inshore distribution of eggs during the period showed that the larvae were drifting away from the spawning grounds.

1972 Pre-monsoon season (Fig. 16)

The larval concentration has been low, as in the case of eggs during the period. Off Quilon, the concentration of larvae was on the mid-shelf, while the concentration of eggs during the period was found inshore. An inshore concentration of larvae with moderate value was noticed between Cochin and Calicut, while no concentration of eggs was noticed here. No larval concentration has been seen in the Coondapur - Karwar zone, where there was the best concentration of eggs. However, in the offshore areas north of Vengurla, there were pocket concentrations of larvae. It would again be a logical conclusion that Coondapur - Vengurla area was the spawning ground at the time, with the larval population rather evenly dispersed over a wide area of the shelf, with also some pocket concentrations.

1972 Monsoon season (Fig. 17)

The larval distribution showed concentration in the southern half of the surveyed area from Kasaragod and southwards. Rest of the area over the shelf and beyond showed only low values. The density after increasing to a high core value of more than 50 larvae/m^2 in waters off Quilon, showed decrease towards oceanic waters. The strip of inshore belt from Calicut to Quilon showed only a low larval index, of less than 10 nos./m^2. There was evidence of a larval drift southwards and offshore from the nearshore spawning pockets in the north. The southward drift of the larvae is in tune with the direction of the surface drift in the area during the SW monsoon season.

1972 Post-monsoon season (Fig. 18)

Larval density was poor generally north of Vengurla and in the inner half of the shelf south of Calicut to Quilon. High value strips (50 larvae/m^2) from Vengurla to Coondapur and off Calicut over the mid-shelf and a similar pocket in oceanic waters off Quilon were noticed. A wide belt of moderate density (20 larvae /m^2) spilling beyond the shelf in its widest part, but narrow in the north and south was observed from Coondapur to Calicut. Compared to concentration of eggs at this time which showed a shoreward increase in density, a seaward wide dispersal of larvae was evident.

1973 Pre-monsoon season (Fig. 19)

The entire shelf and oceanic waters upto the survey limit, north of Coondapur and the nearshore belt from Cochin to Tuticorin showed poor larval distribution. Eventhough there was a relative increase in larval abundance over the shelf south of Coondapur, the major densities were distributed south of Cochin, with a high core value strip over the outer shelf which deflected seawards to oceanic waters off Quilon. A wide seaward extention of this distribution was seen between Quilon and Cape Comorin. The concentration of eggs in this region was also moderately high during this period. A dense concentration of eggs during the period however was also observed over the shelf in an area approximately between Kasaragod and Karwar. The larval concentration indicated dispersal and southward drift.

1973 Monsoon season (Fig. 20)

The inshore area from south of Coondapur to Tuticorin was poor in larval abundance, the low abundance belt extending to mid-shelf off Kasaragod. There was a high density belt over the outer shelf and farther offshore between Calicut and Trivandrum with peak core value (200 larvae/m^2) off Quilon. From Tuticorin to Calicut, there was a wide area of moderate density, which ran closer to the shore north of Coondapur. A high density pocket over the Angria Bank area off Ratnagiri and another in the offshore waters off Tuticorin were also evident. The distribution of the larvae appeared to overlap to a great extent with that of eggs in the southern part, where both showed high density concentrations. The larval abundance indices during the period were higher all over, than in the previous year.

1973 Post-monsoon season (Fig. 21)

The inshore area was generally devoid of larval concentrations. A wide area of moderate (> 20 larvae/m^2) larval abundance encompassing the mid and outer shelf and wider at its north and south ends was observed between Karwar and Quilon. A dense strip inside this over the outer edge of the shelf between Karwar and Kasaragod and a mid-shelf pocket of very high density, (over 200 larvae/m^2) off Karwar were also seen. Another pocket of high density (> 50 larvae/m^2) was seen over the Wadge Bank. Other areas over the shelf showed only moderate values.

However, the major concentration of eggs during the season was between Vengurla and Kasaragod and in the Quilon - Cape Comorin area, in rather narrow belts. The larvae appeared to disperse into wider areas towards offshore and the abundance indices of larvae consequently showed lesser values.

1974 Pre-monsoon season (Fig. 22)

Larval abundance indices were higher during the season than those of the same period of 1973. The rather extensive seaward and linear coverage showed that the southern sector from Calicut to Tuticorin was richest in larvae, with very high value strips over the outer shelf and oceanic waters from 10°30' N to 7°N. The dense concentration of larvae appeared to extend farther to oceanic waters as seen from the values of the outer contour line. From the concentration of eggs observed at the same time in a wide southern offshore belt, it is quite evident that there was wide-spread spawning in the area. However, the extension of the larval distribution indicates some northward transport of larvae from the southern spawning areas, which is quite possible due to the northward surface drift over the shelf during part of the pre-monsoon period.

1974 Monsoon season (Fig. 23)

A high concentration of larvae in the offshore areas from Kasaragod to Tuticorin was seen. The entire inshore belt from Vengurla to Tuticorin was however poor in larval abundance. The high core value in the dense belt south of Kasaragod was shifted further south than observed in the same season of the previous year and this extended from Quilon southwards in the offshore waters, touching the outer areas of the Wadge Bank. Northward from Kasaragod, a wide extension of larval distribution of moderate density (> 20 larvae/m^2) over the outer shelf and beyond was seen. The typical high concentration patches off Ratnagiri was evident during the season.

From the pattern of distribution of eggs at the same time, it was clear that there was wide dispersal of larvae towards offshore areas as observed before.

1974 Post-monsoon season (Fig. 24)

The larval concentration was relatively more extensive and denser than in the previous post-monsoon seasons studied, except in the limited nearshore areas between Kasaragod and Calicut and off Tuticorin. The major concentration was observed between Karwar and Cochin over the shelf and offshore waters. High value patches were observed in the offshore waters off Ratnagiri. The larval abundance indices appeared on the whole higher than those of eggs at the same period and wider in their distribution.

1975 Pre-monsoon season (Fig. 25)

The nearshore waters along the entire area from Ratnagiri to Tuticorin showed low (less than 10 larvae/m^2) densities but increasing concentrations were observed towards offshore region all along. High concentrations of larvae were observed on the outer shelf and beyond in the entire area. Best densities were observed in a narrow belt over the outer edge of the shelf between 10°30' N to 13° N and in an offshore pocket off Ratnagiri. Simultaneous picture of distribution of eggs showed high densities in the inshore waters from Cochin to Cape Comorin and as a narrow strip in the offshore waters off the Kasaragod - Quilon stretch of the coast. Fairly high larval concentrations were observed in a wide area off Cape Comorin, with the densities increasing sea-ward. However, the concentration of the larvae in the southern sector was relatively less dense than during the same period in the previous year.

1975 Monsoon season (Fig. 26)

Widespread high values of larval distribution with increased densities towards offshore were seen during the period. The inshore strip from Ratnagiri to Vengurla, Coondapur to Cochin and off Cape Comorin were low in larval density. There was a very wide belt (20 - 80 miles) of high density, ($>$ 100 larvae/m^2) from Tuticorin to Karwar, over the outer edge of the shelf and farther seawards. Relatively high values persisted seaward, as far as observations were made. A very high value concentration ($>$ 200/m^2) was observed in the offshore waters off the Cape Comorin - Tuticorin region. The area north of Karwar was less dense in larvae. The 1975 monsoon season had the highest density of larvae as well as eggs compared to the previous years, indicating intensive spawning during this season.

1975 Post-monsoon season (Fig. 27)

The entire shelf and contiguous offshore waters from Calicut to Tuticorin showed high values of larval concentration with the core value (> 200/m^2) centred south west of Quilon. Rather moderate densities prevailed in the area north of Calicut, except over the shelf off the Karwar - Vengurla region and the inshore area north of Vengurla. The outer shelf off Ratnagiri showed a patch of high density with lighter distribution farther seawards.

There was more or less a close overlapping in the distribution of eggs and larvae in this season and also a much denser larval distribution, south of Calicut to Tuticorin.

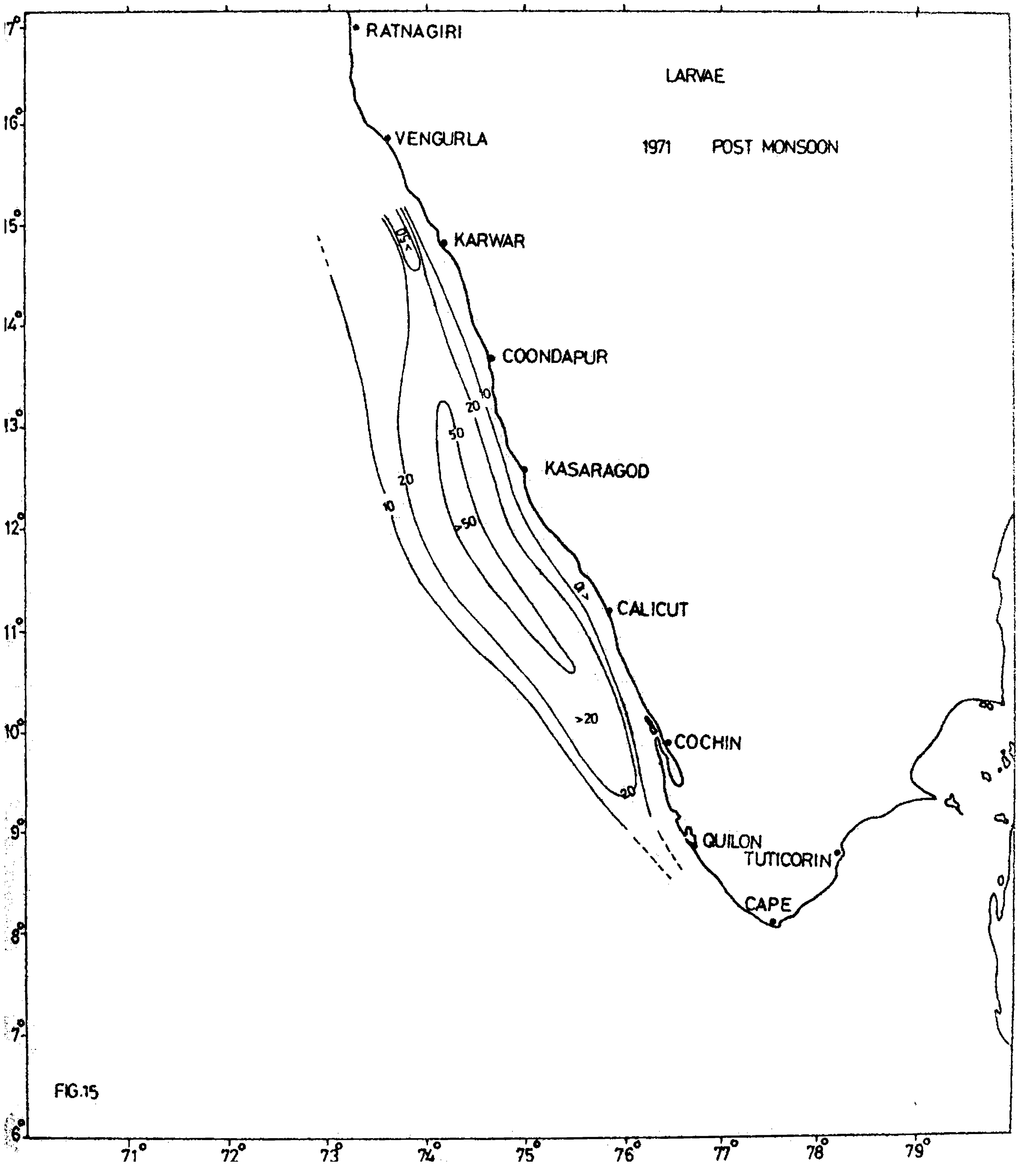
The general seasonal picture of the distribution of fish larvae during pre-monsoon season showed low to moderate values, with relatively higher concentrations in the southern areas, where again the nearshore values were low.

During the monsoon season the best concentrations of larvae were usually seen in areas south of Kasaragod (12° 30' N), the nearshore areas showing low values of density. The larvae showed wide seaward dispersal during the period with high density patches in the offshore waters off Ratnagiri. The post-monsoon season presented low densities of larvae in the inshore areas, while wide-spread and relatively denser distribution were usually seen in offshore areas.

The distribution and abundance of fish larvae point to the same conclusion arrived at from the distribution of fish eggs, that the major spawning activity of the fishes along the SW coast of India is during the monsoon period, which partly spreads on either side; the pre-monsoon and post-monsoon periods. The distribution of eggs and larvae do not overlap strictly in density gradients. It is seen that there is a wide dispersal of larvae from the points of spawning to offshore waters and to the southern sector particularly during the Monsoon and Post-monsoon periods, when the surface current along the SW coast is towards the south.

Fig. 15 - 27

SEASONAL DISTRIBUTION AND ABUNDANCE OF FISH LARVAE - SEPTEMBER, 1971 TO DECEMBER, 1975.



LARVAE
1971 POST MONSOON
RATNAGIRI
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COONDAPUR
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CALICUT
COCHIN
QUILON
TUTICORIN
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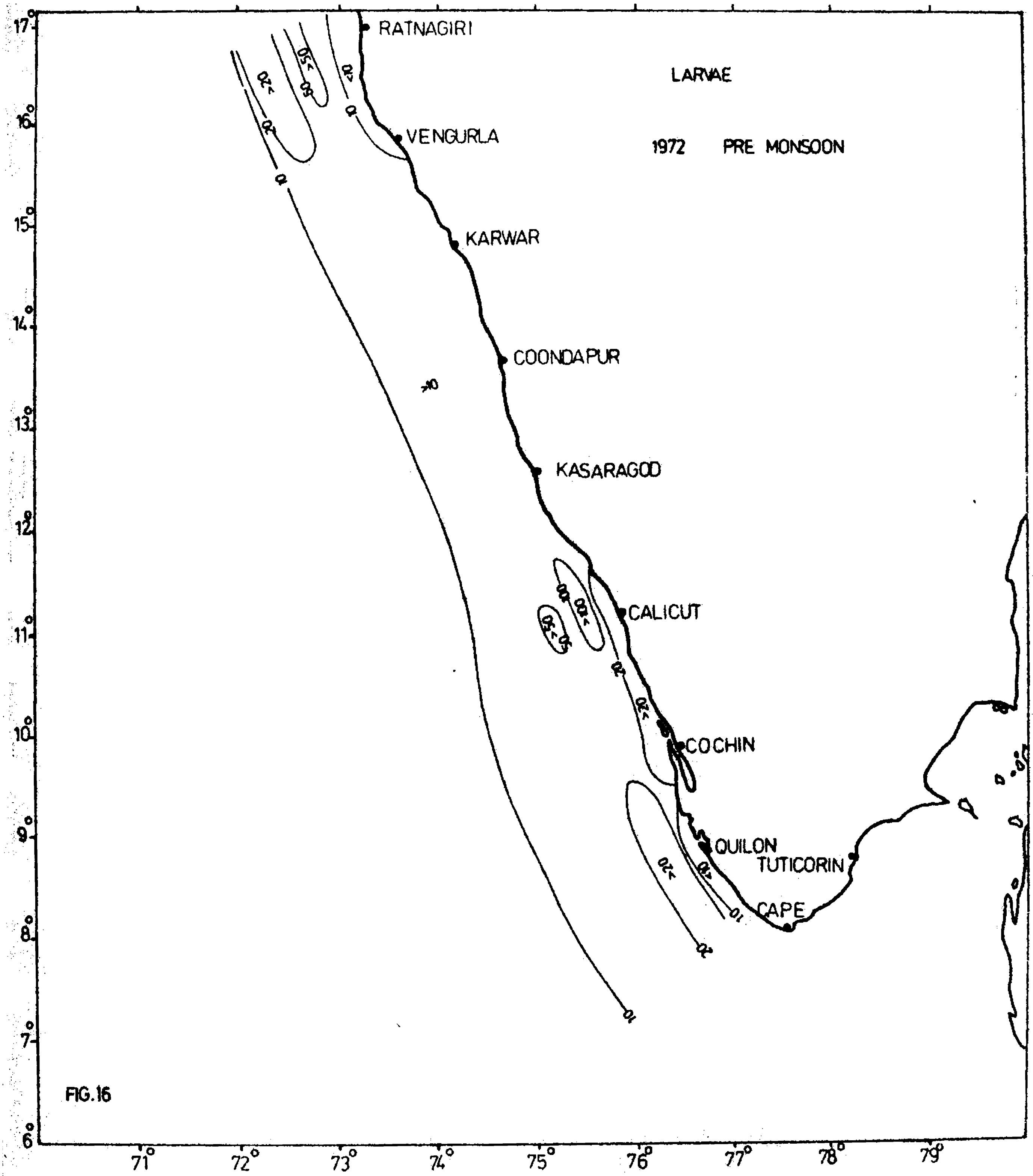
FIG.15


RATNAGIRI
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COONDAPUR
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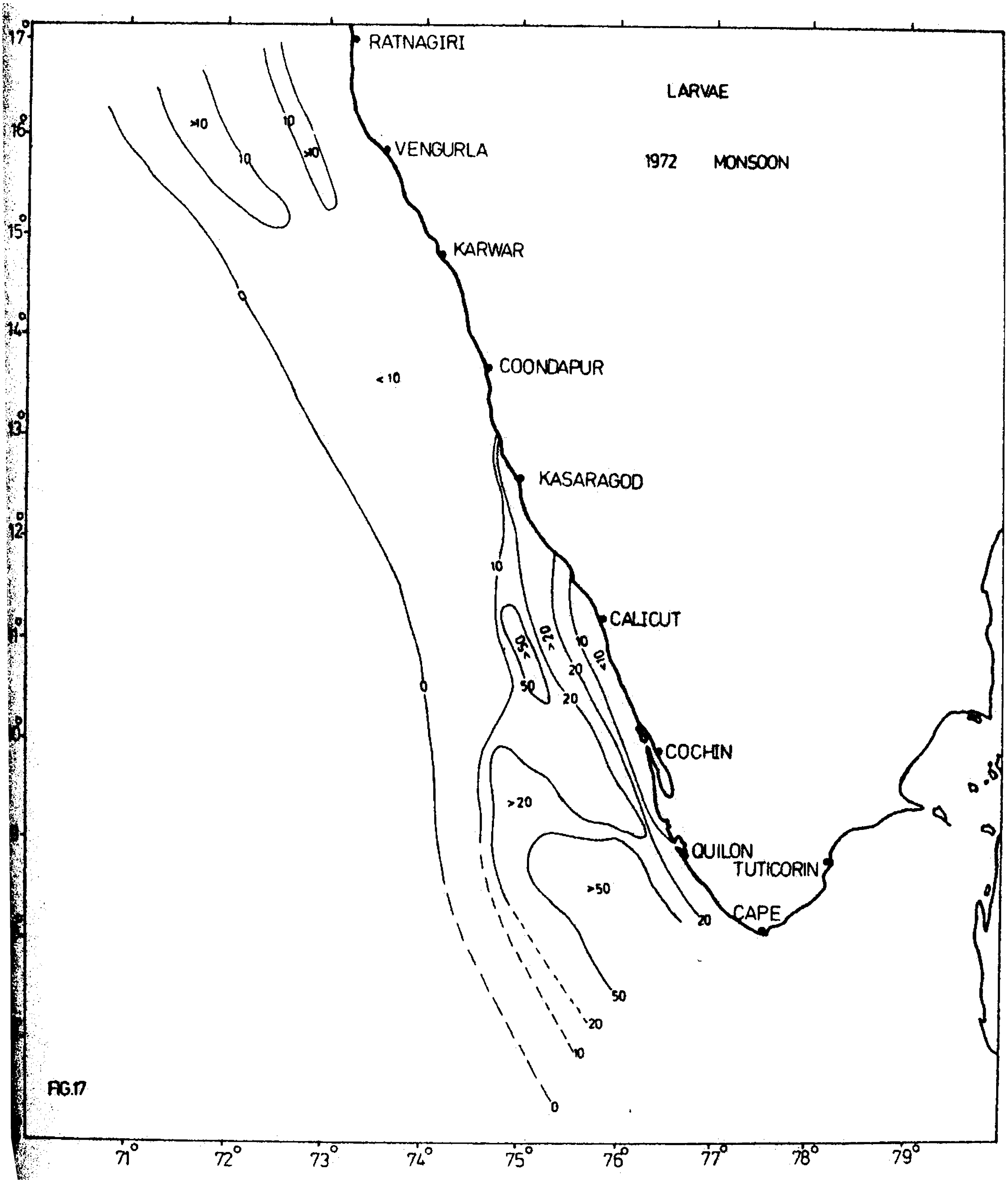
FIG.16



RATNAGIRI
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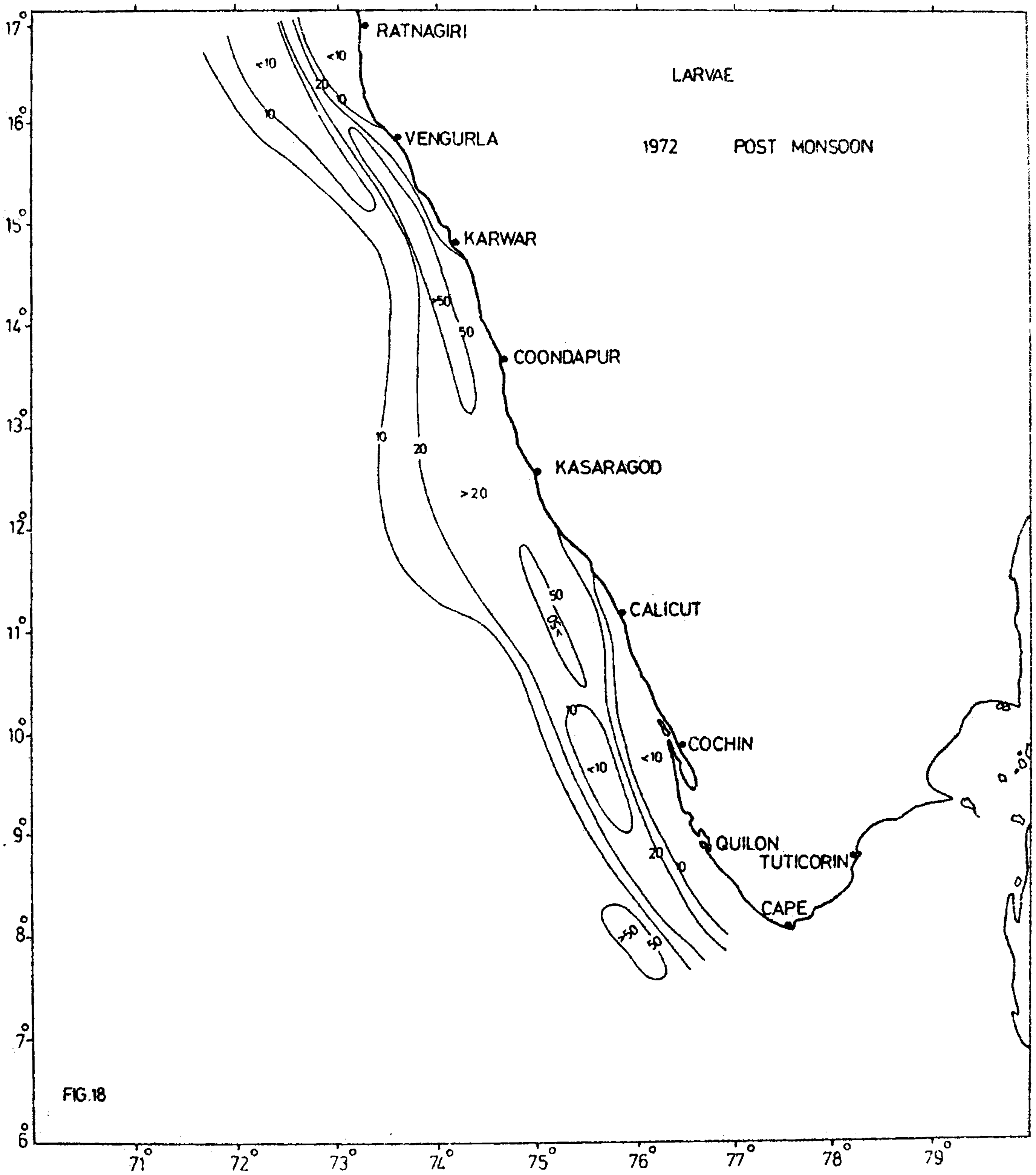
FIG.17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LARVAE
VENGURLA
1972 POST MONSOON
KARWAR
COONDAPUR
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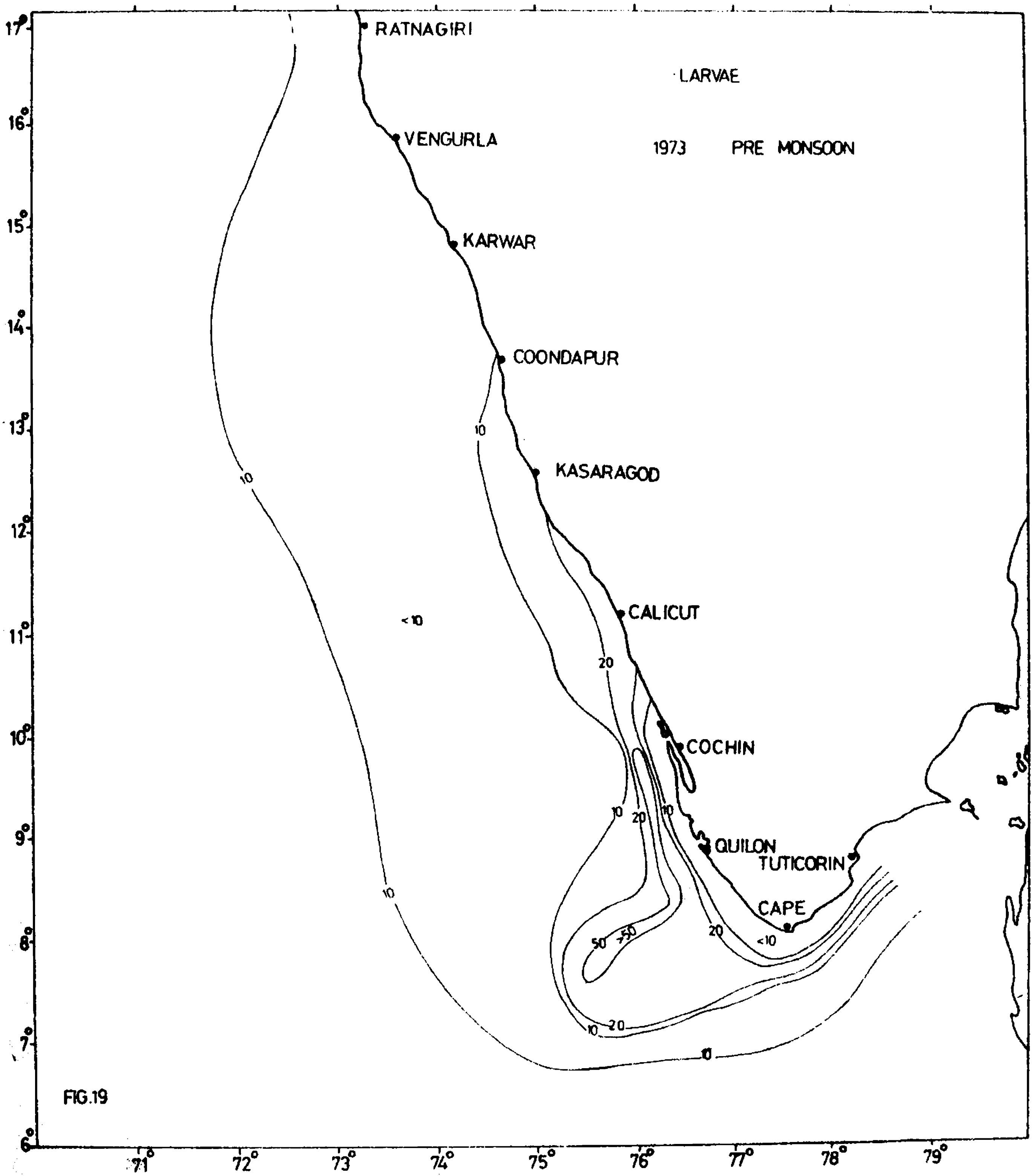
FIG.18



LARVAE
1973 PRE MONSOON
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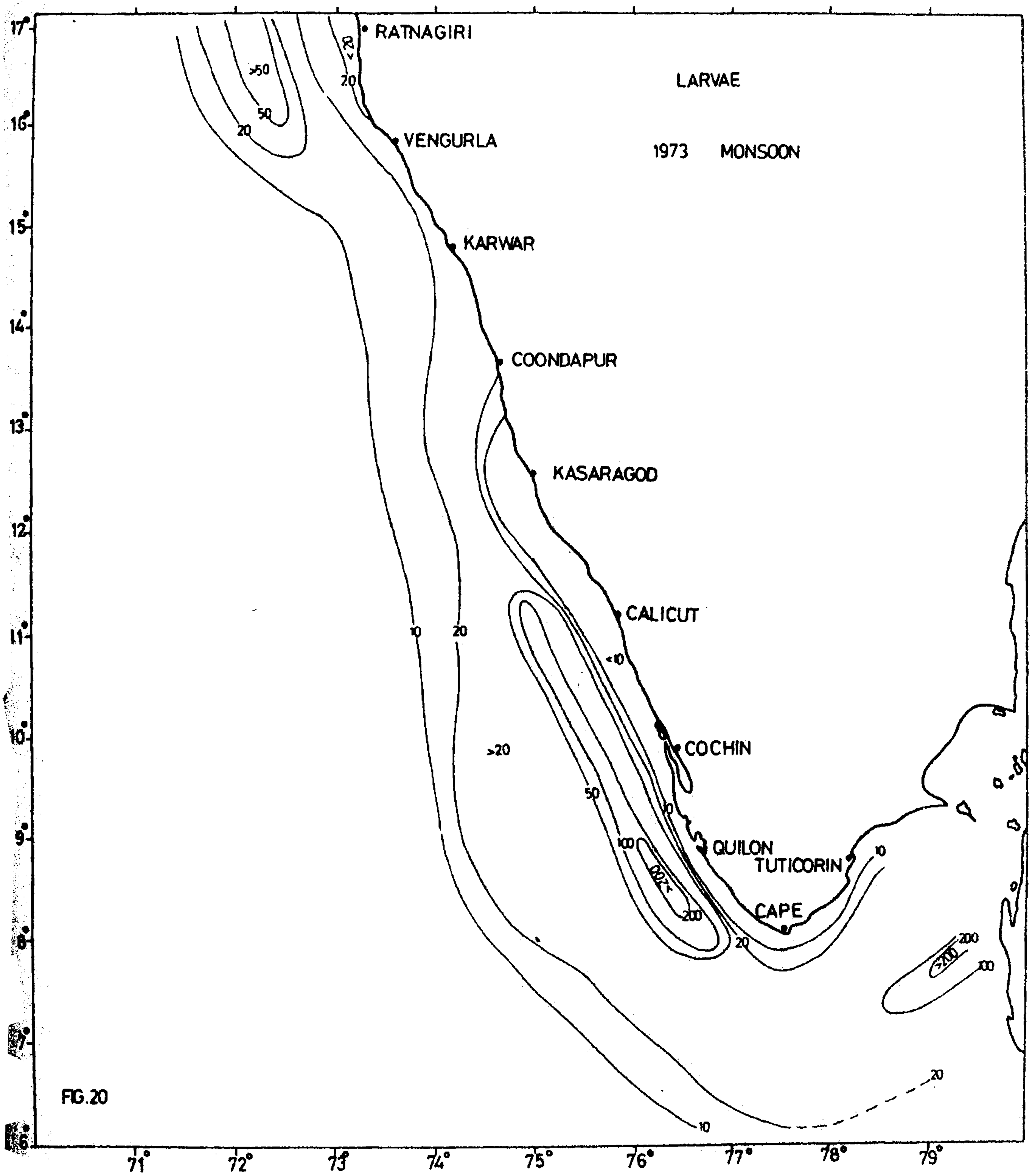
FIG.19



LARVAE
1973 MONSOON
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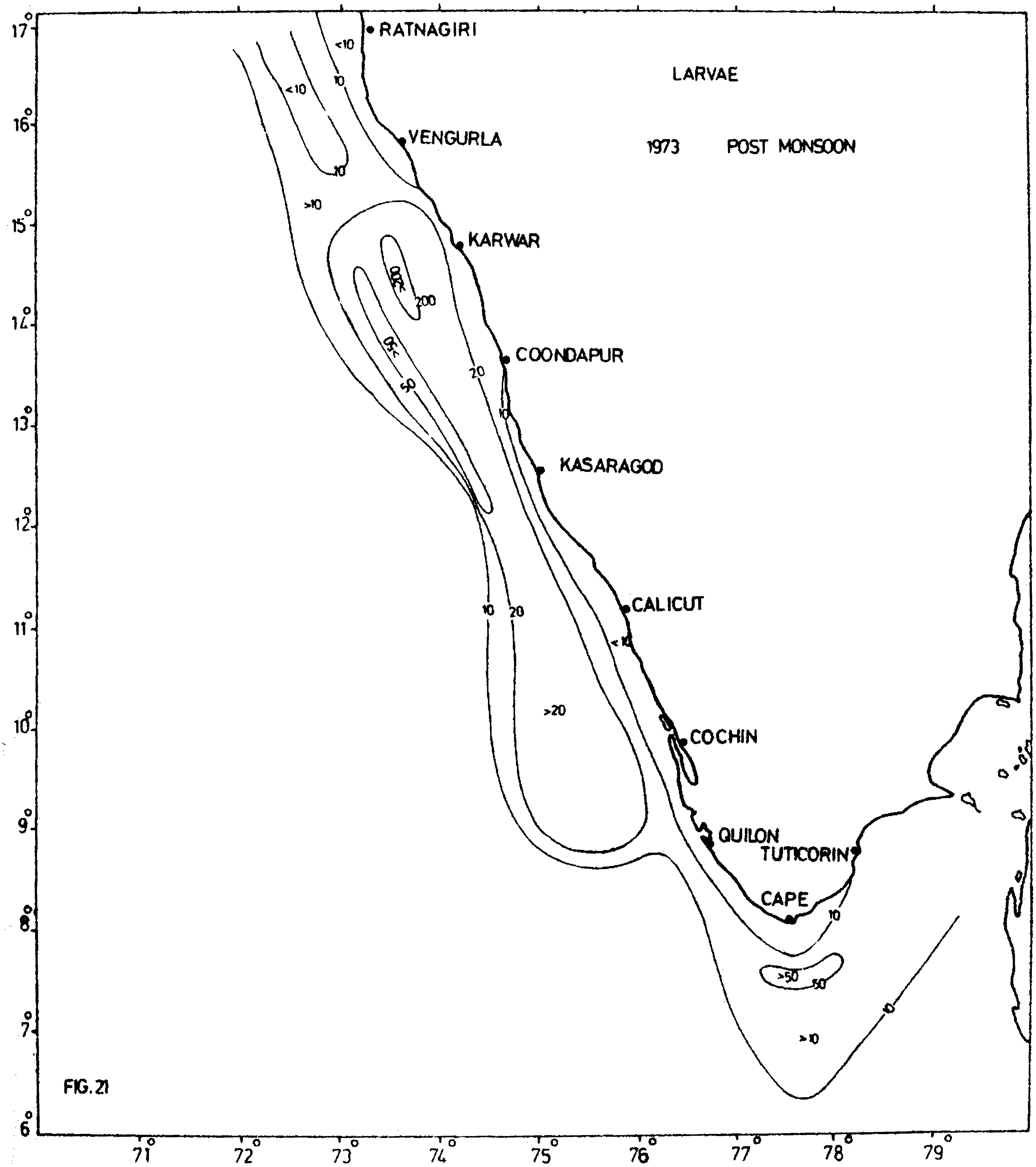

LARVAE
1973 POST MONSOON
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QUILON
TUTICORIN
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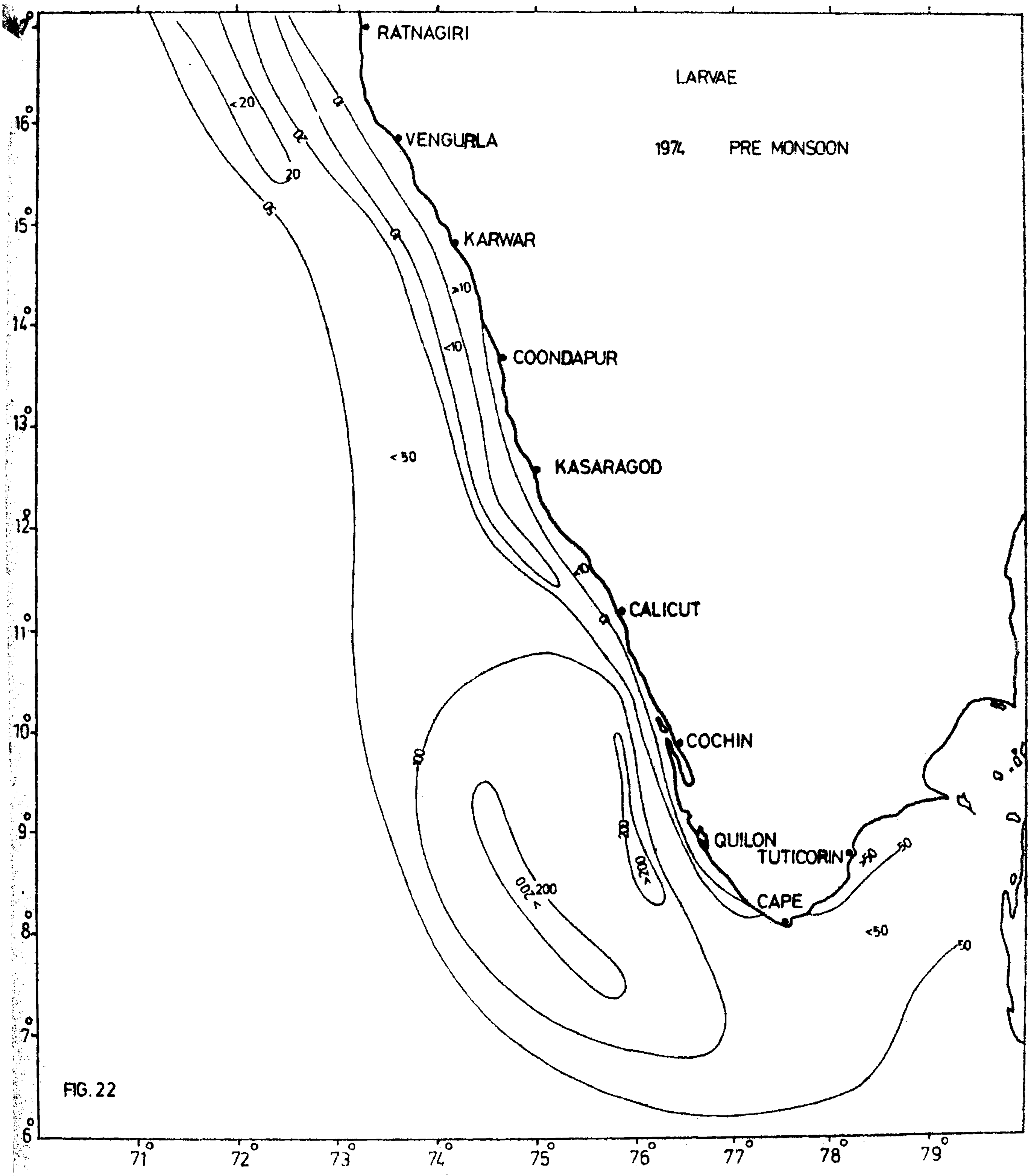
FIG. 21



RATNAGIRI
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FIG. 22

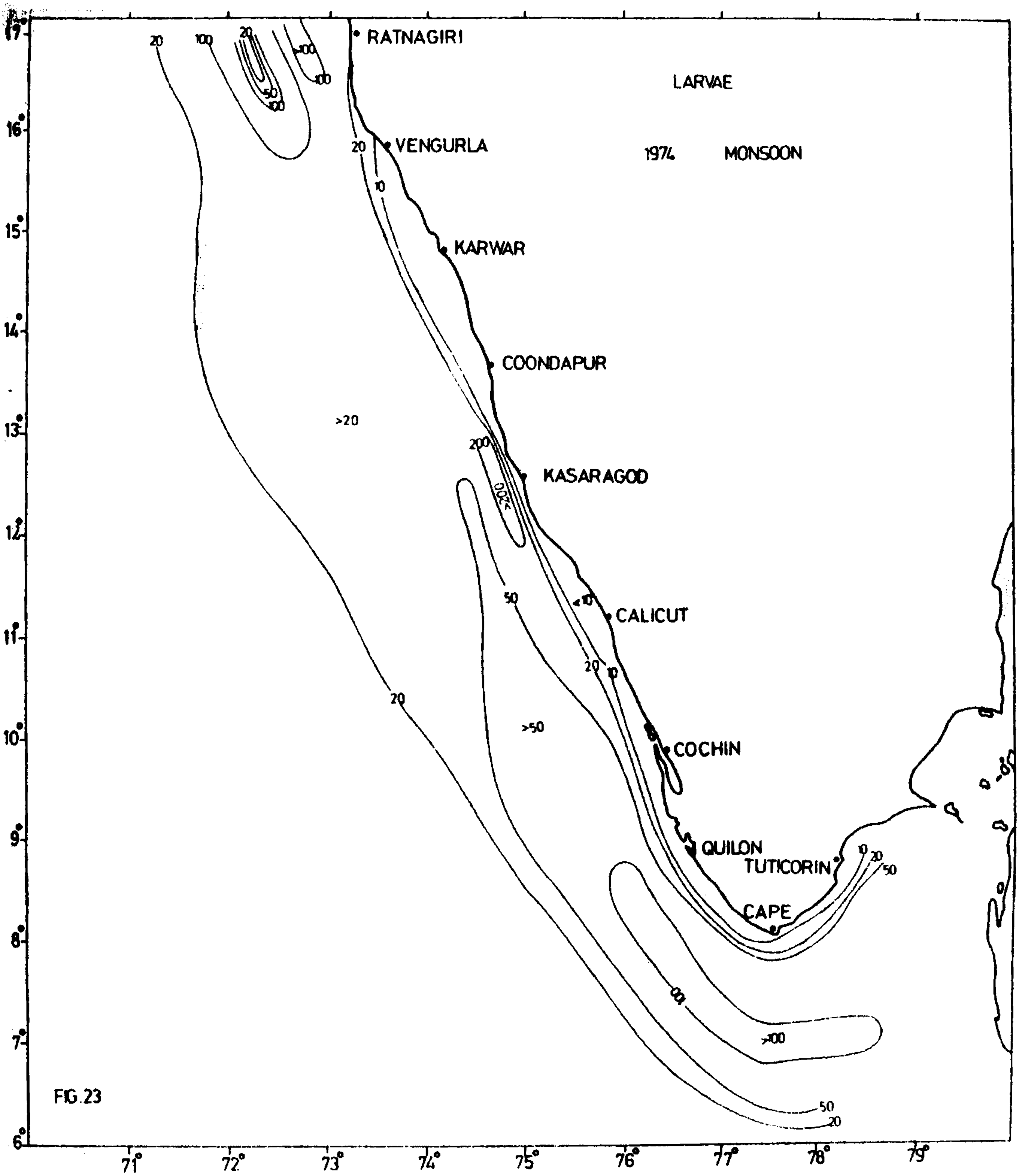

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FIG.23

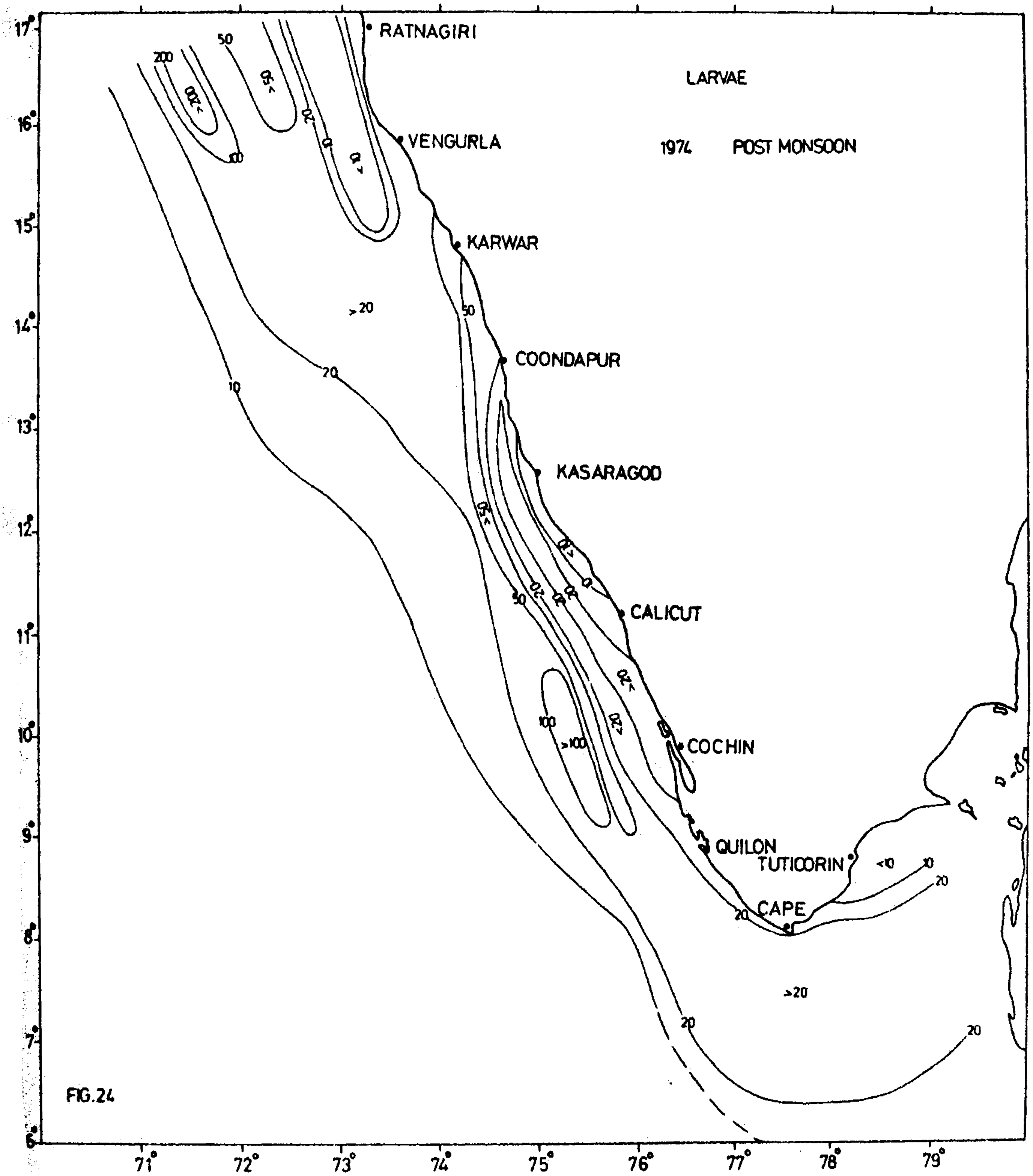
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FIG.24

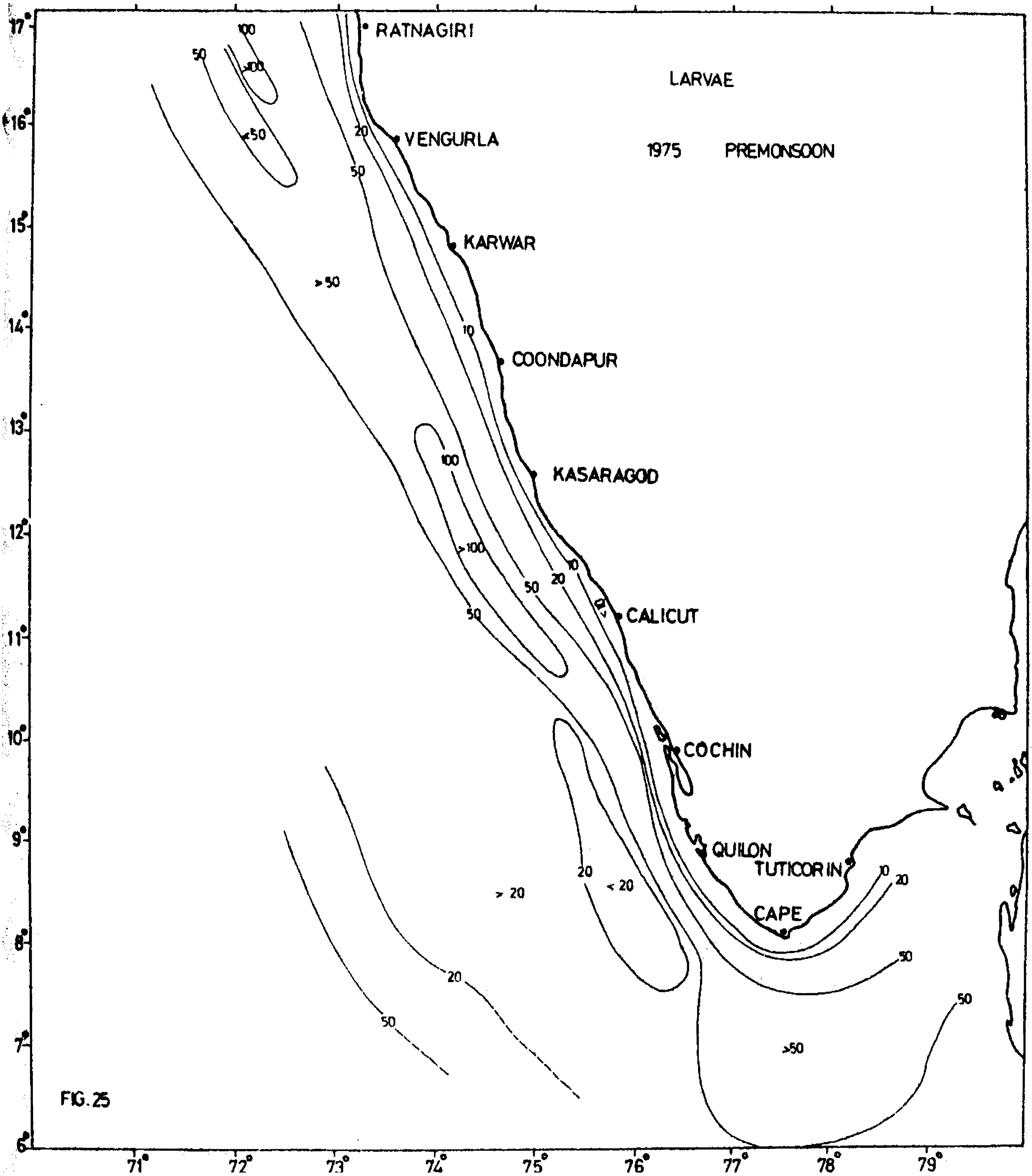
LARVAE
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FIG. 25

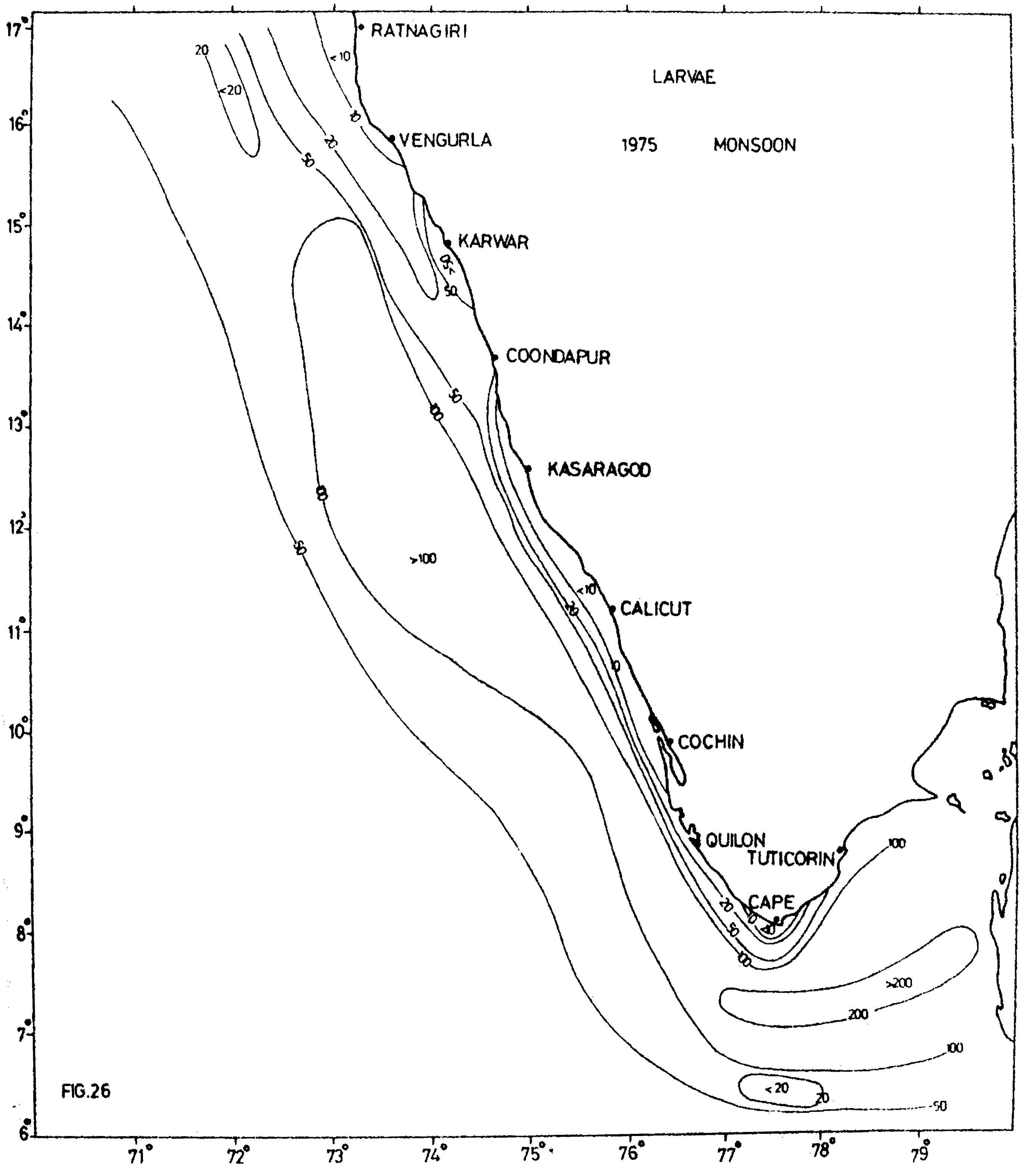
LARVAE
1975 MONSOON
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FIG.26

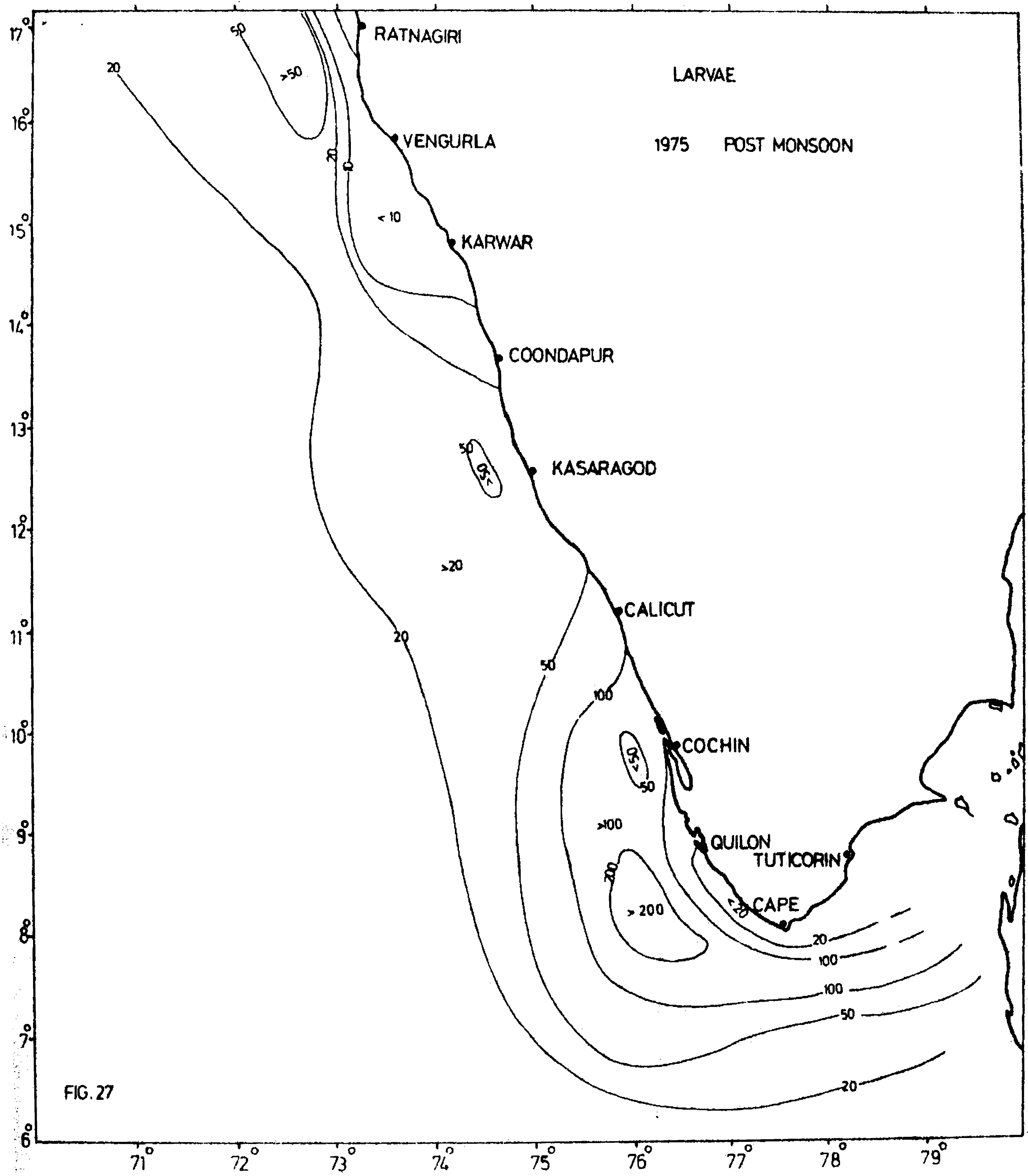
LARVAE
1975 POST MONSOON
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FIG. 27

THE SCOMBROID LARVAE

5.1 Scombroid fishes of the Indian waters with special reference to SW coast of India

The important contributions to the systematics and fisheries of Indian scombroids are those of Jones and Silas (1960, 1961, 1963 a, 1964), Jones (1967 b), Silas (1967), Silas and Rajagopalan (1967) and Nair (1970). Fischer and Whitehead (1974) dealt with the identification of Scombroidae occurring in the Eastern Indian Ocean with illustrations emphasising the important taxonomical features. The nomenclature of the various species followed here is based on this last cited work, except when mentioned otherwise.

A list of the confirmed records of scombroid fishes from the Indian waters based on the cited literature (Section 5.1) are given in Table - 5.

In addition to the species tabulated, there are others which are either expected to be present in the Indian seas due to their occurrence in the nearby contiguous areas or reported from the Indian seas by foreign fishing vessels. In this category Jones and Silas (1960) include the dotooth tuna *Cybiosarda* elegans*

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*Nomenclature after Jones and Silas, 1964.

(Whitley), the oriental bluefin *Thunnus** (Thunnus) *orientalis* (Temminck and Schlegal) and the albacore *T. (Thunnus)** *alalunga* (Bonnaterre), the last two having been mentioned in the tuna catch records of Japanese vessels from Indian seas (Mimura *et al.* 1963).

5.2 Scombroid fishery of the SW coast of India

Jones (1967) gave a brief account of the scombroid fishery of India. The major scombroid fishery of India is sustained by the Indian mackerel (*Rastrelliger kanagurta*). On an average, 90% of the mackerel catches are landed along the SW coast. *R. faughni*, observed in small numbers on the east coast (Gnanamuthu, 1972), is not recorded from the SW coast. Next to the mackerel, seerfishes (*Scomberomorus* spp.) form a significant component of the scombroid fishery. *S. commerson* and *S. guttatus* are more common than *S. lineolatus*. In addition to the seerfishes, the wahoo (*Acanthocybium solandri*) is caught occasionally in small numbers in the Gulf of Mannar and the contiguous regions of peninsular India. The little tunny (*Euthynnus affinis*), the frigate mackerels (*Auxis* spp.), mainly *A. thazard* and the oriental bonito *Sarda orientalis* are the components of the coastal tuna

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*Nomenclature after Jones and Silas, 1964.

fishery of the area. The northern bluefin *Thunnus tonggol* is caught in the coastal waters of the west coast and SE coast. The skipjack tuna (*Katsuwonus pelamis*) is predominantly caught in the Laccadives and also stray into the coastal waters of the SW coast. The yellowfin (*Thunnus albacares*) contribute a small share in the Laccadive tuna fishery.

There is virtually no fishing for billfishes along the SW coast of India. This group, mainly represented by the sailfish (*Istiophorus gladius*) and marlins (*Tetrapturus* spp. and *Makaira* spp.) are caught occasionally in the Gulf of Mannar.

The relative magnitudes of the contribution of the major groups of scombroids in the Indian fisheries are reflected in a typical year's landings* (1978) given below:

Mackerel	-	85233	tonnes
Seerfishes	-	20779	"
Tunnies	-	13893	"

*Figures from *Mar.Fish.Infor.Serv.* *T & E Ser.* 9 1979, CMFRI.

Table - 5

Scombroid fishes recorded from Indian waters

Sl. No.	Scientific name	Popular name	Areas of occurrence in the Indian seas - Remarks.
1	2	3	4
1.	*Auxis thazard* (Lacepede)	Short corseletted frigate mackerel	(Syn. *A. tapeinosoma*) West and East coasts Laccadives.
2.	*Auxis rochei* (Risso)	Long corseletted frigate mackerel/ Bullet mackerel.	(Syn. *A. thynnoides*) West and East coasts.
3.	*Sarda orientalis* (Temminck & Schlegel)	Oriental bonito.	West coast, SE coast.
4.	*Grammatorcynus bicarinatus* (Quoy and Gaimard)	Double lined mackerel	Andamans
5.	*Gymnosarda* unicolour (Ruppell)	Dogtooth tuna	Minicoy, Andamans.
6.	*Thunnus obesus* (Lowe)	Bigeye	(Syn. *Parathunnus mebachi*, *P. sibi*) Laccadives and Japanese records from Indian seas.
7.	*Thunnus tonggol* (Bleeker)	Northern bluefin/ longtail tuna.	West coast, SE coast, Andamans.
8.	*Thunnus albacares* (Bonnaterre)	Yellowfin	Syn. *Neothunnus macropterus* West coast, SE coast, Laccadives.
9.	*Katsuwonus pelamis* (Linnaeus)	Skipjack	West coast, SE coast, Laccadives.
10.	*Euthynnus affinis* (Cantor)	(Eastern) Little tuna	West and East coasts.

1	2	3	4
11.	*Rastrelliger kanagurta* (Cuvier)	Indian mackerel	West and East coasts.
12.	*R. brachysoma* (Bleeker)	Chub mackerel	Andamans
13.	*R. faughni* Matsui	Faughn's mackerel	East coast
14.	*Scomberomorus commerson* (Lacepede)	Narrow barred Spanish mackerel	*Scomberomorus* spp., known as seerfishes in India. West and East coasts, Andamans
15.	*S. lineolatus* (Cuvier)	Streaked Spanish mackerel	West and East coasts.
16.	*S. guttatus* (Bloch & *Schneider*)	Indo-pacific spanish mackerel	West and East coasts, Andamans.
17.	*Acanthocybium solandri* (Cuvier)	Wahoo	SW coast, Minicoy, Andamans.
18.*	*Istiophorus gladius* (Broussonnet)	Sailfish	West coast, SE coast.
19.*	*Tetrapturus audax* Philippi	Striped marlin	SE coast, Andamans.
20.*	*T. tenuirostratus* Deraniyagala	Indian long-nosed spearfish	-do-
21.*	*Makaira indica* (Cuvier)	Black marlin	-do-
22.*	*M. nigricans* Lacepede	Blue marlin	-do-
23.*	*Xiphias gladius* Linnaeus	Swordfish	Laccadives

*Nomenclature after Jones and Silas, 1964.

5.3 The scombroid larvae in the present collections, their sorting and identification

The scombroid larvae in the present collections included mostly those of *Auxis* spp., *Rastrelliger kanagurta*, *Katsuwonus pelamis*, *Euthynnus affinis* and of *Thunnus* spp. One post larva each of *Scomberomorus commerson*, *Xiphias gladius* and *Istiophorus gladius* were found in the collections. Larvae of *Sarda orientalis* and *Acanthocybium solandri* have not been identified from the collections, eventhough adults of both the species occurred in the area, with the former supporting a seasonal coastal fishery. The larvae of *Auxis* spp. (*A.thazard* and *A.rochei*) have not been identified to specific level in the present study. *Auxis*, type-I and type-II (Matsumoto, 1959) larvae were met with, but they could not be assigned to the species. Larvae of *Thunnus* spp. also have not been identified to specific level. Some of these could perhaps be assigned to *T.albacares*, but it is felt that there is a possibility of *T.tonggol* and *T.obesus* larvae also occuring among them.

Looking at the relative frequencies of occurrence of the major scombroid larvae in the collections (Table - 6) it is seen that larvae of *Auxis* spp.dominated followed by those of *Rastrelliger kanagurta*. Among the major tunas, the larvae of *Katsuwonus pelamis* were available more than those of *Euthynnus affinis* and *Thunnus* spp. In terms of the numbers of larvae caught also, *Auxis* spp. by far dominated all the other scombroid larvae.

Sorting and identification of larvae

For classifying the various scombroid larvae in the collections, published descriptions and illustrations from the Indian region and from other areas have been relied upon.

For the identification of the young stages of the mackerel, the well illustrated publications of Matsui (1970), Peter (1969 a), Balakrishnan and Rao (1971), Silas (1974), Boonprakob and Debtaranon (1974) and Vatanachai (1974) have been particularly useful. With regard to the identification of tuna larvae, the descriptions and illustrations of Mead, 1951, Matsumoto (1958, 1959, 1962), Matsumoto et al (1972), Yabe (1955), Ishiyama and Okada (1957), Mimura (1963), Ueyanagi (1964 a, 1966, 1974), Yabe and Ueyanagi (1962 a), Ueyanagi et al (1963), Ueyanagi and Ahlstrom (1963 c), Jones (1959 b, 1960 a, b, 1963 a), Jones and Kumaran (1964 b) and Richards and Potthoff (1974) have been mainly consulted.

Contributions of Pinkas (1961), Klawe (1961) and Gorbunova (1963) have been useful for the taxonomical considerations of bonito larvae and of Jones (1962), Jones and Kumaran (1964 b) and Gorbunova (1965 b) for the seerfish larvae.

In identifying the billfish larvae contributions of Arata (1954), Gehringer (1956), Jones (1958, 1959 a, 1959 c), Jones and Kumaran (1964 a, b) and Ueyanagi (1963, 1964 a, 1974) have been referred to.

Illustrations and descriptions of Strasburg (1964) and Matsumoto (1968) have been useful in looking for the larvae of the wahoo (Acanthocybium solandri).

While the above cited references on the different scombroid larvae were directly accessible to the author, several others (Wade, 1951, Ueyanagi 1963, 1964 b, 1966, 1969, Schaefer and Marr, 1948 a, Matsui, 1963, Boonprakob, 1965, Nakamura et al 1951, Yabe 1951, Yabe et al 1959, Yabe and Ueyanagi, 1962 b, Nakamura et al, 1968 and Wollam 1969) have been consulted only as cross references.

5.4 Present status of the taxonomy of young stages of scombroid fishes

A good amount of work has been carried out on the early life-history of scombroid fishes, particularly of the family scombridae (mackerels, tunas and other closely related species). This is evident from the recent bibliography published on this subject, covering the period from 1880-1970 (Richards and Klawe, 1972).

The generic identification of the young stages of Thunnus, Katsuwonus, Euthynnus, Auxis, Rastrelliger, Scomber, Allothunnus, Acanthocybium, Sarda, Scomberomorus and Grammatorcynus are fairly clear, eventhough only few records are available in the case of Allothunnus, Acanthocybium, Sarda and Grammatorcynus. Identities of the larvae of Cybiosarda, Gymnosarda and Orcynopsis are poorly understood (Richards and Potthoff, 1974).

The specific identity in case of some of the genera of scombroids is clear beyond doubt, due to their monotypicity eg. Katsuwonus pelamis, Xiphias gladius, Acanthocybium solandri. Specific identities of the larvae of Scomberomorus and Auxis need to be further clarified. Because of their close similarity, the larvae of some species of Thunnus also need to be studied further to establish clearly the specific characters.

Of the billfishes, consisting of two families Istiophoridae and Xiphiidae, the taxonomy of even the adults of the former need some clarification. The family Xiphiidae includes the only species Xiphias gladius. At least five species of istiophorids occur in Indian waters (Jones and Silas 1964, Silas and Rajagopalan, 1967).

The identities of the larvae of Xiphias gladius, Istiophorus gladius, Tetrapturus spp. and Makaira spp. are fairly clear (Yabe, 1951, Jones and Kumaran, 1964 a, Ueyanagi, 1959, 1974, Ueyanagi and Yabe, 1959).

5.5 Taxonomic notes on Scombroid larvae

5.5.1 The larvae of the Indian mackerel

Balakrishnan (1957) recorded pre-larvae ascribed to R.kanagurta from Vizhinjam, near Trivandrum. Matsui (1970) expressed the opinion that "Balakrishnan's pre-larvae 2.8 mm to 5 mm are too large to be a Rastrelliger". Peter (1969 a) described 3 larvae of Rastrelliger sp. 2.7, 3.1 and 5.3 mm total length collected from Persian Gulf, Red sea and Bay of Bengal respectively during the IIOE. Silas (1974) published an illustrated detailed account of R.kanagurta larvae (1.73 to 8.6 mm) from the

SW coast of India. Girijavallabhan and Gnanamuthu (1974) recorded one larva of *Rastrelliger* sp., 2.98 mm total length from the inshore waters of Madras.

Over 500 young stages of *Rastrelliger* from 1.75 to 11.7 mm were obtained in the present collections. These material closely agree in their morphology and pigmentation pattern with the larvae of *R.kanagurta* described by Silas (1974). The larvae of *R.kanagurta* described by him lack melanophores at the base of second dorsal, even in specimens upto 8.6 mm total length, while in the larval *Rastrelliger* of Matsui (1970) from Thailand, melanophores are present from about 6 mm length. In the *R.neglectus* larvae illustrated by Boonprakob and Debtaranon (1974), about 10 melanophores in a row are indicated at the base of the soft dorsal fin of the larvae of 8 mm total length.

In some of the present *Rastrelliger* larvae measuring 6.6 mm and above in total length, about 8 or more pigment spots in a row are observed in the dorsal margin of the body at the base of soft dorsal. The value of this pigmentation as a possible specific character as indicated by Silas (1974) however, needs further checking.

In the case of fish larvae, where specific differences are not clearly established, availability of a good series of young stages upto the juvenile and knowledge of the distribution of the adults are important criteria for indicating specific identity. On this basis, as well as due to their striking similarity to the larvae of R.kanagurta already described from the SW coast of India (Silas, 1974), the present larvae of Rastrelliger are assigned to R.kanagurta (Fig. 49, photographs). No other species of Rastrelliger are recorded from this area or the Gulf of Mannar.

The salient diagnostic characters of Rastrelliger larvae can be summarised as follows, based on the study by the previous authors cited above and from the present observations:

- characteristic short bodied larvae with about 31 myotomes
- anus placed well forward
- Larval fin-fold begins at the occiput
- Lack pre-opercular spines (unlike the larvae of tunas)
- A post vent row of melanophores along the ventral margin of the body, reaching upto the urostyle.

5.5.2 Larvae of the frigate mackerels

Two species of frigate mackerels are recorded from Indian waters, namely Auxis thazard and A.rochei. A.thazard is more common in the seasonal fishery of the Indian coasts and is recorded from various parts of the west coast, from Gujarat to Cape Comorin and from Tuticorin on the East Coast and also from the Laccadive sea. A.rochei (Syn. A.thynnoides and A.tapeinosoma) has been recorded from different centres of the SW coast from Mangalore to Cape Comorin (Jones and Silas, 1964). Jones (1960 b) described larvae of Auxis sp. from the Laccadives sea. The 9 specimens collected from plankton during January and April, 1959 ranged from 3.36 to 7.94 mm in total length. Subsequently Jones (1963 a) described two types of Auxis larvae of the Dana collection from the Indian Ocean (December, 1929 - January, 1930) and provisionally assigned them to A.thazard and A.thynnoides (Syn. A.rochei). Of these larvae, one type is stout with slightly longer head (length of body less than 3 times the head) and the second type is elongate with smaller depth of body and shorter head (body about 3 times the head) and with the mid-ventral row of pigments on the caudal peduncle less prominent. In this latter type the spinous dorsal was noticed to develop late.

Matsumoto (1958) described *A.thazard* larvae based on material collected from equatorial and Hawaiian waters, as well as from East and West Indies and the Gulf of Panama. Later, Matsumoto (1959) distinguished two types of *Auxis* larvae, after examining material from Pacific, Atlantic and Indian ocean, west of Sumatra and Java, the stout *Auxis*, type-I (*A.thazard* type) and the elongated *Auxis*, type-II. The *Auxis* type-II larvae of Matsumoto (1959) and the elongated type of *Auxis* larvae described by Wade (1951) from the Phillipine sea are suggested to belong to *Auxis thynnoides* (Jones, 1963 a).

The two *Auxis* post-larvae figured by Mead (1951) as *A.thazard* from the Pacific coast of Central America are the stout type (Jones, 1963 a). Jones and Kumaran (1964 b) have reproduced the figure of an elongated type of *Auxis* larva, 8.1 mm, described by Yabe and Ueyanagi (1961) as *A.thynnoides*, but its mid-lateral pigment line appears clear as on the stout type.

Matsumoto (1959) however comments that the most obvious difference between the two types of *Auxis* larvae is the variation in pigmentation in the caudal peduncle region of specimens upto 8 mm total length. In specimens larger than 8 mm, the 3 rows of pigments seen in type-I extend anteriorly with increasing number of chromatophores. Type-II larvae of comparable sizes were not observed by Matsumoto (1959) and it is believed that both types assume similar external appearance above this size. Matsumoto (1959) also observed extreme inconsistency of pigmentation at the mid-lateral line. In many specimens he observed 1 - 5 chemotophores on one side of the body but none on the other side. According to Matsumoto (1959) "such a wide variation in pigmentation between the two sides of the same fish renders the separation of Auxis into types I and II rather doubtful. Judging on this basis and also on the fact that the type-II series stopped at about 8 mm one may conclude that the two types are merely variants of a single species".

It may be mentioned here that the maximum length (T.L) of Auxis thynnoides larvae (type-II) examined by Jones (1963 a) is 8.68 mm, while that of A.thazard (type-I) is 14.42 mm.

The Auxis larvae may be distinguished from other tuna larvae mainly on the basis of the following characters:

- Tuna larvae with a relatively elongate body.
- Presence of two or more rows of chromatophores in the region of the caudal peduncle.
- A pigment spot at the symphysis of the pectoral girdle.

- 39 myotomes
- A single pigment spot anterior to anus may be present. (Also noticed in *Euthynnus yaito* larva)
- The relatively small number of spines, less than 9 or 10 in the first dorsal fin in older larvae.
- Paucity of chromatophores in the first dorsal fin.

The *Auxis* larvae of the stout type have been more common in the present collections. However, some elongate type larvae have also been encountered along with the former. In view of the uncertain specific identity of *Auxis* larvae, in the present study on the distribution and abundance, all the *Auxis* larvae are treated together.

5.5.3 Larvae of other tunas

Skipjack tuna

Katsuwonus pelamis found in all the major oceans of the world sustains a significant fishery in the Laccadives and marginal coastal fisheries along the West and East coasts of India. Yabe (1955), Ishiyama and Okada (1957) and Matsumoto (1958) described larvae of skipjack from the Pacific. Wade (1951) described the larvae from Phillippine waters and Gorbunova (1965) from the Indian ocean. Jones (1959 b) recorded 38 larvae of the length range of 2.63 to 7.08 mm from the Laccadives sea and described with illustrations, a series of 5 young stages from 2.97 mm to 27 mm. Achari and Vincent (1972) have recorded larvae and juveniles measuring from 4 mm to 25 mm (S.L), from the coastal waters off Trivandrum. During the present survey, skipjack larvae occurred in 45 stations accounting for 93 larvae.

Little tuna

Euthynnus species are found in the Atlantic (*E.alleteratus*), the Pacific (*E.yarito*, *E.lineatus*) and the Indian ocean (*E.affinis*). The specific identities of *E.affinis* and *E.yarito* are still under discussion. Collette and Gibbs (1963) considered *E.yarito* as a synonym of *E.affinis*. Jones and Silas (1964) after examining a specimen of *E.yarito* from Hawaii found difficult to distinguish it from *E.affinis* and suggested that they may be synonymous.

Mastumoto (1958, 1959) described the larvae of *E.yarito*, *E.alleteratus* and *E.lineatus*. Jones and Kumaran (1963) reported 179 larvae (4.6 to 12.7 mm) of *E.affinis affinis* (= *E.affinis*) from *Dana* collection from the Indian ocean. Gorbuneva (1963) described larvae of *E.alletteratus* from Gulf of Aden and *E.affinis* from Bay of Bengal from the *Vitiaz* collections.

The smallest stage of Euthynnus affinis previously described (Jones, 1960 b) from Vizhinjam has a total length of 29.5 mm. Altogether 82 specimens (24.5 - 321.5 mm S.L) were available in the above collection which included some specimen from Calicut also. All specimens collected in January and May were 75 mm or below in standard length. The smallest was collected in May (Jones, 1960 a). Euthynnus larvae isolated from the present collections (3.0 to 12.8 mm T.L) are assigned provisionally to Euthynnus affinis based on the description and illustrations of larvae of E.yavito (Matsumoto, 1958, 1959) which is considered to be either synonymous or very close to Euthynnus affinis of Indian waters (Williams, 1963 b). The present collection of E.affinis larvae came from 29 stations of the surveyed area and accounts for a total of 89 larvae.

Thunnus spp.

Mainly two species T.albacares and T.tonggol are caught in the Indian waters. There is also mention of the presence of T.obesus in Indian seas in the Japanese fishing records. One tuna collected from the Laccadives sea has been indicated as a bigeye (Parathunnus obesus mebachi = T.obesus) by Jones and Silas (1960).

T.albacares is distributed in the warmer parts of the Indian and Pacific oceans and is caught in small numbers from the Laccadives sea. Matsumoto (1958) described the larvae of Neothunnus macropterus (= T.albacares) from the central pacific. Jones (1959 b) recorded 35 larvae of Neothunnus macropterus from the Laccadives sea, ranging in size from 3.88 to 9.54 mm total length and one early juvenile 10.56 mm total length from the Gulf of Mannar.

T.tonggol sustains seasonal fisheries along the west coast and SE coast. It is also recorded from the Andamans. There are no records of T.tonggol larvae from Indian waters. Matsumoto (1962) described the larvae of K.tonggol and illustrated one larva, 6.94 mm total length, from the Dana collections in the East Indies and Western Pacific.

T.obesus larva has not been recorded from Indian waters, one larva 6.05 mm (T.L) has been described and illustrated by Matsumoto (1962) from Dana collections from west of Sumatra, Sulu sea and Celebes sea. Gorbunova (1963) recorded 4 positive stations for T.obesus larvae in the Indian ocean, approximately between 1°N. and 18°S. Kume (1962) artificially fertilised ripe bigeye tuna from the Indian ocean and produced two larvae; one of the newly hatched larva measuring 1.5 mm in total length.

Thunnus larvae in the present collections are classified to generic level only and it is likely that the material contains more than one species. In all, 23 positive stations were observed for *Thunnus* spp., accounting for 56 larvae.

5.5.4 Larvae of the tunas of Indian waters, their diagnostic characters and a key for identification

The term tuna is generally used to include fishes of the genera, *Thunnus*, *Euthynnus*, *Katsuwonus* and *Auxis*. A detailed discussion of *Auxis* larvae has been made in section 5.5.2. Matsumoto (1959) and Matsumoto *et al* (1972) while discussing identification of young stages of tunas, state that it is difficult to separate larvae and post-larvae of tunas because the adult characters develop gradually and separately, some of them more rapidly than others. All individuals with less than the full fin ray counts, especially in the first dorsal fin are considered as larvae. This includes normally specimens less than 11 mm or less in total length, 12 to 18 mm specimens are considered as post-larvae. In specimens within the above size range, the anal opening, which on smaller individuals is situated at less than half the distance from the pelvic to the origin of the anal fin, is relocated near the anal fin. All young tuna larger than 18 mm are classed as juveniles.

Matsumoto (1958) has illustrated a typical tuna larva and given its general features. Tuna larvae are characterised by a large head, with opercular spines, a triangular visceral mass located well forward in the body, the pre-anal distance being less than half of total body length in specimens upto about 9 mm, myotome number between 38-42, pigmentation (melanophores/chromatophores*) rather sparse, most of it concentrated over abdominal sac, over the brain and in the caudal region, larvae about 10 mm (S.L) lose most of the pigment characters.

The main characters relied upon for the identification of tuna larvae are some fairly consistent black pigmentation such as those over the fore-brain, tip of jaws and posterior half of the trunk. Meristic characters such as numbers of the myotomes, vertical fin rays and morphometrics of the head and eye and sizes at which structures differentiate are also found useful. Ueyanagi (1966) found characteristic red pigmentation (erythrophores) in freshly caught larvae of the yellowfin, albacore, bigeye, skipjack, frigate mackerel and the little tuna. The red pigmentation is not species specific as seen from its similarity among Katsuwonus pelamis, Auxis spp. and Euthynnus affinis and among Thunnus obesus and T. albacares. (Matsumoto et al. 1972). They also fade in a few days after death and preserved in formalin for about 3 days. The appearance and the extent of red pigment

*The term chromatophores or melanophores has been used by different authors to indicate black pigments.

cells varied in larvae taken in night and day, the pigment being expanded and less visible in larvae caught during day (Matsumoto *et al* 1972).

Key for identification of larval tunas based on chromatophore distribution .

I. Chromatophores present on trunk

1. Chromatophores present over fore-brain

   1.1 A distinct chromatophore mid-ventrally in the caudal region - no chromatophore at the symphysis of the pectoral girdle - *Katsuwonus pelamis*

   1.2 A series of chromatophores along ventral margin on the trunk, from base of anal fin to caudal region - chromatophore at symphysis of the pectoral girdle. Series of chromatophores along mandible - *Euthynnus affinis*

2. No chromatophores over fore-brain

   2.1 Three short seriesof chromatophores on the mid-dorsal, mid-lateral and mid-ventral lines of the caudal region - chromatophore at the symphysis of the pectoral girdle - *Auxis* sp.

   2.2 1 - 3 chromatophores along the dorsal margin on the trunk, initial one being anterior to origin of second dorsal - 1 - 5 chromatophores along ventral margin of the trunk - *Thunnus tonggol*

   2.3 No chromatophore along the dorsal margin on the trunk - 1 - 5 chromatophores along ventral margin of the trunk - *Thunnus obesus*

II. No chromatophores on trunk

1. No chromatophores over forebrain presence of chromatophores at tip of lower jaw - *Thunnus albacares*

(adopted from: Yabe, Yabuta and Ueyangi, 1963, Matsumoto, 1958, 1962 - referable to adults recorded from Indian waters).

5.5.5 Larvae of billfishes and their diagnostic characters

Among the scombroids, young stages with prolonged beaks are found in the billfishes (Swordfish, sailfish, spearfish and marlins) and wahoo. However, in the wahoo larva there is neither a spiny supra-orbital ridge, as in swordfish nor the long pterotic and pre-opercular spines as in the istiophoridae. Myotome number in wahoo larvae is more than 60.

The billfishes include the monotypic *Xiphias gladius* and the 3 genera of istiophorids namely, *Istiophorus*, *Tetrapturus* and *Makaira*, with 5 species of these recorded from Indian waters. The diagnostic features listed here are adapted from Jones and Kumaran, (1964 a) and Ueyanagi, (1974).

The swordfish larva can be distinguished from the istiophorids by the following characters:

- Prominently beaked larva (except very young specimens below 5 mm)
- No long pterotic spine and pre-opercular spines of normal size.
- Supra-orbital ridge with spines.
- Vent far posterior to mid-point of total length.
- Body heavily pigmented, with lighter ventral side.

In comparison, the istiophorid larvae could be distinguished by the following characters:

- Beaked larvae with long serrated pterotic and pre-opercular spines.
- Supra-orbital ridge with only serrations.
- Vent relatively not far posterior to mid-point of total length.

The following enumeration of the diagnostic characters of some of the istiophorids are based on Ueyanagi (1963, 1974).

Sailfish (*Istiophorus gladius*) (= *I.orientalis* and *I.platypterus*)

- Elongated snout
- Small eyes
- Relatively small depth of head
- Pterotic spine rises obliquely
- Pre-opercular spine runs nearly parallel to ventral profile of body
- Centre of eye above the level of tip of snout
- Pigment spots present at posterior periferal area of the gulor membrane and also just above the mid-line of the gular membrane (Larvae without these pigments also occur, Ueyanagi, 1974).
- Shape of first dorsal, 'posterior high' type in larvae of more than 20 mm (S.L).

<u>Striped marlin</u> (<u>*Tetrapterus audax*</u>)

- Elongated snout
- Large eyes
- Centre of eyes about same level as the tip of snout
- Pterotic spine runs nearly parallel to body axis
- Pre-opercular spine inclined sharply downward
- Generally no pigmentation of lower part of head
- Shape of first dorsal, 'anterior high' type, in larvae of more than 20 mm S.L.

<u>Blue marlins</u> (<u>*Makaira nigricans*</u> and <u>*M.mazara*</u>)

- Pectoral fins rigid and stand out laterally at right angle
- Anterior edge of orbit does not project forward
- Centre of eye above the level of the tip of snout
- No pigments on branchiostegal membrane
- Shape of first dorsal, 'anterior high' type, in larvae more than 20 mm S.L.(presumed - Ueyanagi - 1963).

<u>Spear fish</u> (shortbill) *<u>Tetrapterus angustirostris</u>

- Centre of eye above level of tip of snout
- Pterotic spine rises obliquely
- Pre-opercular spine shorter than blue marlin and is inclined further downward
- Pigment spots present on branchiostegal membrane and also above the mid-line of the gular membrane
- Shape of first dorsal, 'anterior high' type in larvae of more than 20 mm S.L.

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*An Indo-pacific species, not yet recorded from Indian waters.

5.5.6 Larvae of other scombroids - bonito, double-lined mackerel, wahoo, dogtooth tuna and the seerfishes

Bonito:

Sarda orientalis, the only species recorded from the Indian waters, supports a sporadic fishery along the SW coast of India (Silas, 1963 b). Youngest specimen recorded from Indian waters measure 63 mm (Ashari and Vincent, 1972). Jones,(1960 b) recorded one specimen of 80 mm standard length. Larval records of bonitos are not numerous anywhere.

Klawe (1961) described a 3.5 mm larva of *Sarda* sp. from Baja California. Gorbunova (1963) recorded one post larva of *S.orientalis* 11.56 mm from the Indian Ocean collections of R.S.*Vitiaz*. Pinkas (1961) described post-larva of the pacific bonito *S.chiliensis* (16.7 mm fork length). Demir (1963) has reproduced the illustrations of *Sarda sarda* larvae (5.45 - 11 mm) of Vodianitski and Kazanova (1954) and of Padoa (1956), (4.32 to 4.6 mm).

The larval *Sarda* are characterised by having 44 - 45 myotomes, bold mid-ventral chromatophores on trunk and a spiny supra-orbital ridge in the older larva, which character appears to be unique in the larvae of tuna like fishes.

No bonito larva has been isolated from the present collections.

Double-lined mackerel

The double-lined mackerel (*Grammatorcynus bicarinatus*) is recorded from the Andamans. Its larva is distinguished from those of other tunas by the fewer myotome count (31). While this same low count is characteristic of *Rastrelliger* spp., *Grammatorcynus* larva differs in having pre-opercular spines, which in *Rastrelliger* are lacking. Wade (1951) described larval stages of *G.bicarinatus*, two illustrations of which; one 8.5 mm larva and a 17.5 mm post-larva were reproduced by Silas (1963 a).

Wahoo:

The wahoo, *Acanthocybium solandri* is occasionally caught along the SW and SE coasts of India. Larval stages of the wahoo, originally assigned doubtfully to swordfish have been recorded by Jones (1958) from the Laccadives sea and Balasubrahmanyam (1973) recorded similar ones from the Bay of Bengal. On the basis of the descriptions and illustrations of the continuous series of the larval stages of *A.solandri* by Matsumoto (1968), the above cited records of larvae can be clearly assigned to *A.solandri*. Wahoo larvae can be distinguished by its beaked swordfish like appearance, presence of over 60 myotomes, lack of spiny supra-orbital ridge and the single pigment spot on the caudal region of the trunk.

Records of young stages of seerfishes, from Indian waters are rare. Jones (1962) described and illustrated late post-larval stages of S.guttatus (14.8 mm, S.L) and S.commerson (14.4 mm, S.L) and also juveniles from Trivandrum coast. He also referred to the earlier reports on the life history stages of S.guttatus by Delsman (1931) from Indonesian waters, of S.commersoni by Munro (1942) from Australian waters, of S.guttatus by Vijayaraghavan (1955) and S.lineatus by Kuthalingam (1959) from Madras. However, the identifications of the last two authors have been shown to be not correct by Jones (1962). Gorbunova (1965 b) described and illustrated post-larvae of S.commerson and S.guttatus from the Gulf of Tonkin (South China Sea).

One post-larva of S.commerson (10.7 mm, T.L) obtained from the present collections is described in detail in Appendix-I.

DISTRIBUTION AND ABUNDANCE OF SCOMBROID LARVAE

6.1 Distribution and abundance of 'all scombroid' larvae

For charting the annual pattern of distribution and abundance of scombroid larvae, the annual average numbers (No/m^2) of the larvae for each station of the different sections were plotted on the map and suitable isodensity contour lines drawn. The annual average picture of the larval abundance for the years 1972, '73, '74 and '75 are given:

1972 (Fig. 28)

During the year the collections from Ratnagiri to Quilon showed that the inner half of the shelf from Ratnagiri to Coondapur and the near-shore waters farther southwards upto 10°30' N. were devoid of larvae. The best larval concentration (> 10/m^2) was restricted to a 20 mile wide oceanic strip between 8° - 10° N. with adjoining light to moderate (2 - 5/m^2) shoreward densities upto the edge of the shelf. Much of the shelf and off-shore waters north of Calicut had very poor larval densities. A strip of very moderate density over the mid-shelf from Calicut to Cochin extending southwards nearer to the shore was observed upto Quilon. A similar density patch over the mid-shelf off Ratnagiri was also seen during the year.

1973 (Fig. 29)

Scombroid larval distribution showed better density values and localised concentrations from Quilon to Cape Comorin area with the high core value of more than 20 larvae/m^2 over the shelf edge, off Quilon. A high value pocket of similar density was noticed over the shelf edge, off Calicut. The shoreward half of the Karwar-Ratnagiri shelf and most of the shelf area off Cochin and the nearshore areas south of Cochin upto Tuticorin were devoid of larvae. The shelf and offshore waters between 12°30' to 14° N were very poor in larval density. A small moderate value (> 5/m^2) pocket on the outer shelf, off Karwar has been evident.

1974 (Fig. 30)

The entire nearshore belt of an average width of about 10 miles from Ratnagiri to Cape Comorin was devoid of larvae. The larval concentration was in an outer shelf strip of moderate value (> 5 larvae/m^2) from 11° N, down south to Cape Comorin and further eastwards. A mid-shelf strip of slightly denser values from north of Karwar to Ratnagiri extending to outer shelf northwards was also seen. Nearshore areas off Tuticorin showed moderate larval densities.

1975 (Fig. 31)

As in 1974, the inshore belt of an average width of 10 miles was devoid of larvae in the entire area from Ratnagiri to Tuticorin. The best concentration of larvae (more than 10 larvae/m^2) was observed in an elliptical area outside the shelf between 10°30' to 13°30' N. One patch of moderate density off Tuticorin and another of slightly lesser density, extending eastward from the Wadge Bank area have been observed. A strip of moderate density extended from 13° to 16° N. on the shelf, 15 - 20 miles away from the coast. Light to moderate densities were noticed in the oceanic waters outside the shelf, in the entire area from Tuticorin to Ratnagiri. Larval density gradually decreased seaward.

The general pattern of scombroid larval distribution during the 1972 to '75 period showed two areas of concentration, one south of Calicut to east of Cape Comorin and a smaller concentration off Ratnagiri in the north. A dissimilar picture from this average pattern was seen in 1975, when the major concentration shifted to a large central patch between 10°30' and 13°30' N. in the offshore waters, with moderate values spread over the other areas. An inshore belt, about 10 miles or more wide was

Fig. 28 - 31

ANNUAL DISTRIBUTION AND ABUNDANCE OF SCOMBROID LARVAE - 1972 - 1975.

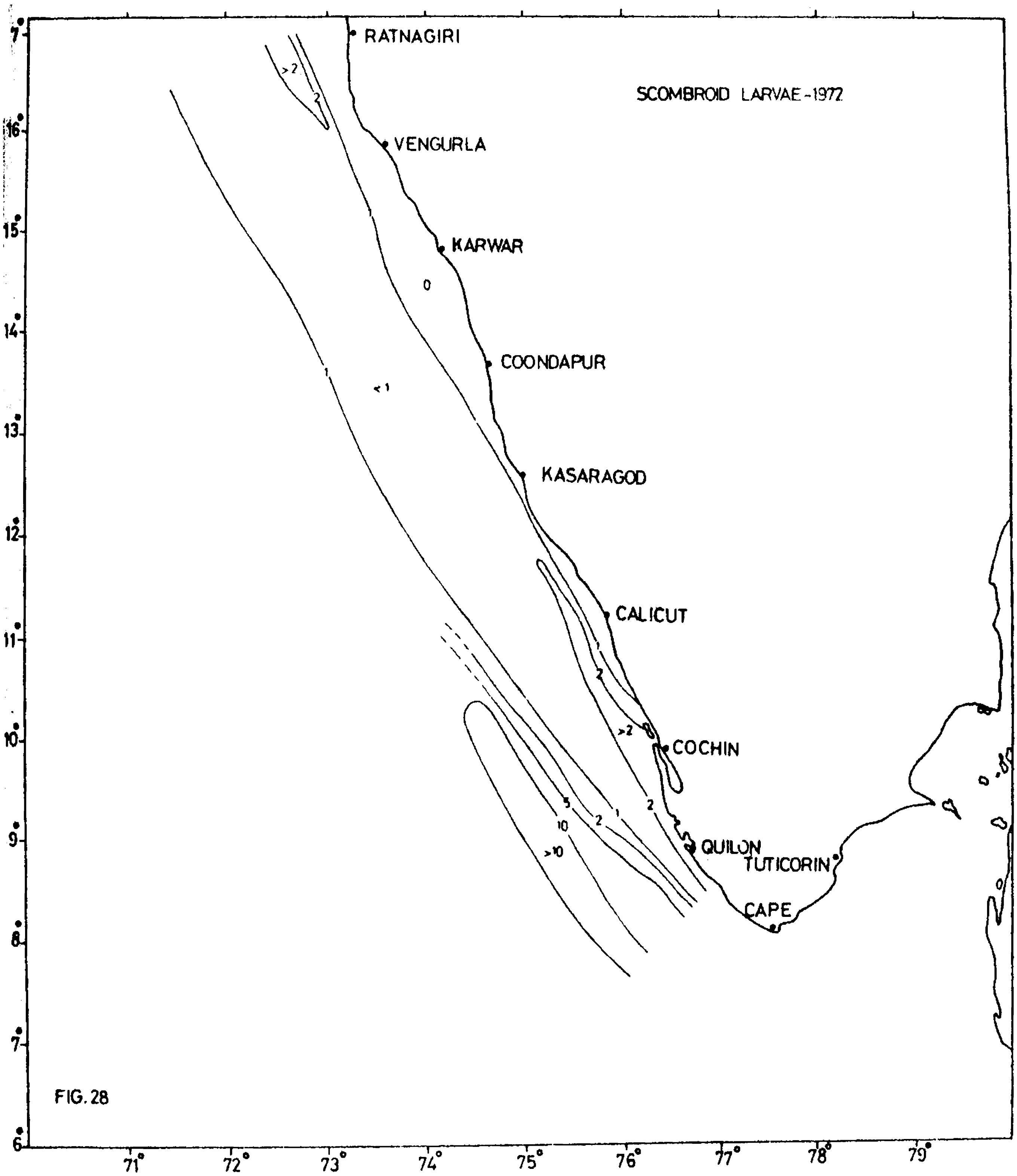
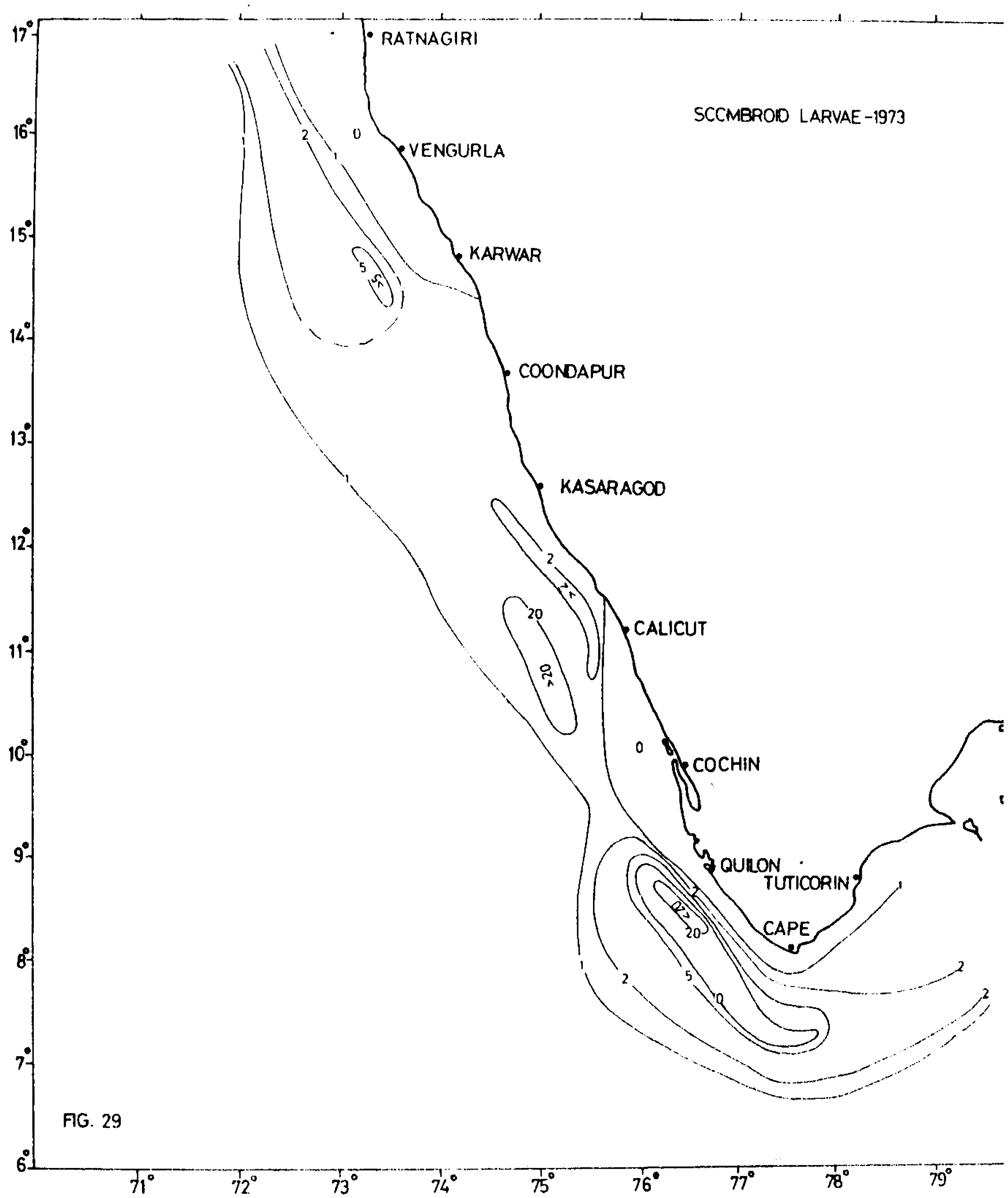

SCOMBROID LARVAE - 1972
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
71°
72°
73°
74°
75°
76°
77°
78°
79°

FIG. 28



SCCMBROID LARVAE - 1973
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
71°
72°
73°
74°
75°
76°
77°
78°
79°

FIG. 29

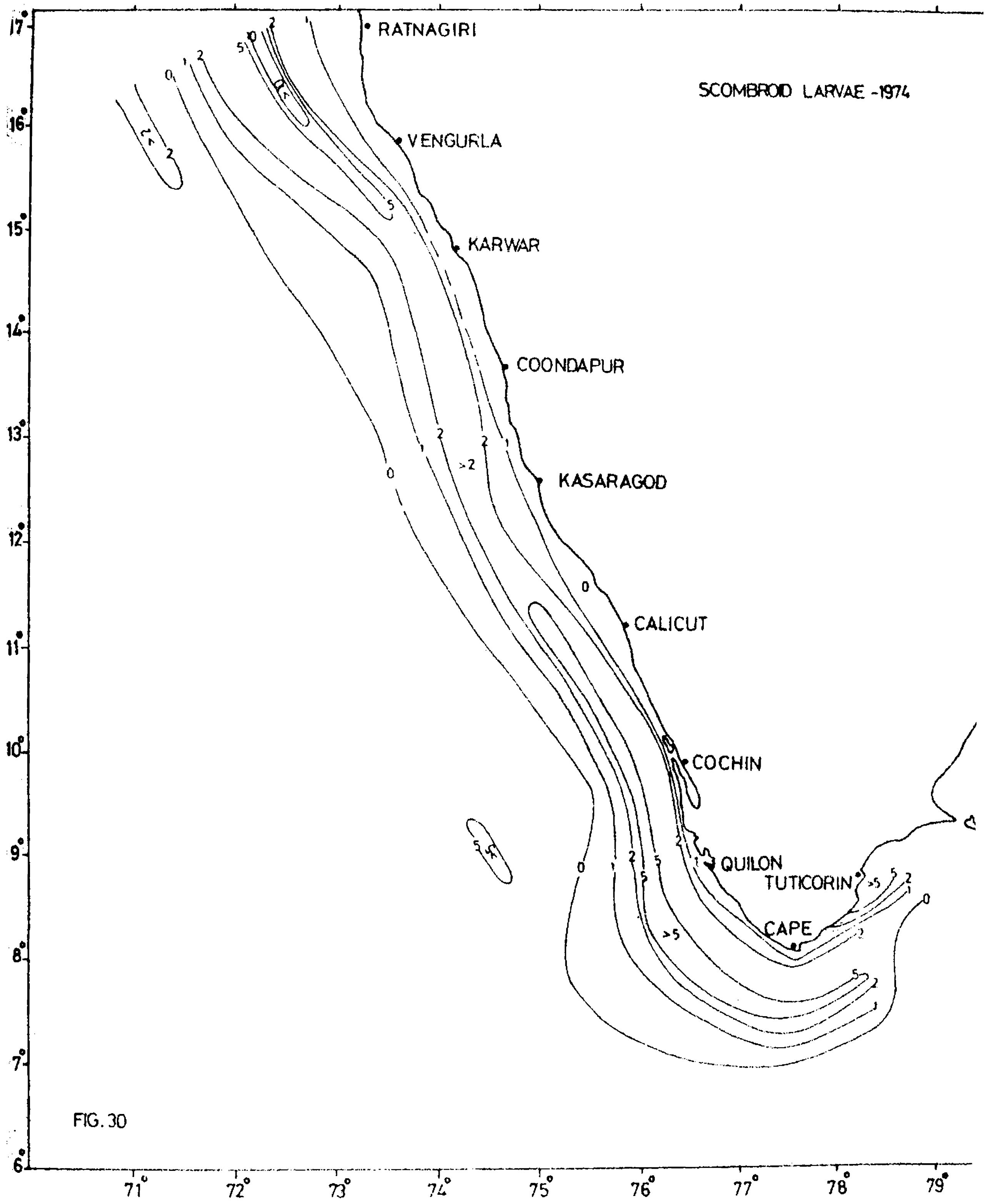
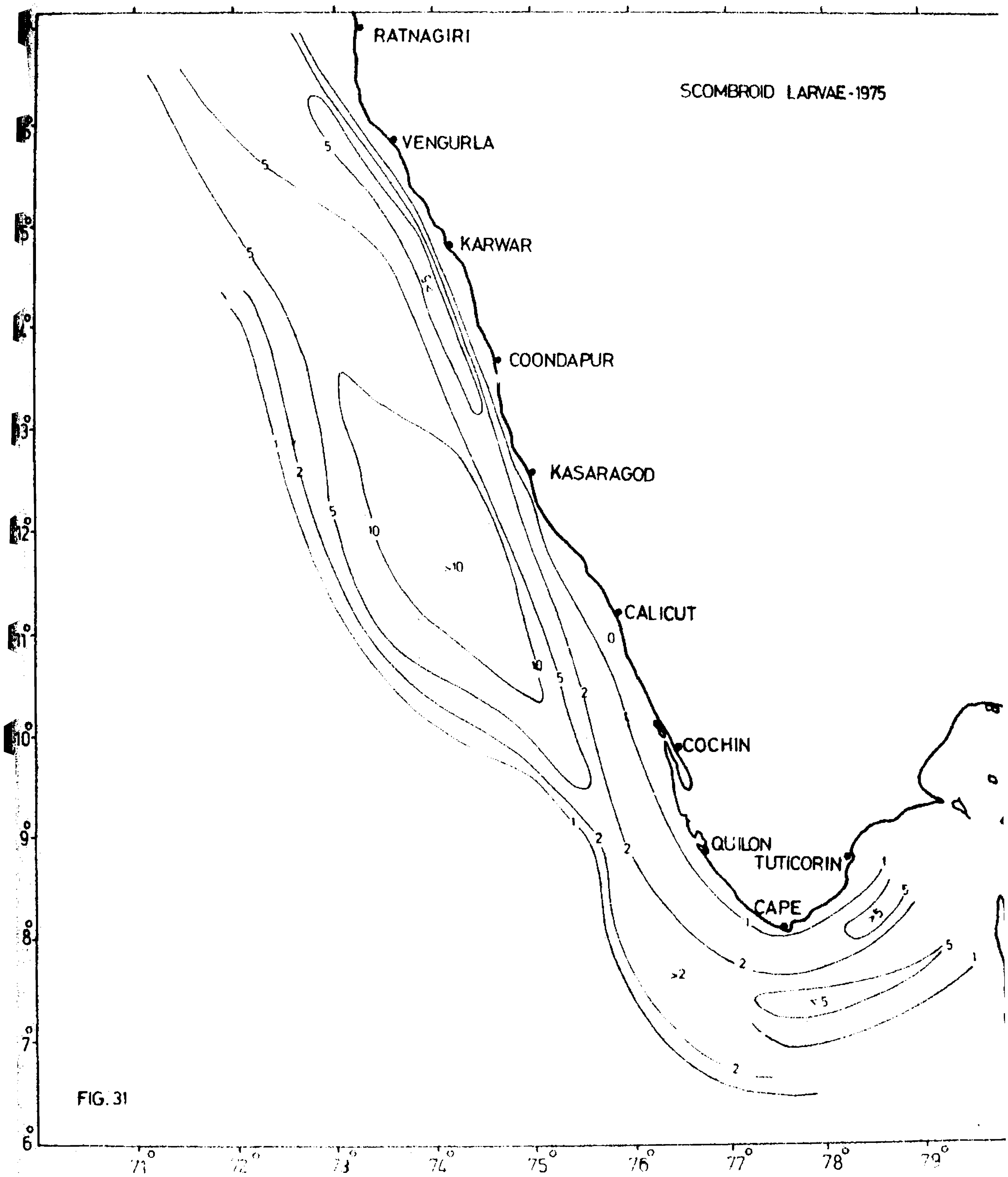

SCOMBROID LARVAE -1974
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
71°
72°
73°
74°
75°
76°
77°
78°
79°

FIG. 30



SCOMBROID LARVAE-1975
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE

FIG. 31

often seem to be devoid of larvae, usually, all along the area.

Scombroid larvae present in all the months of the year in the area were more abundant during the March to August period. The monsoon period, from May to August showed the maximum abundance of these larvae (Table -6).

6.2 General aspects of the distribution of tuna larvae

This brief resume of the distribution of larval tunas is based on the information given by Yabe, Yabuta and Ueyanagi (1963), Gorbunova (1963), Jones and Kumaran (1964 b), Ueyanagi (1969) and Peter (1977).

Tuna larvae occur in the sub-tropical and tropical waters of the Pacific, Atlantic and Indian oceans. Their distribution appears to be generally limited to within 30° latitude of the equator. The east-west distribution is trans-oceanic, but not uniform in the entire width.

Euthynnus larvae are found closer, to land masses than those of all other tunas (Matsumoto, 1959). Auxis larvae are presumed to be most abundant in waters close to land masses but are also found far distant from the land (Matsumoto, 1959, Yabe and Ueyanagi, 1961, Klawe, 1963).

The larvae of Katsuwonus pelamis and Thunnus albacares are trans-oceanic in distribution, but limited to the sub-tropical and tropical waters, where the north and south equatorial counter currents dominate. The range of larval distribution of K.pelamis is known to be widest among the tunas (Ueyanagi, 1969). Klawe (1963) observed T.albacares spawning over an extensive area of the Eastern Pacific both along the coast and in offshore waters.

Matsumoto (1962) reported occurrence of larvae assigned to big-eye tuna (Parathunnus sibi) from the East Indies and Western Pacific area. Information on distribution of Sarda larvae is scarce. Jones and Kumaran (1963) dealt with the distribution of 5 species of larval tunas of the Dana collections from the Indian ocean. It is stated that the larvae of K.pelamis and T.albacares constituted the bulk of the larval tunas in this collection and that they have a wide range of distribution in the Indian ocean. Most of these tuna larvae were obtained from an area west of 50°E long.between 0° - 25° Latitude.

Gorbunova (1963) found tuna larvae altogether absent in the Arabian sea, but good quantity of all scombroid larvae were taken in the Aden Bay and in the western part of the Indian ocean. It was also observed that larvae of *Auxis thazard* and *Euthynnus affinis* were taken mainly in the coastal regions, while those of *T.albacares* and *K.pelamis* were more common in the open ocean.

Peter (1977) dealt with the distribution of tuna larvae in the Arabian Sea collected during the International Indian Ocean Expedition. Of the 694 stations worked, 88% were in the offshore and oceanic waters. Tuna larvae were present only at 10.6% of the total number of stations worked. The areas rich in the larvae were coastal and offshore waters parallel to the coast and the equatorial zone noted for seasonal upwelling. Larvae of almost all species of tunas of the Indian ocean are represented in the equatorial zone, including those of *Auxis* sp. and *E.affinis*. Tuna larvae were collected only from a few stations, off the SW coast of India.

In the present collections, out of 1409 stations considered for 'occurrence' of different types of larvae, nearly 19% of the stations, recorded tuna larvae, inclusive of *Auxis* sp. which alone were collected from 12% of all the stations.

6.3 Distribution and abundance of frigate mackerel larvae

Auxis larvae were the most numerous of all scombroid larvae in the present collections. The abundance and distribution of *Auxis* larvae for the 1972 - '75 period have been charted (Fig. 32) based on the average number (no/m^2) of the larvae collected at the different stations during the period.

The larvae were encountered over most part of the shelf and outwards in the oceanic waters upto a distance of about 120 miles from the shore, all along the surveyed area. However, the inshore area varying in width from 4 to 20 miles was found to be devoid of the larvae.

The concentrations of the larvae were found over the outer shelf and slope of the shelf and even beyond, in a belt of an average width of 30 miles from Kasaragod to Tuticorin. There was a gradual increase in the number of positive stations beyond 50 m depth. Relatively high core densities were located between 10° and 11°30' N. and also off Quilon.

The larvae of *Auxis* spp. were recorded in the area in all the months of the year. However, they were available in significant numbers from March to August and

Fig. 32

DISTRIBUTION AND ABUNDANCE OF AUXIS LARVAE - 1972 - '75.

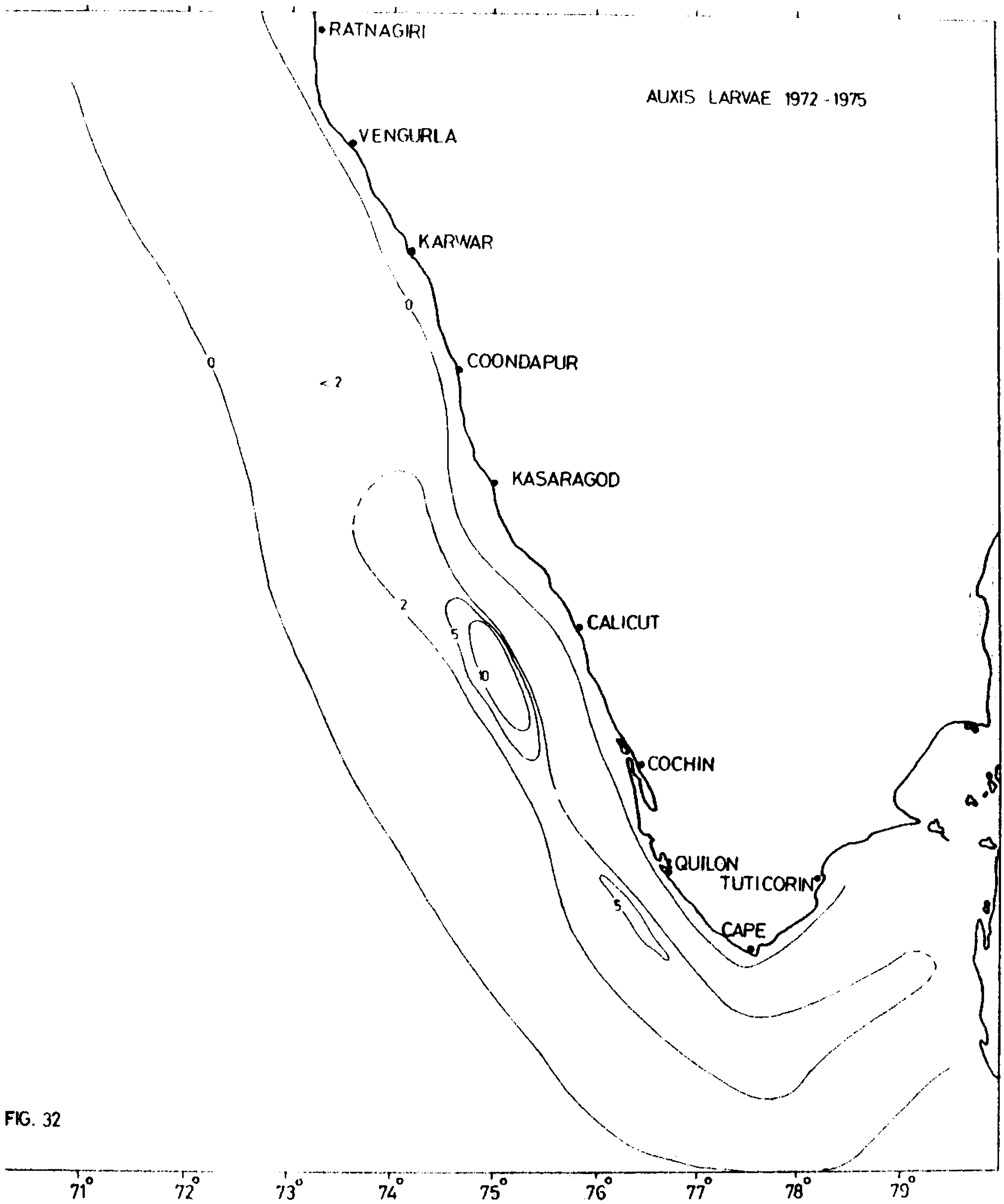

RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
AUXIS LARVAE 1972 - 1975
0
< 2
0
2
5
10
5
71°
72°
73°
74°
75°
76°
77°
78°
79°

FIG. 32

least available during November to February period (Fig. 48). Maximum abundance of the larvae were noticed during the SW monsoon period (May to August), with the peak occurrence in July.

6.4 Distribution and abundance of the larvae of the Little tuna, skipjack and other tunas

The occurrence of the larvae of *Euthynnus affinis*, *Katsuwonus pelamis* and of *Thunnus* spp. are plotted in Fig. 33. Larvae of *Thunnus* spp. in the present collections possibly included *T. albacares*, *T. tonggol* and *T. obesus*. Peter (1977) reported *T. obesus* larvae from two stations of the IIOE collections from the Arabian sea (03°00' N. Lat. - 55°03'E. and 01°00' N. Lat. - 53°00' E, in July and August 1962).

The number of occurrences of the different types of these tuna larvae and their numerical abundance during the entire period (1972 - 75) were not found to be sufficient to make density contour lines of the distribution. However, the individual occurrences at different stations with symbolic indication of the numerical abundance (larvae/m^2) are presented in the map for the species discussed.

It would be seen (Fig. 33 and Table - 6) that the maximum frequency of occurrence was for *K. pelamis* larvae

Relative frequencies of the occurrence of some larval scombroids during 1972 - 75 period

*Type of larvae	Pre-monsoon					Monsoon				Post-monsoon			Total
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Auxis	2	3	11	13	22	32	36	29	5	9	2	2	166
Rastrelliger kanagurta	2	3	11	11	16	13	33	14	7	3	12	4	129
Katsuwonus pelamis	-	10	9	7	3	11	1	3	-	-	1	-	45
Euthynnus affinis	-	-	2	2	9	11	2	3	-	-	-	-	29
Thunnus spp.	-	6	7	2	2	6	-	-	-	-	-	-	23
	4	22	40	35	52	73	72	49	12	12	15	6	392

*Specimens from some tows whose identity could not be confirmed due to damage or other reasons are not included here. However, such instances are less than 5% of the total number examined.

(45), followed by _E.affinis_ (29) and _Thunnus_ spp. (23). It was also noticed that most of them were caught from all the sections, mainly during the February - August period. This is in contrast to the occurrence of the larvae of _Auxis_ spp. and _R.kanagurta_ in all the months of the year (Table - 6). The northern sections off Karwar and Ratnagiri and the Cochin and Quilon sections showed relatively more incidence of tuna larvae. The lesser frequency of occurrence in Coondapur and Calicut could be attributed to the infrequent coverage of these sections as well as their limited sea-ward extension. However, the Tuticorin section eventhough covered adequately from the beginning of 1973 showed only 2 occurrences.

Larvae of the little tuna

Euthynnus affinis larvae occurred in all sections, except Cochin. More frequently they occurred off Ratnagiri. The number of larvae caught however were seen to be more from stations off Karwar, Kasaragod and Quilon. Eventhough there is a coastal fishery for this tuna particularly, south of Quilon, the larvae were caught in more offshore waters than the other species like skipjack, which were caught in nearshore waters also. The percentage of positive tows with little tuna larvae were more at stations beyond

50 m sounding depth, the maximum positive tows in relation to number of total tows at each depth range being in the 151 - 200 m depth zone (Fig. 34). Jones and Kumaran (1963) observed that the E.affinis larvae of the Dana collections from the Indian ocean were obtained from off-shore waters, while Gorbunova (1963) observed that larvae of E.affinis were taken in the coastal regions. The occurrence of the larvae in the present collections were limited to the March to August period with the maximum occurrence in June.

The larvae of the skipjack

Katsuwonus pelamis larvae occurred in all the sections, except in the short section worked off Calicut. The larvae were more frequently caught off Karwar, followed by Ratnagiri and Kasaragod sections in that order. It may be mentioned here that the previous most northern collection of K.pelamis larvae referred to from the Arabian sea (11°70'N, 72°65'E), (Jones, 1959 b) and from approximately 13°30'N in the Bay of Bengal (Gorbunova, 1963), whereas the present collections extended the distribution of the larvae upto about 16°40'N in the Arabian sea. However, the Laccadives, particularly the Minicoy waters area has not been covered at all regularly during the survey and as such no statement can be made on the abundance of these larvae in these areas, where a significant pole and line fishery for the species is in vogue.

K.pelamis larvae were encountered in nearshore waters as well as far of oceanic waters, whereas in the case of other tunas, except frigate mackerel, the larvae were not met with close to the shore. More positive stations for K.pelamis larvae were however in the area beyond 75 m depth (Fig. 34).

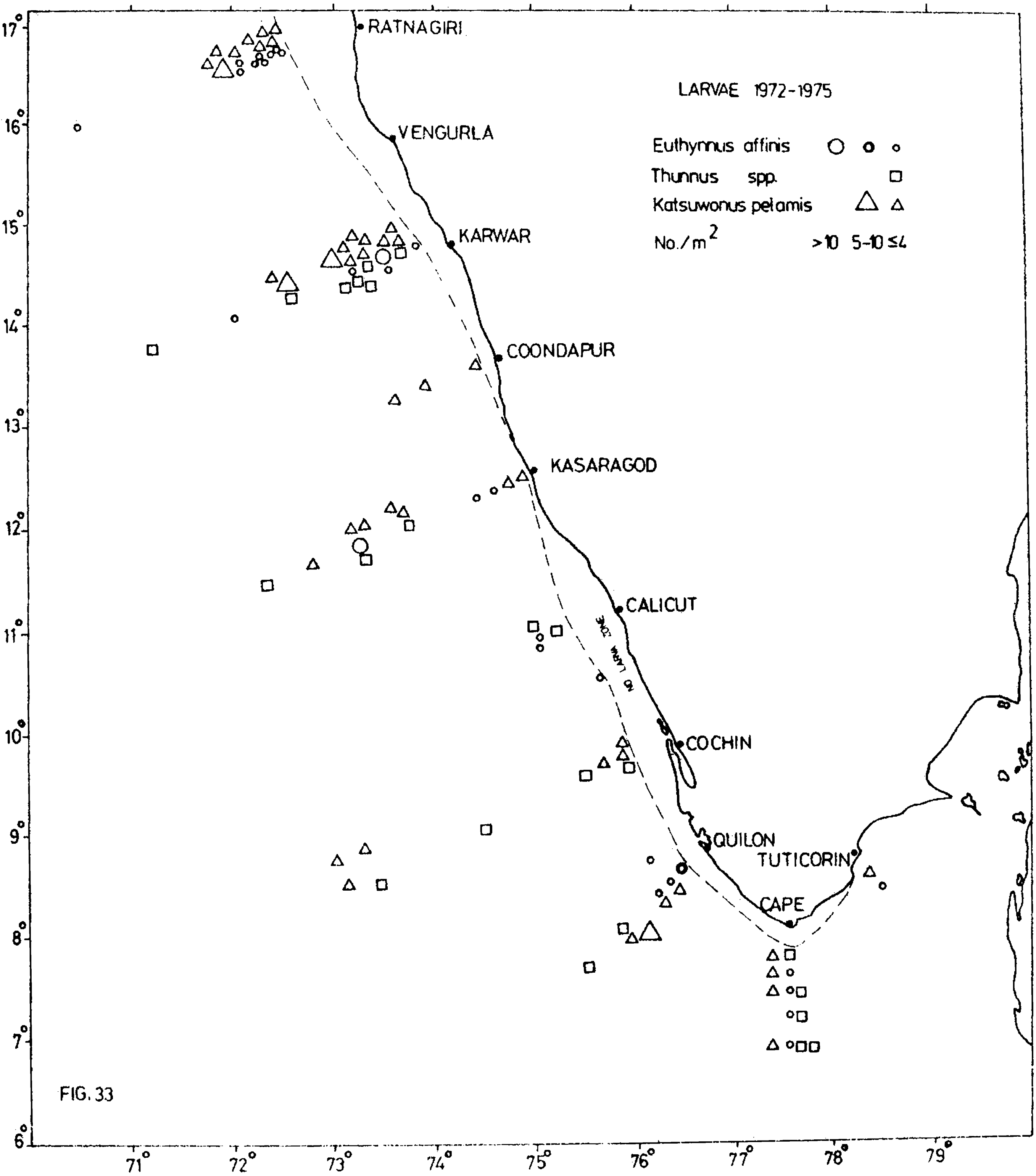
The seasonal appearance of the larvae indicated significant abundance during February to June period (Table - 6).

Larvae of Thunnus spp.

The occurrence of the larvae of Thunnus spp. was the least of all the tunas (Table - 6). These larvae did not occur in the Ratnagiri, Coondapur and Tuticorin sections (Fig. 33), but occurred frequently off Karwar and Cape Comorin sections. More often they were caught over the deeper shelf more than 100 m depth, maximum positive tows being from over the stations in the 150 - 200 m depth range (Fig. 34). Dana collections from the Indian ocean showed T.albacares larvae from mid-ocean and also close to land (Jones and Kumaran, 1963). Larvae of Thunnus spp. were encountered during the February to June period.

33

STATI[illegible] OF OCCURRENCE OF THE LARVAE OF *EUTHYN[illegible]* *AFFINIS*, *KATSUWONUS* *PELAMIS* AND *THUNNUS* [illegible]p., INDICATING ALSO THEIR ABUNDANCE - 1972 - 1[illegible].

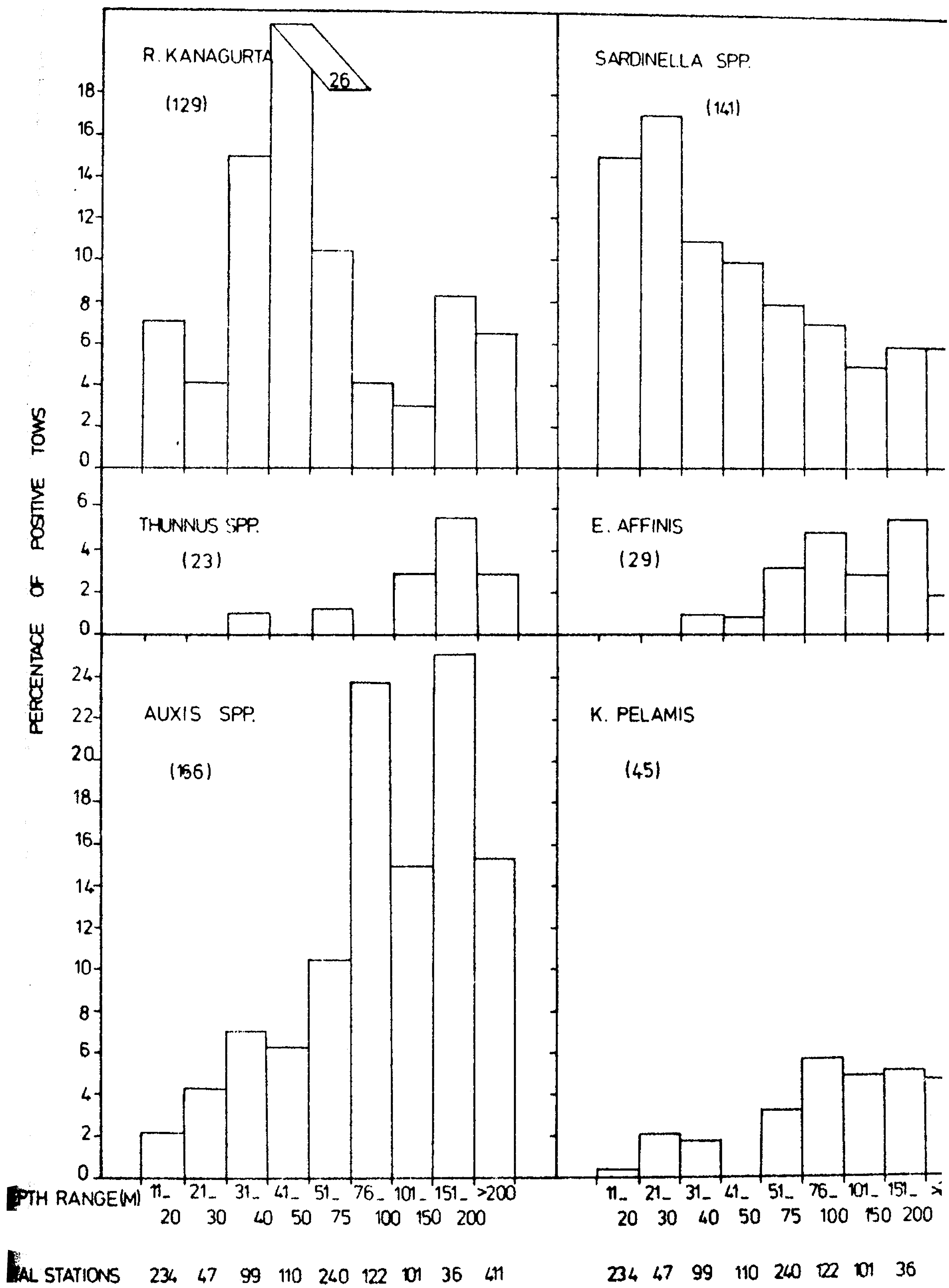


RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
NO LARVA ZONE
LARVAE 1972-1975
Euthynnus affinis
Thunnus spp.
Katsuwonus pelamis
No./m2 >10 5-10 ≤4
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
71°
72°
73°
74°
75°
76°
77°
78°
79°

FIG. 33

Fig. 34

DEPTH-WISE DISTRIBUTION OF POSITIVE TOWS FOR CE
CATEGORIES OF LARVAE IN RELATION TO TOTAL TOWS
AT DIFFERENT (SOUNDING) DEPTHS RANGES, SHOWING
NERITIC AND OCEANIC DISTRIBUTION OF THE LARVAE.


R. KANAGURTA
(129)
26
SARDINELLA SPP.
(141)
THUNNUS SPP.
(23)
E. AFFINIS
(29)
AUXIS SPP.
(166)
K. PELAMIS
(45)
PERCENTAGE OF POSITIVE TOWS
PTH RANGE(M) 11-20 21-30 31-40 41-50 51-75 76-100 101-150 151-200 >200
AL STATIONS 234 47 99 110 240 122 101 36 411
11-20 21-30 31-40 41-50 51-75 76-100 101-150 151-200
234 47 99 110 240 122 101 36

G. 34

6.5 Distribution of the Indian mackerel larvae

There are only few contributions showing the seasonal and geographical distribution of the larvae of *Rastrelliger kanagurta*. Silas (1974) dealt with the distribution of mackerel larvae along the SW coast, based on 92 plankton stations worked by R.V. *Varuna*, in May 1964. The material caught from 38 stations during the cruises occurred mostly between 9° and 10° N, on the shelf waters, over the 30 - 80 m depth zone. The distribution of mackerel larvae along the SW coast during Sept. 1971 - Sept.'75 period has been briefly dealt with in the Progress Report of the Pelagic Fishery Project (Anon, 1976 d). The present discussion is based on the same material.

Among all the scombroid larvae caught during the present survey, mackerel larvae was second in order to frequency of occurrence and abundance, (Table - 6), the first being those of the frigate mackerel. The larvae occurred in about 9% of all stations worked, including the special stations. The survey during four full years, covering all the months of the year and the entire SW coast shelf and farther seaward, showed that mackerel larvae occurred in the area in all the months in varying numbers. They were more frequent during March to August and November with the peak in July. Fifty five percent of all positive stations were distributed over the 31 - 75 m depth range, 13% within 11 to 20 m and 21% beyond the shelf. Figure-34 shows the percentage of positive stations in different depth ranges, in relation to the total number of stations worked, in the respective depth ranges. Of a total of 411 stations worked beyond the shelf, only 27 were positive.

The distribution of the larvae in the different sections, showed that their occurrence as well as numerical abundance were more in the Cochin, Quilon, Cape Comorin and the Karwar sections. Figure - 35 shows the average larval densities (No./m^2) for the entire period of observation, taking into consideration all the coverages made during the period. It was seen that the distribution of the larvae was relatively dense on the mid-shelf from 8° to 15°N with maximum concentration south of Cochin. While the larval occurrence spilled beyond the shelf, to the open ocean south of Mangalore, it was restricted to the inner third of the shelf north of Mangalore. The nearshore areas north of Karwar and of the Gulf of Mannar were devoid of mackerel larvae. In the Gulf of Mannar the occurrence of mackerel larvae was mostly in the off-shore waters.

PHOTOGRAPHS OF MACKEREL LARVAE

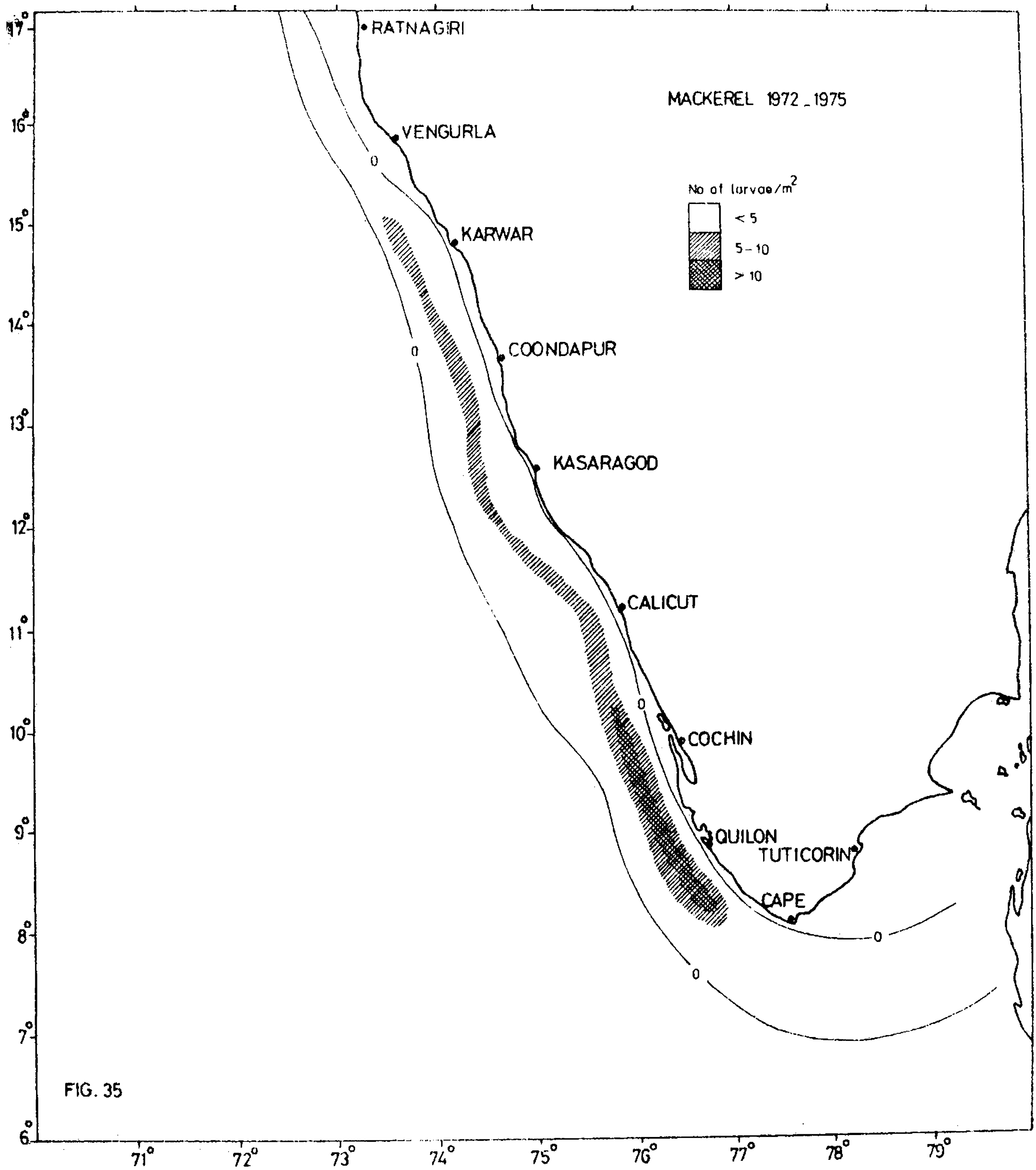
1. 4.0 mm T.L

2. 5.3 mm T.L

3. 12.1 mm T.L

Fig. 35

AVERAGE PICTURE OF THE DISTRIBUTION AND ABUNDANCE OF MACKEREL LARVAE, 1972 - 75. (The figure is reproduced from the Progress Report of the Pelagic Fishery Project, No.17, prepared by the author, Anon, 1976 d).



RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
MACKEREL 1972 _ 1975
No of larvae/m2
< 5
5 – 10
> 10

FIG. 35

6.6 Occurrence of billfish larvae

The swordfish larvae

Xiphias gladius is a widely distributed cosmopolitian fish found in the Indian, Pacific and the Atlantic oceans. Arata (1954), Nakamura *et al* (1951), Yabe (1951) Yabe *et al* (1959) and Taning (1955), have dealt with the larvae and juveniles of the species. Jones and Kumaran (1964 a) dealt with the distribution of the larval billfishes from the Indo-Pacific. Jones (1958) described one post larva (16.27 mm) from the Laccadives. Jones (1965) later described a younger larva (6.8 mm) from the *Dana* collection (Station 3857, lat. 4°31.8' S, 99°13' E), off the west coast of Sumatra.

One post larva of *Xiphias gladius*, 8.4 mm (T.L) was isolated from the present collections. The specimen was collected in April 1974, at Station 194, off Ratnagiri, about 50 miles away from the shore, with a sounding depth of 83 m (16°40' N, 72°25' E) in an oblique tow with Bongo net, from 50 m upwards. The surface temperature at the station was 29.7° C and salinity 35.51‰.

Sailfish larvae

Sailfish of the Indian and Pacific ocean comprises only of a single species (Jones and Silas, 1964), *Istiophorus gladius* (= *I. platypterus*). Yabe (1953) described the larvae of *I. orientalis* (= *I. gladius*) from the South Western sea of Japan. Ueyanagi (1963, 1964 a) dealt with the taxonomy and distribution of istiophorid larvae in the Indo-pacific.

Jones (1959 a) described larvae of *I. gladius* (3.4 to 11.75 mm T.L) from the Laccadives, the smallest and the largest specimens of the series were collected from the same station. Later Jones (1959 c) described one juvenile, measuring 432 mm total length from the Laccadives sea.

Balasubramanyan (1973) recorded 10 larvae (3.0 to 6.9 mm) of *I. platypterus* (= *I. gladius*) from the collections of '*Anton Bruun*' from the Bay of Bengal.

One post-larva of *I. gladius* measuring 10.8 mm total length was identified from the present collection. It was taken on the shelf off Kasaragod, at station 43 (12°30'N, 74°14'E) of R.V. *Varuna*, in April 1972. The depth at the station was 92 m and the oblique tow with the Bongo net was made from 25 m to the surface. The surface temperature at the station was 30.12 °C and salinity 33.62‰.

Larvae of Marlins and Spearfishes

The larvae of marlins and spearfishes (*Tetrapturus* and *Makaira* spp.) are not recorded from the Indian waters eventhough the adults are met with. No larvae of these species were isolated from the present collections. Jones and Kumaran (1964 a, b) discussed these larvae with special reference to the *Dana* Expedition collections.

6.7 Sizes of the major species of scombroid larvae caught during the survey

Total length measurements of several formalin preserved larvae of mackerel, frigate mackerel, little tuna, skipjack tuna and *Thunnus* spp., collected during the survey were made to get a general idea of the size ranges and dominant sizes of the specimens caught. Measurements were made on a sample basis, when numerous larvae were available, as in the case of frigate mackerel, or on all larvae except the damaged and twisted ones, when the number of larvae collected were limited. Measurement of all larvae under 10 mm were made under a binocular dissection microscope with a calibrated micrometer eye piece, to an accuracy of 0.05 mm. The limited number of larvae about 10 mm total length were measured in a petridish with a graph paper attached outside the bottom of the dish. The length data sorted into 1 mm groups are presented in Figures 36 and 37 (the length group designated as 1 mm includes all larvae from 1 to 1.9 mm total length). The number of larvae measured are given in brackets.

Rastrelliger kanagurta

The smallest undamaged prolarva of the mackerel measured was 1.75 mm and the largest post-larva 11.70 mm in total length. The 2 to 4 mm length groups dominated the catches. The largest specimen, 11.70 mm was caught in the day time haul, while the largest specimen caught in night haul was 10.50 mm.

Auxis spp.

In the case of two larvae of the frigate mackerels the 3 to 5 mm length groups dominated in the collections. The largest specimen collected was a post-larva of 13.60 mm length, caught in the day time. The largest post-larva caught at night was 12.80 mm in total length.

Euthynnus affinis

In the case of the little tuna also the 3 to 6 mm length group dominated the catches with the 5 mm group as the modal size. The largest specimen collected measured 12.80 mm and was caught at night, while the largest one caught during the day measured only 8.6 mm.

Katsuwonus pelamis

The 3 to 6 mm length groups were dominant in the case of skipjack tuna larvae also, with the mode at 5 mm. The largest post larva, 12.70 mm was caught in the night and the largest one caught in the day measured 8.35 mm.

Thunnus spp.

Larvae of this group showed larger average size than the other tunas. The 4 to 7 mm length groups dominated in the catches, with the largest specimen, 10.40 mm, caught in the night. The largest specimen caught during day time measured 9.50 mm.

In the case of all the larvae dealt with above, it was observed that large specimens have been more frequently caught at night than during the day. The largest larvae of little tuna, skipjack and *Thunnus* spp. were also obtained in night hauls. Eventhough, in the case of mackerel and frigate mackerel, the largest larvae came from day hauls, the frequency of occurrence of specimens above 10 mm were more in night hauls. This probably indicates that the larger larvae avoided the net during day time.

Fig. 36

LENGTH FREQUENCY HISTOGRAMS OF LARVAL TUNAS CAUGHT DURING THE PRESENT SURVEY (Numbers in brackets indicate the number of larvae measured).

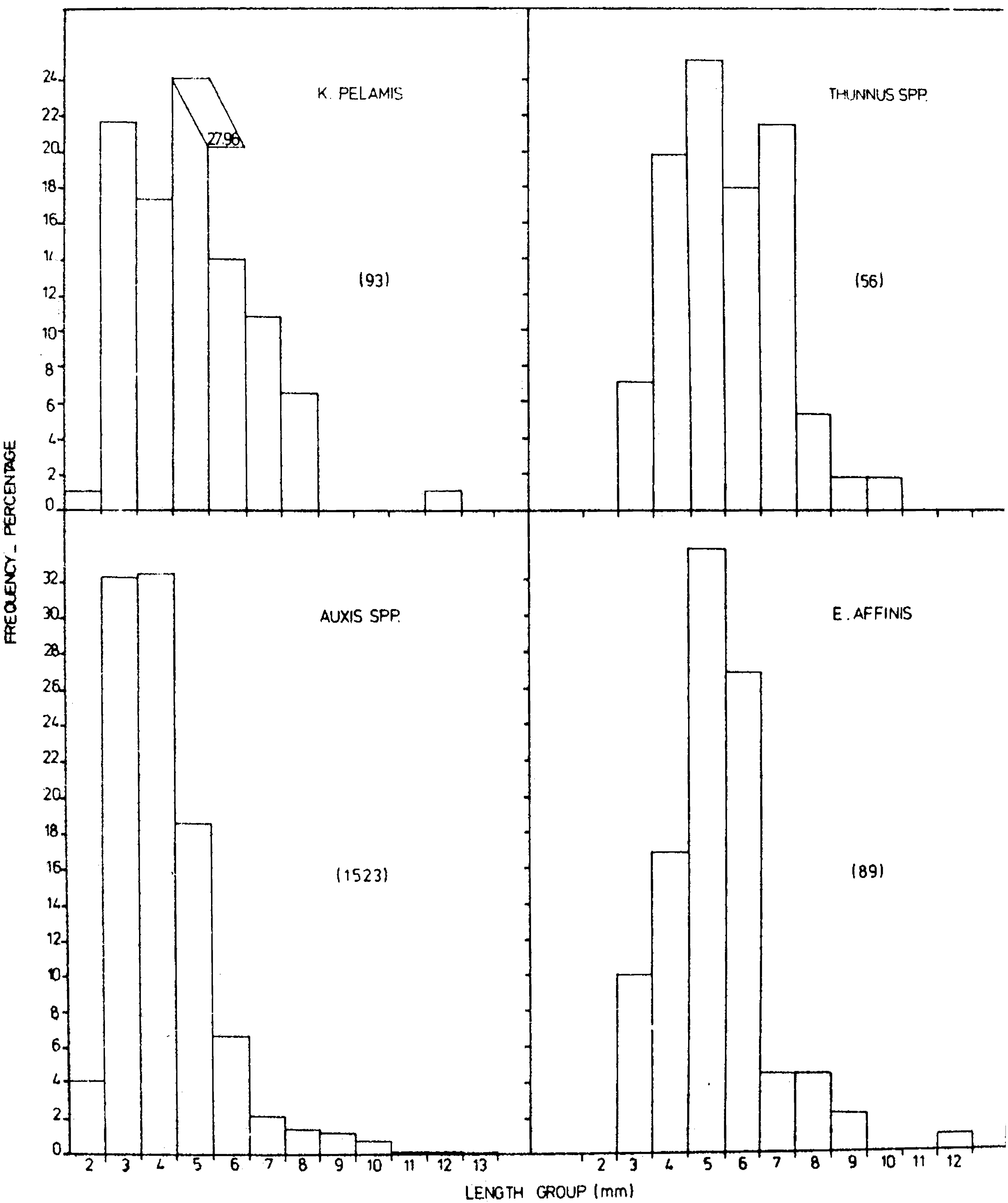

K. PELAMIS
27.96
(93)
THUNNUS SPP.
(56)
AUXIS SPP.
(1523)
E. AFFINIS
(89)
FREQUENCY_ PERCENTAGE
LENGTH GROUP (mm)

FIG. 36

Fig. 37

LENGTH FREQUENCY HISTOGRAM OF MACKEREL LARVAE CAUGHT DURING THE PRESENT SURVEY. (Numbers in brackets indicate the numbers of larvae measured).

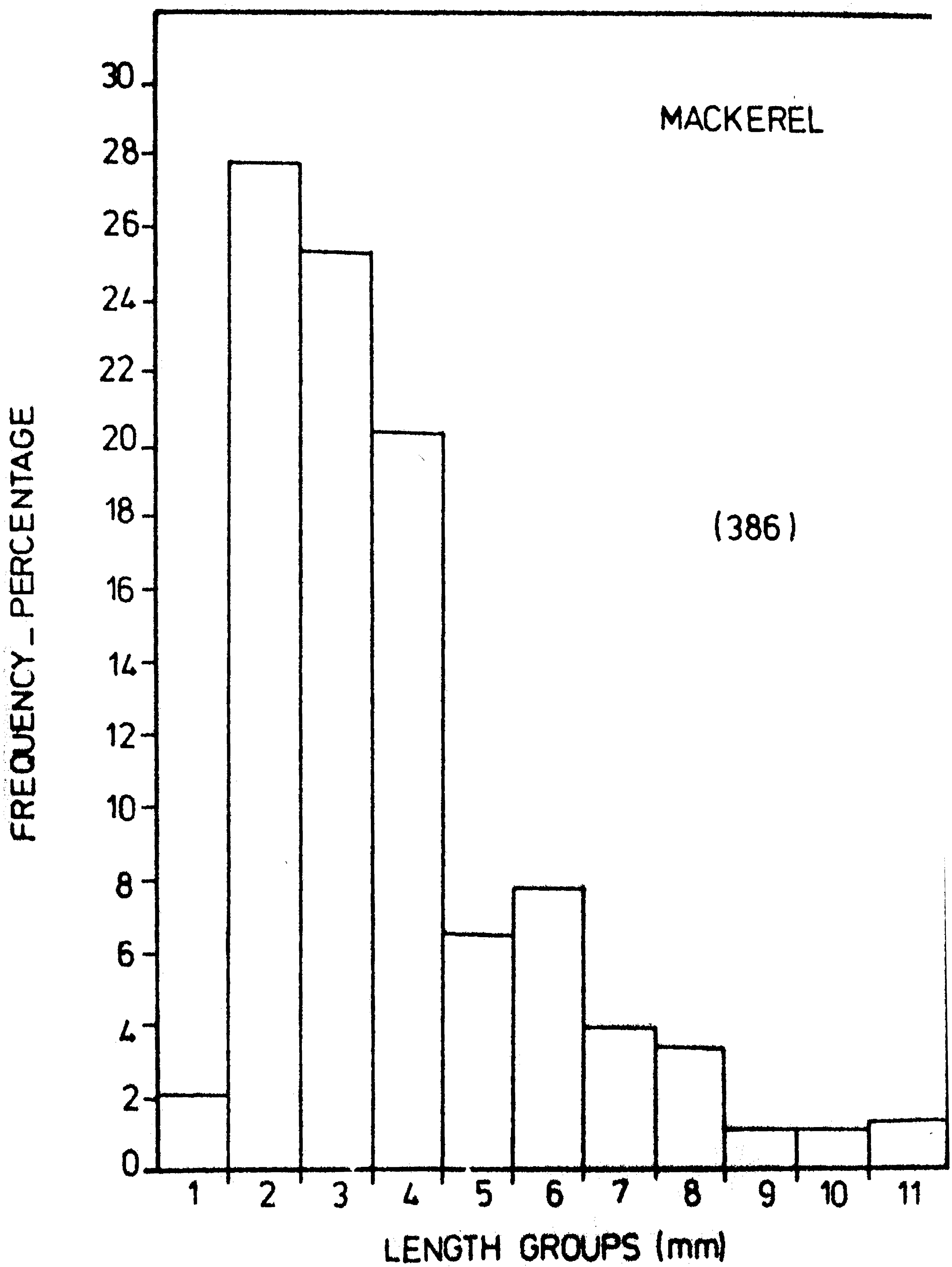

MACKEREL
(386)
FREQUENCY _ PERCENTAGE
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
LENGTH GROUPS (mm)

FIG. 37

7. DISTRIBUTION AND ABUNDANCE OF OTHER COMMON FISH LARVAE

7.1 Clupeoid larvae

7.1.1 Life-history and spawning studies on clupeoid fishes in Indian waters:

Several contributions, limited to descriptions of clupeoid eggs and early larvae hatched out from them are available in Indian literature. Hornell (1910), Hornell and Nayudu (1924) Devanesan (1943), John (1951), Chacko (1946, 1950) Chacko and Mathew (1956), Bapat (1955), Nair (1959), Kuthalingam (1960) and Bensam, (1971 a, 1973) dealt with eggs, larvae and spawning of different Sardinella spp.

Bensam, (1971 b) reviewed the early life-history studies on clupeiformes from Indian waters and gave a provisional key for identifying the eggs and early larvae.

John (1951), Nair (1952 b), Bapat (1955), Sudarsan and Rajapandian (1967) and Sreekumari (1977) have recorded or described the eggs and larvae of white-baits.

Eggs and early larvae of Thrissocles spp. have been described by John (1951), Nair (1952 b), Bapat (1955), Vijayaraghavan (1957) and Balakrishnan (1969).

Rao (1964) observed the occurrence and distribution of post-larvae of *Thrissocles mystax*, *T. kammalensis* and *T. purava* in the Mahanadi estuary.

Other clupeoids which have received the attention of Indian workers with regard to eggs and larval studies and spawning habits are, *Kowala coval* (Devanesan and John, 1941; Nair, 1952 a); *Hilsa ilisha*, (Jenkins, 1938; Hora, 1938, 1940, Nair, 1939; Jones and Menon 1950 b); *Opisthopterus tardoore* (Bensam, 1968 a); *Dussumieria* sp. (Devanesan and Chacko, 1944; Kuthalingam, 1961 b) and *Setipinna phasa* (Nair, 1940; Jones and Menon, 1950 a, 1951 b).

Study of intra-ovarian eggs have been resorted to by Prabhu (1956) and Dharmamba (1959) to elucidate the spawning habits of several Indian clupeoids.

7.1.2 Distribution and abundance of 'all clupeoid' larvae

Large majority of the clupeoid larvae collected from the surveyed area consisted of those of *Stolephorus* spp. Next in importance were the larvae of *Sardinella* spp., of which *S. longiceps* was the most dominant. However, the relative abundance of the above two groups did not truly reflect the proportionate magnitude of the adult population size, as indicated by their landings in the area (vide table-4). This suggested under exploitation of Stolephorus spp. This contention is substantiated by the findings of the acoustic surveys made by the Pelagic Project, which showed a very large average standing stock of about 500,000 tonnes of white-baits in the area (Anon 1976 a). Other types of clupeoid larvae met with in lesser numbers in the collections were those of the white sardine (Kowala coval), the rainbow-sardine (Dussumieria sp.) and the anchovies (Thrissa spp.)

Reports of the Pelagic Fishery Project (Anon 1974 b, 1976 d) presented some information on the distribution of clupeoid larvae along the SW coast of India, on a cruise-wise basis, from April 1972 to August 1975 period.

In the present studies the annual average pictures of clupeoid larval distribution and abundance along the SW coast of India for the years 1972, '73, '74 and '75 are given.

For charting the annual pattern of the distribution and abundance of the clupeoid larvae, the same method as adopted for the scombroid larvae has been used.

1972: (Fig. 38)

The clupeoid larval abundance was very moderate, with less than 5 larvae/m^2 in a large part of the shelf and oceanic waters surveyed. A relatively dense nearshore belt of larval distribution 10 - 20 miles wide, from Coondapur to Quilon was observed during the period. The highest density noticed was in a patch centred off Calicut on the mid-shelf and outer shelf with a density value of around 20 larvae/m^2. A high value offshore pocket was also observed south west of Quilon. The density values showed a decreasing trend seaward.

1973: (Fig. 39)

There was an overall increase in clupeoid larval abundance during this year than in 1972. A narrow inshore belt of moderate density was observed from north of Cochin to nearly as far as Vengurla during this year. The core of high density values were over the mid-shelf and outer shelf from 8°30' N to 10°30' N. A pocket of very high concentration of larvae were seen over the outer shelf off Quilon and in a patch on the mid-shelf off Karwar. A strip of larval concentration of more than 5 larvae/m^2 was observed over the outer shelf from Cape Comorin to

Tuticorin. The outer shelf and oceanic waters off Vengurla-Ratnagiri area also showed moderate (5 - 10/m^2) densities of larvae. The trend of decreasing densities towards off-shore was noticed as in 1973.

1974: (Fig. 40)

Widespread distribution of clupeoid larvae was observed during the year, extending over almost the entire area from Ratnagiri to Tuticorin. Unlike the previous years, the nearshore areas had less larval concentrations, except in the area north of Coondapur to Ratnagiri stretch and the waters off Tuticorin, where larval densities were found to be higher in the inshore waters.

The Kasaragod - Quilon area showed the best larval concentration, with the highest core value of more than 100 larvae/m^2 over the mid-shelf from Kasaragod to Cochin. The high density area was increasingly wide towards the south, being widest off Cochin extending to oceanic waters. The pattern of seaward domination of larval numbers was seen in 1974 also.

1975: (Fig. 41)

Overall widespread abundance was observed during the year, the area of high density being from south of Calicut to Tuticorin, with the highest value off the Cape Comorin - Tuticorin area in the oceanic waters. Continuous moderate

Fig. 38 - 41

ANNUAL DISTRIBUTION AND ABUNDANCE OF CLUPEOID LARVAE - 1972 - 1975.

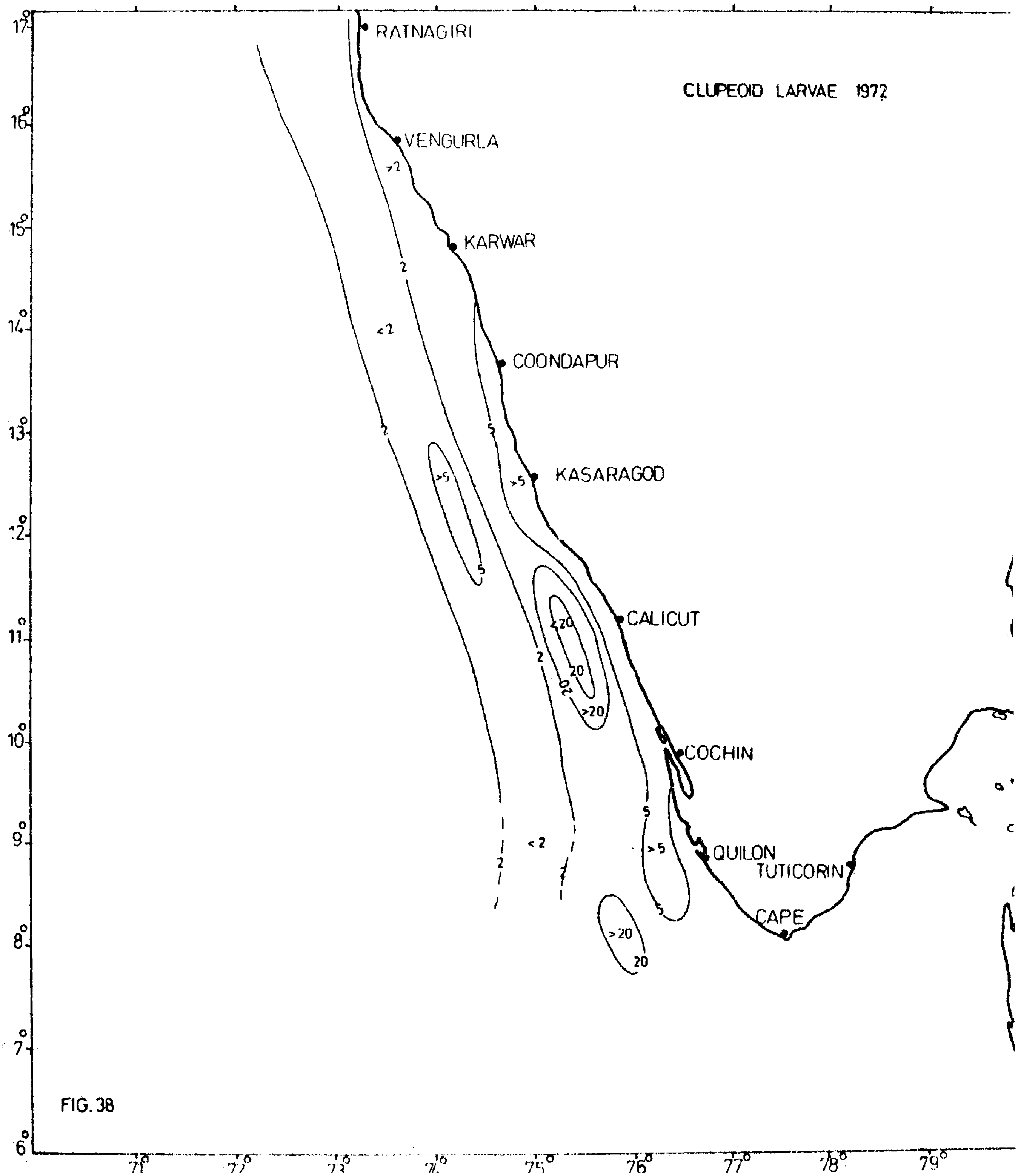

CLUPEOID LARVAE 1972
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
>2
2
<2
5
>5
<20
20
>20
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
71°
75°
76°
77°
78°
79°

FIG. 38

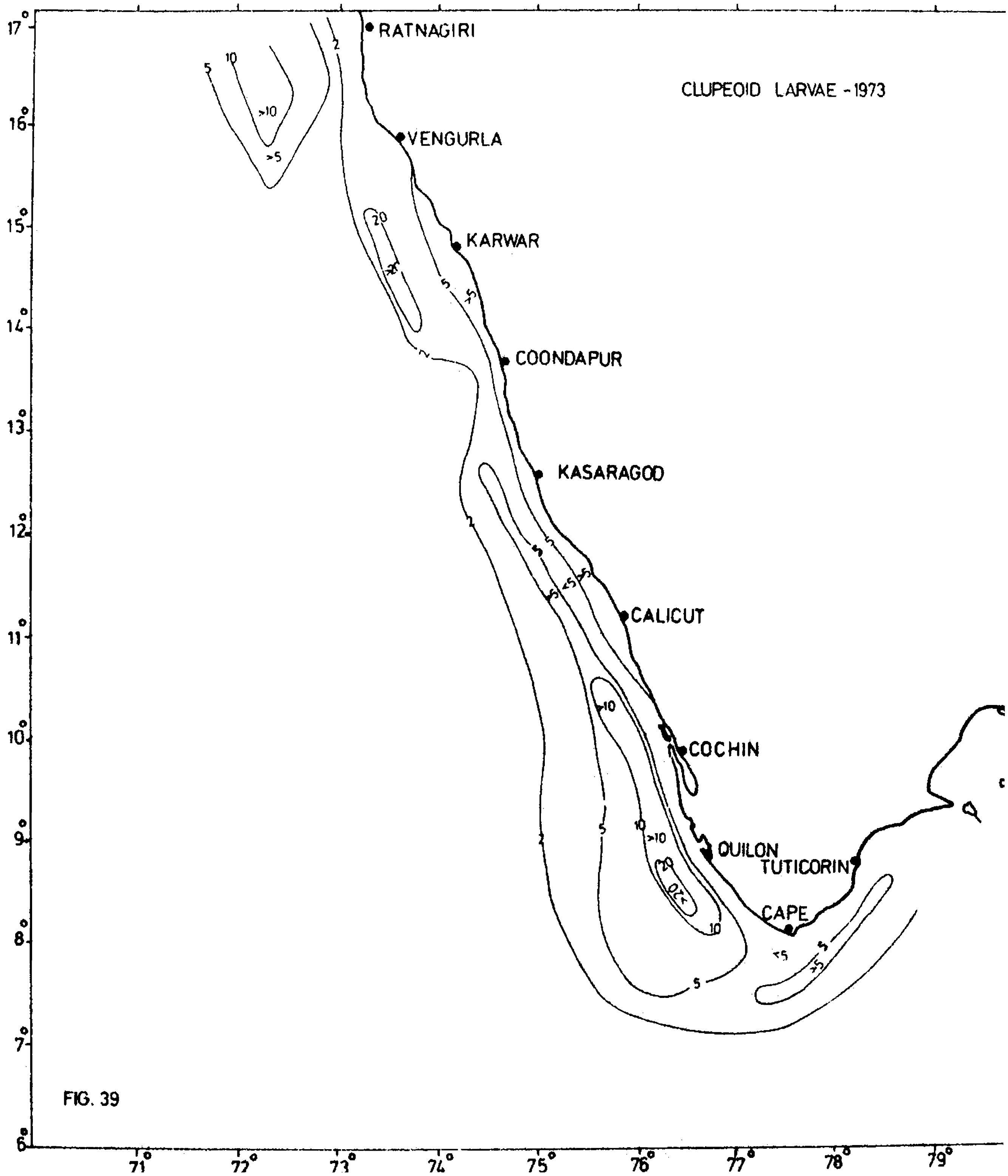

CLUPEOID LARVAE - 1973
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
71°
72°
73°
74°
75°
76°
77°
78°
79°

FIG. 39

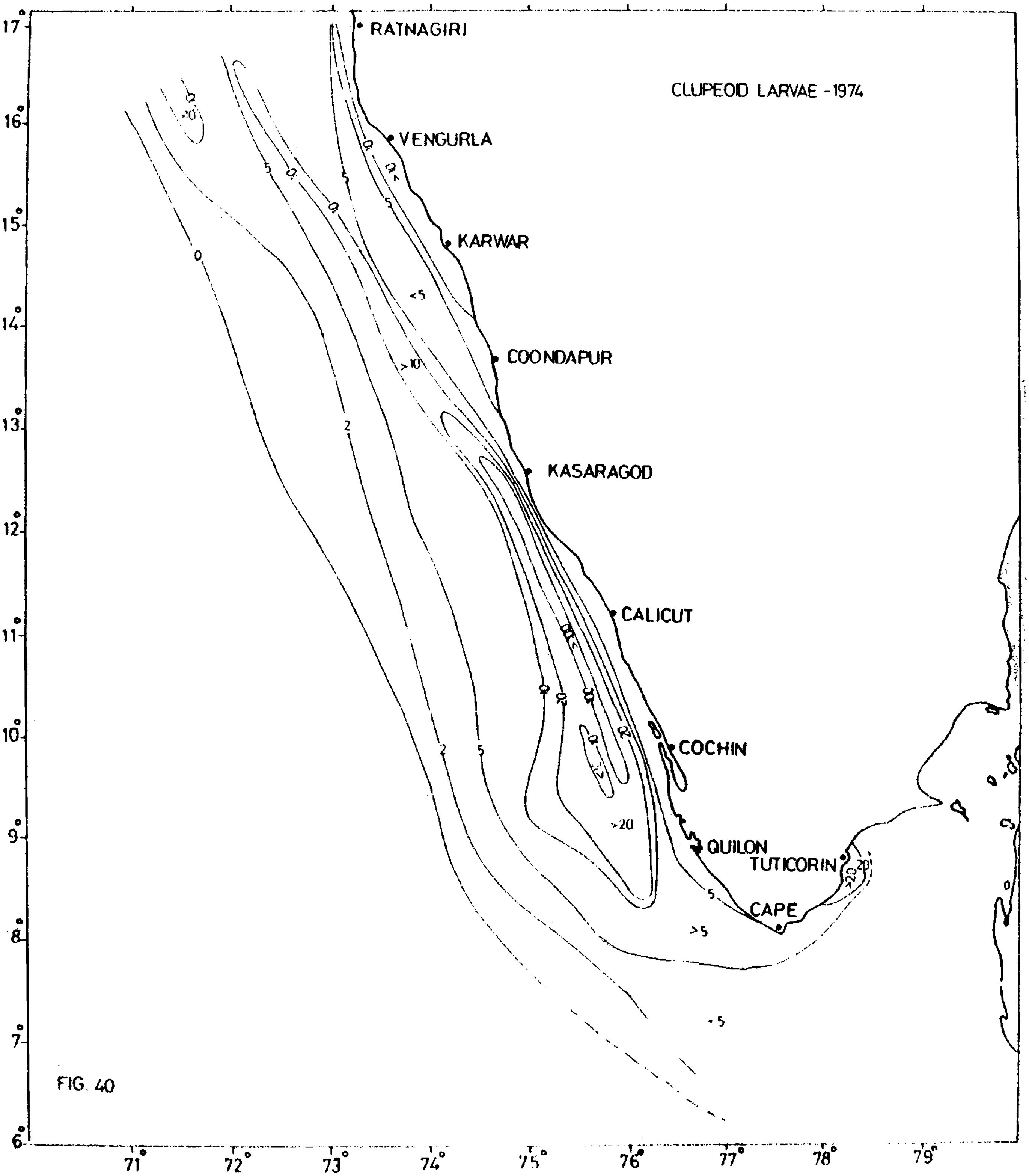

CLUPEOID LARVAE -1974
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
71°
72°
73°
74°
75°
76°
77°
78°
79°
<5
>10
>20
>5

FIG. 40

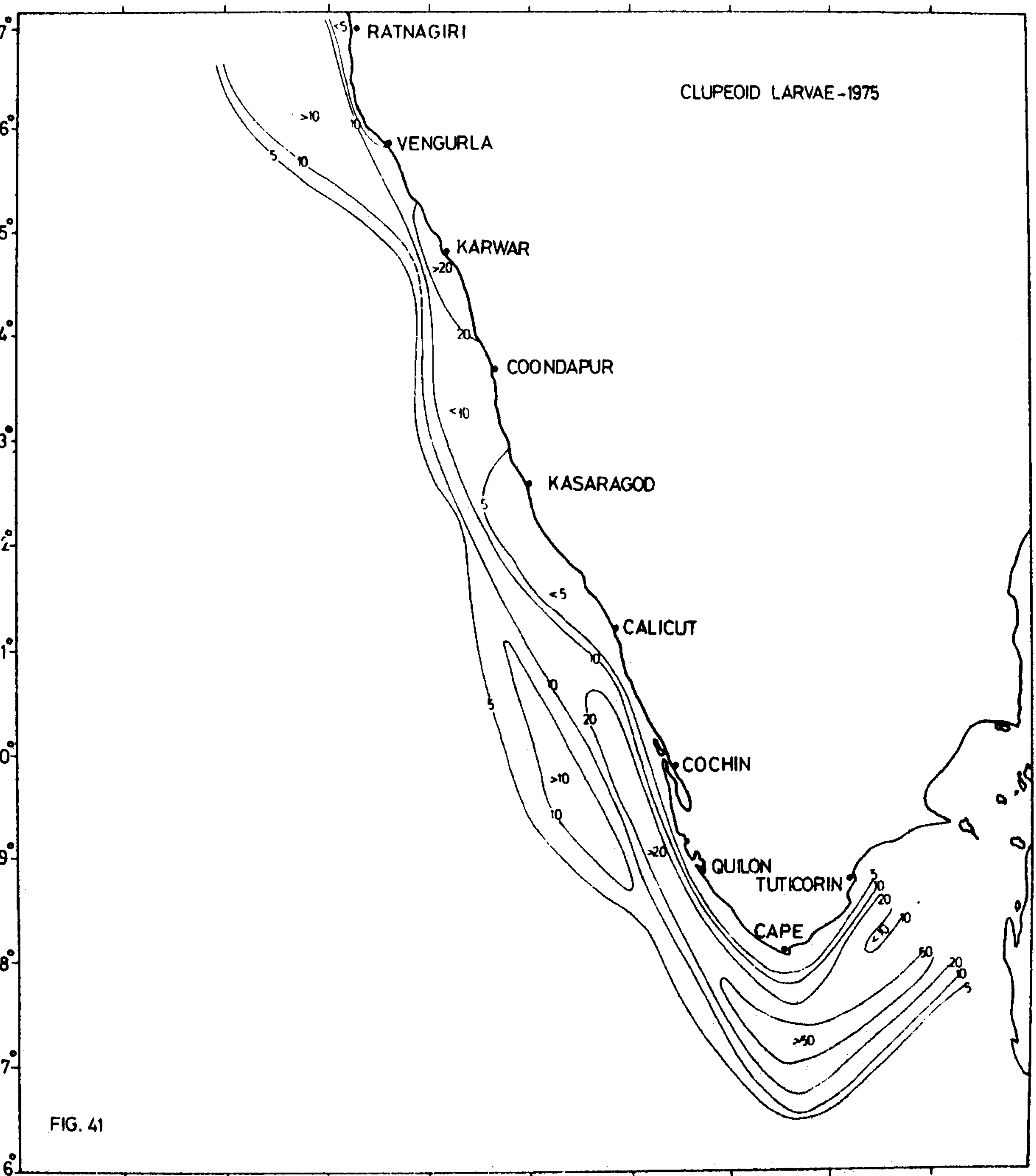

CLUPEOID LARVAE-1975
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
71°
72°
73°
74°
75°
76°
77°
78°
79°

FIG. 41

value (10 larvae/m^2) distribution was observed from Ratnagiri to Calicut, over the outershelf, the distribution being wide off Ratnagiri and narrow from Karwar to Kasaragod. The inshore area from Kasaragod to Tuticorin had only light density (less than 5 larvae/m^2) distribution, while north of Kasaragod, the inshore belt showed slightly higher density, with the highest value centred off Karwar. Seaward distribution of larvae showed a decreasing trend in values.

The average picture of the entire period showed denser distribution of clupeoid larvae in the southern half of the surveyed area. Relatively higher densities of the larvae and their more seaward distribution were seen in areas south of Kasaragod. Moderate larval densities with some high value pockets were seen in areas north of Kasaragod. From the extent and density of larval distribution observed in the area, the years '74 and '75 showed better spawning than the previous years.

7.1.3 <u>Eggs and larvae of sardines - the distribution and abundance of the larvae</u>

The oil-sardine (<u>S. longiceps</u>) contributing to the largest traditional marine fishery along the SW coast of India was perhaps the first clupeoid fish from the Indian seas which attracted the scientific curiosities of early workers. Hornell (1910) who attempted to determine the spawning habits and the factors which controlled its migrations felt that the spawning was extended for a considerable period. Hornell and Nayudu (1924) gave a brief account of the spawning habits of the fish, its rate of growth and migrations and inferred that the spawning took place only once a year from June to August. Devanesan (1943) artificially fertilised oil-sardine eggs and later isolated them from plankton collections. John (1951) gave an account of the egg and newly hatched larvae of Sardinella sirm. Chacko (1946, 1950) recorded eggs and larvae of Sardinella gibbosa. Chacko and Mathew (1956) dealt with the egg and larval development of S.albella. Bapat (1955) gave short notes on the egg and larvae of S.fimbriata. Nair (1959) described eggs and early larvae of S.longiceps hatched from the planktonic eggs collected at Calicut mostly during August and September. Kuthalingam (1960) described eggs and larvae assigned to oil sardine, from Madras. Bensam (1971 b) dealt with eggs, larvae and juveniles of S.jussieu and later (1973) described few post-larval stages and juveniles of S.dayi.

During the present studies, egg of oil sardine (with the characteristic large perivitelline space, segmented yolk, single oil globule about 0.1 mm diameter and egg diameter range of 1.1 - 1.4 mm) were collected within 9°30' - 12°30' N, over grounds less than 25 m depth. However, only on few occasions during the SW monsoon period they were taken in large quantities (sometimes more than 5000 eggs/m^2), usually from nearshore stations.

The larvae of *Sardinella* spp. with dominance of those of *S.longiceps*, occurred often together and these young stages were very similar in appearance. However, the oil sardine larvae could be separated from those of other species of sardines in the area, by their higher myotome numbers, usually 47. In a collection of sardine larvae from the area, those of oil sardine were usually more abundant. The planktonic larval stages of oil sardine (3.4 mm to 17.7 mm T.L) from the present collections have been already described and illustrated (Anon 1976 b).

The sardine larvae were collected in almost all the months from the area, but their dominant occurrence was found during the March to September period, with the peak in July (Fig. 48).

The average picture of the spatial distribution of the larvae for the 4 year period from 1972-1975 are presented in Fig. 42. The larvae were present all along the area and

Fig. 42

AVERAGE PICTURE OF THE DISTRIBUTION AND ABUNDANCE OF SARDINE LARVAE, 1972 - 75 (The figure is reproduced from the Progress Report of the Pelagic Fishery Project, No.17, prepared by the author, Anon, 1976 d).

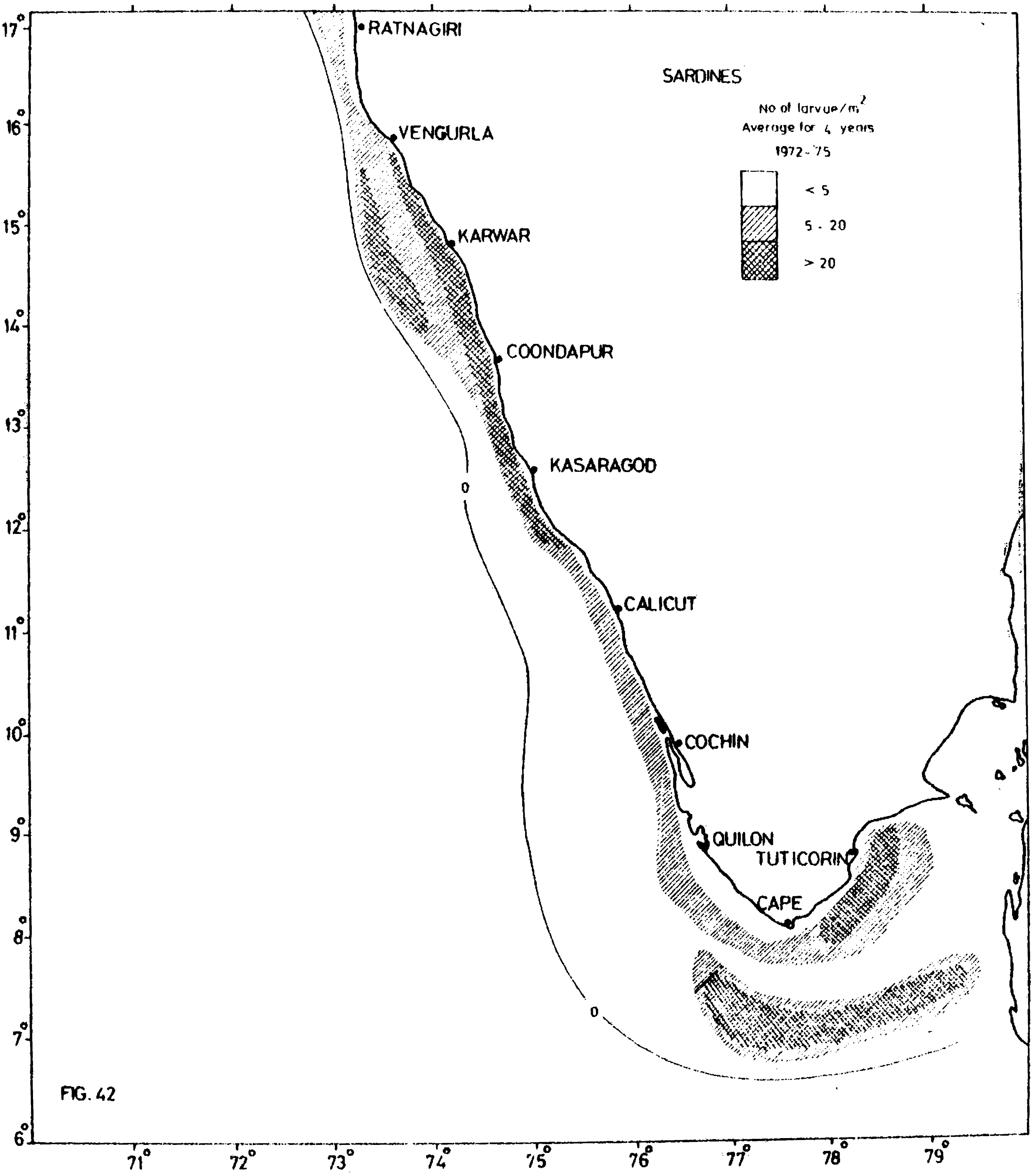

SARDINES
No of larvae/m²
Average for 4 years
1972 - 75
< 5
5 - 20
> 20
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
0
0
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
71°
72°
73°
74°
75°
76°
77°
78°
79°

FIG. 42

was practically restricted to the inner shelf. Off Cape Comorin there was an extensive oceanic patch of high density, spreading eastwards to the Gulf of Mannar and another dense patch between Cape Comorin and Tuticorin near the coast. Dense concentrations of the larvae were seen in the inner shelf, from north of Calicut to Vengurla (11°30' N - 15°30' N). There was a dense patch of larvae in the outer shelf between 13°30' N and 15°30' N.

7.1.4 Larvae of white-baits-distribution and abundance

Gopinath (1946) recorded the seasonal occurrence of large swarms of post-larvae of *Stolephorus commersonii* off the Trivandrum coast during the winter months. Sreekumari (1977) who studied in detail the larvae of *S. zollingeri* from the present collections found them throughout the year along the SW coast, with the maximum abundance in April - May period. She also noticed a secondary abundance in November - December period.

Mixed species of white-bait larvae were found in the present collections in almost all months of the year, with the dominant period of occurrence from March to July and a secondary dominance in November.

Fig. 43

AVERAGE PICTURE OF THE DISTRIBUTION AND ABUNDANCE OF WHITE-BAIT LARVAE, 1972 - 75.

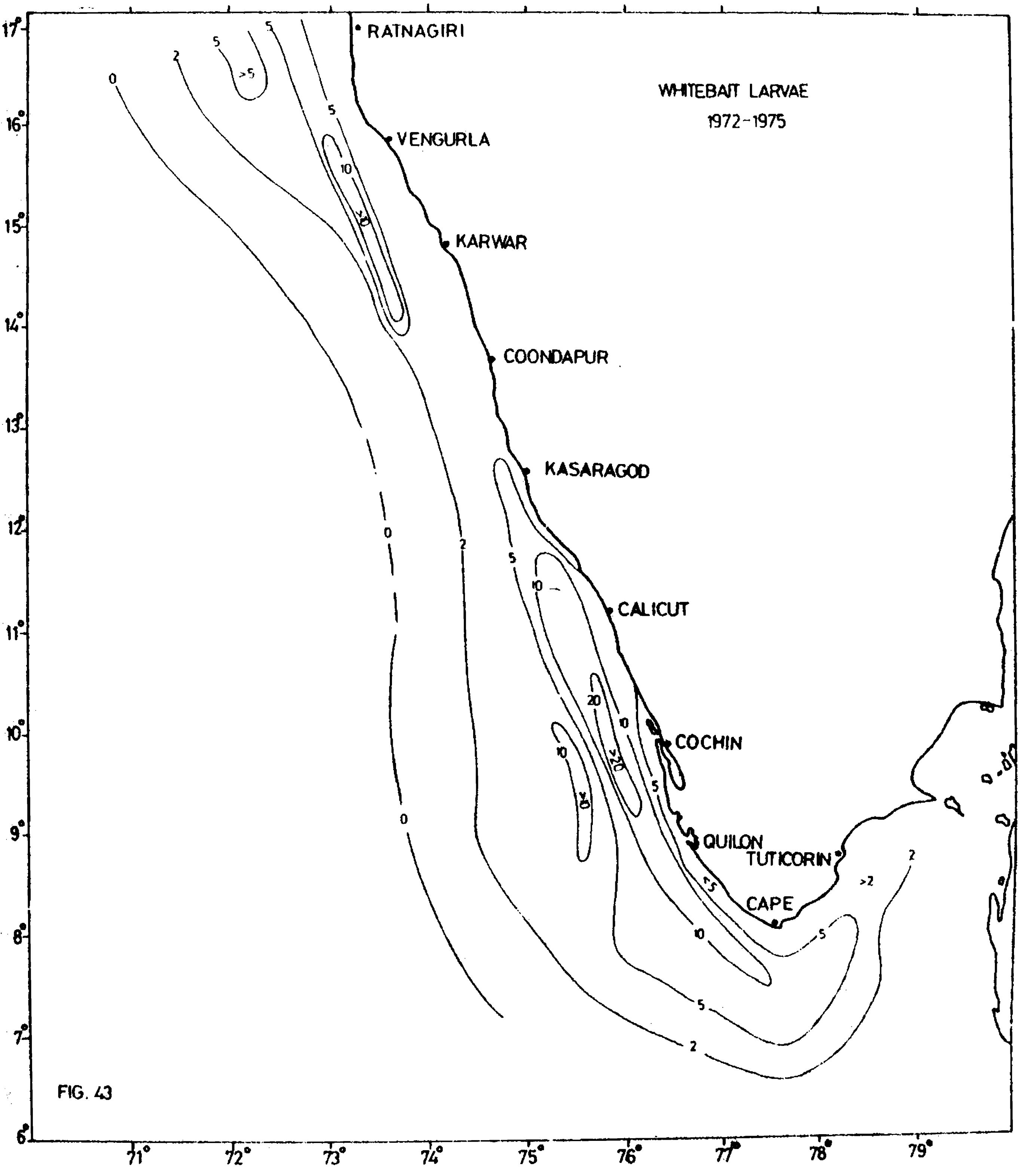

WHITEBAIT LARVAE
1972-1975
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
71°
72°
73°
74°
75°
76°
77°
78°
79°

FIG. 43

The larvae of *S.heterolobus* and *S.zollingeri* have been found in large numbers in the present collections. The other dominant species of white-bait larvae in the collections were those of *S.bataviensis* and *S.baganensis*.

The synoptic picture of the distribution of white-bait larvae for 1972 - '75 period is presented in Fig. 43. The distribution pattern showed a relatively dense concentration of larvae in the area south of Kasaragod to the Gulf of Mannar. The core value of density was mostly over the outer shelf in this area from 7°30' N to 11°30' N.

A northern concentration of lesser density was noticed on the outer shelf, approximately between 13°30' N and 15°30' N. The larval concentrations were found to be of rather light densities outside the shelf, diminishing further seaward.

7.2 <u>Other larvae</u>

The material dealt with under this category were studied only cursorily to indicate in general terms their distribution and abundance.

7.2.1 Larvae of Carangid fishes

Fishes of the family carangidae form a significant component of the marine fish catches of the SW coast of India. The major species contributing to the fishery are the scads (Decapterus spp.) and the horse mackerel (Megalaspis cordyla). The golden scad (Caranx kalla) is a shallow water species caught in good quantities in trawls as well as the traditional gears.

Records of eggs and larvae of carangids and their descriptions from Indian waters are mainly available through the works of Devanesan and Chidambaram (1941), Chacko and Mathew (1955), Nair (1952 b), Bapat (1955), Bapat and Prasad (1952), Vijayaraghavan, (1957), Rao, (1963) and Subrahmanyam (1964, 1966). Premalatha (1977) described the larval stages of Chorinemus sanctipetri from the present collections, which occurred mostly during the February to May period.

Carangid larvae occurred almost throughout the year with a predominance of Decapterus spp. Maximum numbers of larvae were noticed over the shelf waters in the May - June period, with a secondary abundance around the month of October.

The Carangid larval concentrations were mostly seen in the southern sector of the SW coast, between Cochin and Cape Comorin.

7.2.2 Larvae of flat-fishes

The major flat-fish fishery along the SW coast of India is sustained by *Cynoglossus semifasciatus* (= *Cynoglossus macrostomus*). Other flat-fishes represented in the catches of the west coast are *Psettodes erumei*, *Pseudorhombus* spp. *Solea ovata*, *C.dubius*, *C.puncticeps* and *C.bilineatus* (Rao, 1967).

Gopinath (1946) observed large numbers of advanced larval stages of *Bothus* (*Platophrys*) *pantherinus* in shore-seine catches along the Trivandrum coast in the December to March period. Jones and Menon (1951), John (1951), Nair (1952 b, c) described the larval and post-larval stages of flat-fishes. Seshappa and Bhimachar (1955) illustrated eggs and few post larvae assigned to *Cynoglossus semifasciatus* and also indicated its spawning period, from October to May, off Calicut. Balakrishnan (1961) described some stages in the larval development of *C.semifasciatus* and the larvae of some of the deep water flat-fishes collected from the Arabian sea (1963). Devi (1969) recorded the occurrence of the larvae of *Pseudorhombus elevatus* along the SW coast of India. Devi (1967) dealt with the distribution of larvae of flat-fishes in the Indian ocean, obtained from the IIOE collections. She found that the flat-fishes larvae were more abundant in the northern half of the Bay of Bengal, than in other areas in the Indian ocean and concentrated in the neritic region, with relatively low salinities. It was also observed that the larvae were more abundant in April and least in October.

In the present collections, flat-fish larvae occurred all over the area from Tuticorin to Ratnagiri in all the months. However, significant occurrence of the larvae were noticed in the March to November period, March - July and November being the periods of dominant occurrence. The larvae of Bothidae and Cynoglossidae predominated in the collections. The major areas of distribution were the shelf waters, from Quilon to Karwar.

7.2.3 Larvae of lantern-fishes

The larvae of lantern-fishes were most common and wide-spread in occurrence than all other fish larvae in the present collections. /Sorting of these larvae beyond the family level has not been attempted in this study. The larvae occurred in about 45%, of the stations sampled during the entire period. Valsa (1979) described the larval stages of Diogenichthys panurgus from the present collections.

The average pattern of the distribution and abundance of the lantern-fish larvae during the 1972 - '75 period showed the clearly oceanic preference of the larvae. The larvae were collected in waters off the SW coast of India, as far as 200 miles offshore, upto which distance the surveys were extended a few times. However, they were found only in small numbers in a large part of the shelf waters from Ratnagiri to Tuticorin. The major larval concentration (> 10 larvae/m^2) were found in a belt 30 - 40 miles wide, outside the shelf, south of 9°30' N. This strip of larval concentration at about 50 - 60 miles, away from the coast, extended as far as south of Cape Comorin. The next best concentrations (> 75 No./m^2) was in the northern part in a narrow belt over the outer shelf and the continental slope from north of Coondapur to Ratnagiri. The larval abundance showed gradually increasing trend towards oceanic waters upto an average distance of 120 miles from the shore and decreased further seaward.

Myctophid larvae were collected in all months from the area, but their abundance was more during February to August period with the peak in July.

7.2.4 Larvae of light-fishes

The gonostomatid larvae commonly met with in the present collections were those of Vinciguerria spp. Silas and George (1971) who described in detail several stages in the early life-history of Vinciguerria nimbaria from the SW coast of India found them more in the open sea, than in the neritic waters. The average pattern of distribution of the larvae of Vinciguerria spp. showed wide distribution all over from Ratnagiri to Tuticorin. The larvae clearly showed increase in their numbers seawards upto about 100 miles and declined farther off. The oceanic regions off Karwar - Ratnagiri and Quilon - Cape Comorin coasts were richer in larvae compared to the area in between. Few pocket concentrations of larvae were noticed over the mid-shelf, off Cochin and Ratnagiri.

The larvae of Vinciguerria spp. were collected in varying numbers in all the months but relatively more in the February to May period and least during September and October. R.V.*Varuna* collections from the SW coast of India in 1962 and 1963 showed relatively larger numbers of *Vinciguerria nimbaria* larvae during November to January and April - May periods (George and Silas, 1971). Spawning in these fishes appear to be more active in the pre-monsoon period than during the monsoon.

7.2.5 Larvae of Bregmaceros sp.

Bregmaceros macclellandi is the common species recorded from the Indian waters. Other species are expected in Indian waters in view of the records of the larvae of *B.nectabanus*, *B.variisquamosus*, *B.japonicus* and *B.arabicus* in the Indo - Pacific (D' Ancona and Cavinato, 1965). Day (1869, 1878) Bal and Pradhan (1947) and Jones and Pantalu (1958) have dealt with the larvae and adults of *B.macclellandi*. Balakrishnan (1971) collected larvae of *Bregmaceros* sp. from the SW coast of India, in the months of March, April, November and January.

In the present collections, larvae of *Bregmaceros* sp. occurred throughout the year mostly over the mid-shelf. More larvae were encountered during the February to August period, particularly in the months of July and August. December and January were generally the lean months for the larvae. The larvae were present in the entire area from Tuticorin to Ratnagiri, the Quilon - Ratnagiri area being denser in their distribution, with the maximum abundance in the Karwar - Ratnagiri stretch. There was a gradual reduction in abundance southwards from Ratnagiri. Nearly 70% of all positive stations for *Bregmaceros* larvae were located over the mid-shelf and beyond, between 30 - 150 m depths.

7.2.6 Larvae of lizard-fishes

The larvae of lizard-fishes were not as abundant or regular in occurrence as the other groups dealt with. *Saurida tumbil* and *S. undosquamis* are the common lizard-fishes met with in the catches of the SW coast. *Saurida gracilis*, *Saurus myops*, and *Saurus indicus* are the other species recorded from the SW coast.

Gopinath (1946) recorded post-larvae of *S. tumbil*, *Saurus myops* and *S. indicus* from the Trivandrum coast, caught in the shore seines in large swarms during the January - February period. Dileep (1977) described the larval stages (4.4 mm to 12.5 mm) of *Saurida tumbil* from the present collections, obtained mostly during November - December and January to April periods over the shelf and oceanic waters. *S. tumbil* larvae were more common in areas south of Kasaragod.

Larvae of lizard-fishes occurred in all the months, but were more abundant during February - March and November periods and least in July and August. They were seen mostly over the shelf.

GENERAL OBSERVATIONS

8.1 Day and night variations in the catches of larvae

Knowledge of the diurnal variations in the catches of fish larvae are important while planning spawning surveys. Silliman (1943) and Ahlstrom (1954) have pointed out the under sampling of pacific sardine (*Sardinops caerulea*) larvae during day time. Bridger (1956) found that the mean catch of clupeid larvae was nearly 7 times and pilchard larvae 4 times as large at night, than during day. Schnack and Hempel (1971) after a study of herring larvae sampling in the North sea, by Gulf III samplers, stated that the total catch of small larvae was equal at night and day but larger larvae were abundant at night, the ratio of catches being 275 : 440. Ahlstrom (1959 b) found that most kinds of fish larvae occurred off California and Baja California in markedly lower numbers in day time. However, he found no consistent difference between the numbers of *Trachurus symmetricus* larvae in day and night hauls. Ahlstrom (1971) observed marked difference in day and night frequency of occurrence of scombroid larvae in the ratio 31 : 45 during the 'Eastropac-I' survey. In both 'Eastropac-I' and 2 surveys, gonostomatid larvae had the most marked differences between day and night hauls, the night catch being 4.3 times of day catch in 'Eastropac-I' and 2.9 times in 'Eastropac-2' (Ahlstrom, 1972). Ali Khan (1972) found a general trend of higher densities of all larvae in the Gulf of Aden, in the upper 50 m for the night samples, the average number of larvae caught during the night being 2 - 4 times higher than those of the day. Panikkar and Rao (1973) reported that 65% of the fish larvae during the IIOE was taken at night.

Diel variation in catches of larval tunas has been discussed by Wade (1951), Matsumoto (1958), Strasburg (1960), Nakamura and Matsumoto (1966), and Klawe (1963). All reported greater catches at night. Ueyanagi (1969) observed no marked differences in larval tuna occurrence during the night between the surface and 20 - 30 m depth. However, different tendencies by species have been recognised during the day, for eg., larval skipjack and bigeye tunashave been observed to be greater at the surface than at 20 - 30 m depth, whereas in the case of the yellowfin larvae it was almost the same at surface and at 20 - 30 m depth. Richards et al (1971) studying the distribution of tuna larvae in the north-western Gulf of Guinea and off Sierra Leone observed more frequent catches of yellowfin and bigeye tuna larvae at the surface during night. No difference was apparent between day and night tows for Auxis. In the case of the tuna larvae collected by the IIOE, Peter (1977) found that out of 74 stations which recorded tuna, 50 were night stations.

Watanabe (1970) showed in the case of Scomber japonicus larvae, that the number of post-larvae collected near the surface was higher at night than during day and these post-larvae scarcely inhabited deeper than 25 m. Silas (1974) stated that more larvae of the Indian mackerel were obtained at night (1930 hrs - 0050 hrs) than in the day (0630 hrs - 1800 hrs) or during twilight (1800 hrs - 1930 hrs and 0500 hrs - 0630 hrs). The twilight period was poorest in availability of larvae. However, Boonprakob and Dehtaranon (1974) found the post-larvae of the Indo-Pacific mackerel (Rastrelliger neglectus) showing a positive photo-taxis reaction in the early morning, while the sun is rising. A large number of post-larvae were observed to concentrate at the depths 5 - 10 metres during day time and to drift towards greater depths, from dusk through the night.

In the present study, catches of 'all larvae' from 1280 stations were considered for day (0601 - 1800 hrs) and night (1801 - 0600 hrs) variations. Similarly the trend in day and night catches of some categories of larvae were considered, based on the positive hauls for these larvae. Details are presented in Table - 7.

It was seen that the average catch per night station (No./m^2) of 'all larvae' was 1.4 times that of day catches. On the classified basis, the maximum increase in night catch rate was seen in the larvae of *Vinciguerria* spp., being 2.15 times that of day catches, and the least in the case of *Auxis* spp., where the night/day factor being only 1.01, indicating nearly equal catches during day and night. This agrees with the observation of Richards *et al* (1971) for *Auxis* larvae from the Gulf of Guinea and off Seirra Leone, where the collections have been made by an ICITA (International Co-operative Investigations of the Tropical Atlantic) 1 m plankton net towed at the surface.

Fifty percent more *Sardinella* larvae and *Euthynnus affinis* larvae were caught at night than in day hauls. The increase in larval catch at night though consistent in all types of larvae; in the case of mackerel, whitebait and *Thunnus* spp. it was only marginal.

Variations in larval catches during day and night could happen due to the larvae avoiding the net during the day or due to their reactions to light intensities, causing aggregations at different levels. Avoidance rate will be influenced by the type of gear, method of haul and the age of the larvae. Some information on the size of certain species caught in the night and day have been given under section 6.7. In the present case the continuous oblique Bongo net haul at a vessel speed of 2 - 3 knots is expected to reduce avoidance compared to slow speed vertical hauls from stationary ships.

Majority of the observations cited in the chapter shows that more fish larvae are caught at night than during the day eventhough varying results have been reported in some cases like Auxis and Trachurus larvae, where they have not shown increased rates of catches at night.

Table - 7.

The proportion of different categories of larvae caught during day and night hauls.

Type of larvae	DAY (0601-1800 hrs)		NIGHT (1801-0600 hrs)		Night / day factor
	No.of stations considered.	No.of larvae/m^2 per positive station	No.of stations considered.	No.of larvae/m^2 per positive station.	
All larvae	696	32	584	45	1.40
Stolephorus spp.	263	13.21	254	15.34	1.16
Sardinella spp.	68	15.03	59	22.61	1.50
Rastrelliger kanagurta	50	5.68	48	6.37	1.12
Auxis sp.	66	16.86	78	17.18	1.01
Katsuwonus pelamis	13	1.46	32	1.78	1.22
Euthynnus affinis	13	2.23	16	3.50	1.57
Thunnus spp.	10	1.10	13	1.23	1.12
Vinciguerria spp.	162	4.26	173	9.16	2.15

8.2 Plankton biomass and abundance of fish eggs & larvae

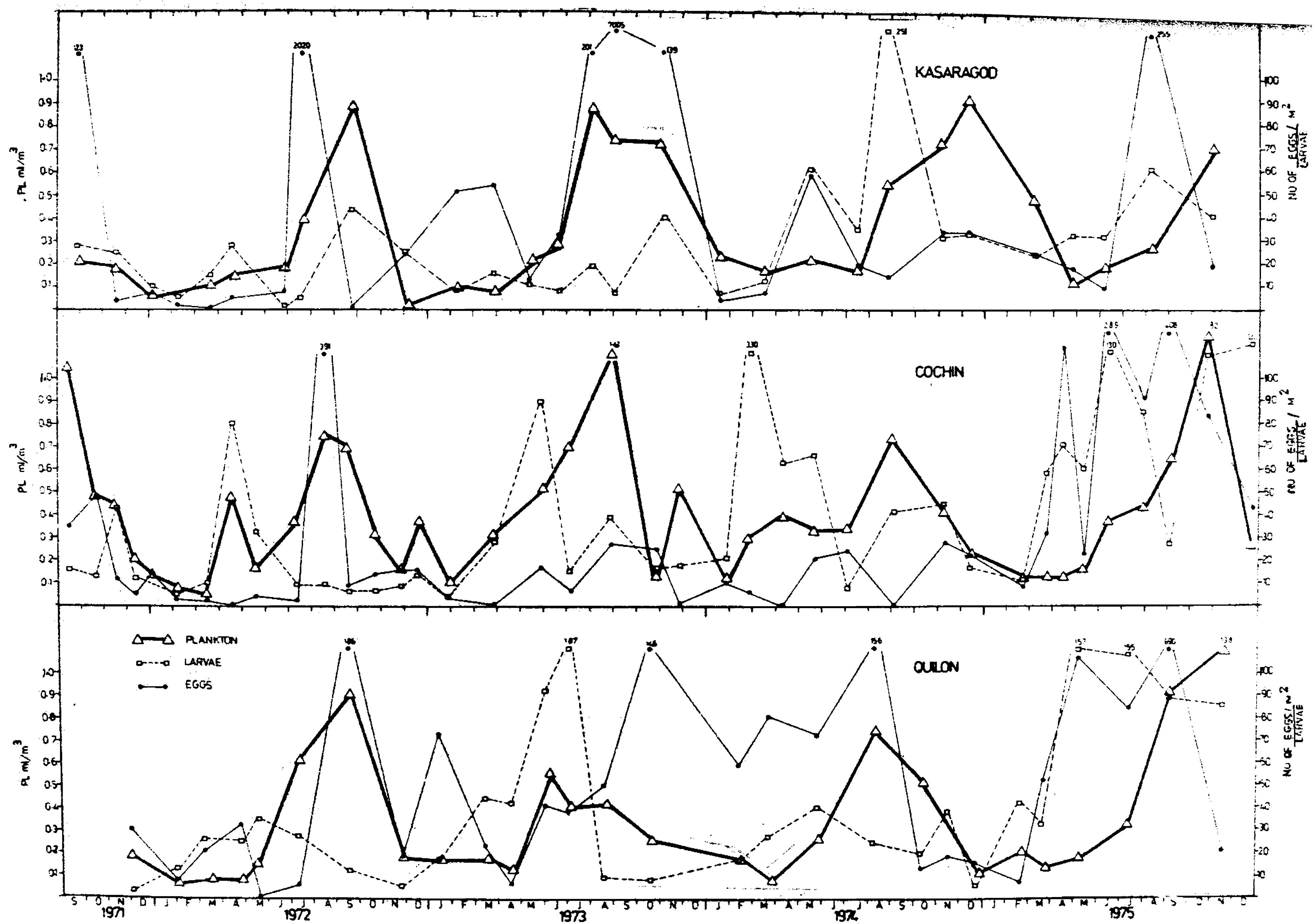
With a view to find out the relationship if any between plankton volume and numbers of eggs and larvae caught, data from three representative sections namely, Kasaragod, Cochin and Quilon have been analysed. The average numbers of eggs and larvae per m^2 andaverage volume of plankton (ml/m^3) for all stations of each of the section have been plotted in sequence of the coverages for the entire period of observation from 1971- '75 (Fig. 44). The numbers of eggs and larvae in the collections showed, in general, a positive relationship with the volume of plankton, in the majority of the observed sequences. In the lean months for plankton, egg and larval abundance was also poor, as was the case, generally in the January to April period. However, preceeding peaks of eggs and larval numbers to those of plankton volumes were also seen, particularly in 1975.

Peter (1969 b) observed that the volumetric relationship between fish larvae and the total plankton biomass of the IIOE samples collected with the Indian Ocean Standard Net (113 ∅, 0.33 mm mesh) was neither very close nor uniformly proportional in all zones. Strasberg (1960) reported high catches of larval tunas from samples of low and moderate volumes of plankton, while samples with lowest and highest plankton volumes contained smaller numbers. Nakamura and Matsumoto (1966) found on an average a positive correlation between abundance of plankton and larval tunas, but in the individual samples, no significant correlations were found. Ali Khan (1972) found an inverse relationship between number of larval fish and zooplankton volumes in the samples taken from the Gulf of Aden, with a Hensen egg net (73 cm Ø, 0.33 mm mesh), large catches of fish larvae being accompanied by low or moderate volume of planktons. It is seen that the relationship between plankton biomass and number of eggs and larvae caught have not been consistent in these observations.

In the present study maximum spawning activity of the fishes were observed during the SW monsoon months when there was maximum production of plankton also and hence the generally evident direct relationship between plankton biomass and number of eggs and larvae caught could be expected.

Fig.44

REPRESENTATION OF THE RELATIONSHIP BETWEEN PLANKTON BIOMASS AND EGGS AND LARVAL CATCH IN THE KASARAGOD, COCHIN AND QUILON SECTIONS.


KASARAGOD
COCHIN
QUILON
PLANKTON
LARVAE
EGGS
PL ml/m3
NO OF EGGS / m2 / LARVAE
1971
1972
1973
1974
1975

8.3 <u>Occurrence of sardine, mackerel and tuna larvae in relation to surface temperature and salinity</u>

Studies on distribution of fish larvae from the Indian seas in relation to abiotic environment are scanty. Bapat (1955) after a preliminary study of the fish eggs and larvae of the Gulf of Mannar stated that the maximum spawning of the fishes in the area took place during the low salinity and temperature period. Venkataramanujam and Ramamurthi (1974) studied the seasonal abundance of eggs and larvae of the coastal waters of Porto novo, on the east coast of India and found that fish larvae were found at a temperature range of 27.0° to 28.0°C and salinity range of 22.5 to 24.0‰.

Ali Khan (1972) correlated surface temperature and the distribution of fish larvae in the Gulf of Aden and in the waters off the coast of West Pakistan. He obtained <u>Sardinella</u> larvae in the surface temperature range of 23.5° to 24.0°C. Larvae of <u>Stolephorus commersonii</u> were caught in the range of 23.5° to 24.5° C and <u>Vinciguerria</u> larvae in 24°C to 26°C. Matsui (1970) observed <u>Rastrelliger</u> larvae in Gulf of Thailand and adjacent waters at stations with a salinity range of 29.43‰ to 34.5‰ and temperature range of 26.2°C to 31.7°C.

Silas (1974) discussed temperature, salinity and dissolved oxygen conditions in May 1964, in the shelf area of the SW coast of India, from where good numbers of mackerel larvae were collected. The vertical temperature noted in the area at the time of collection ranged from 28.6°C at surface to 29.5°C at 30 metre depth and the salinity was 35.13‰ at surface and 35.08‰ at 30 m. Dissolved oxygen values increased from surface downward, being 4.50 ml/l at surface and 5.55 ml/l at 30 m depth.

Boonprakob and Debtaranon (1974) indicated the distribution of the larvae of R.neglectus in the Gulf of Thailand, at a temperature range of 27°C to 29°C and salinity range of 31.75‰ to 32.75‰ . Matsumoto (1959) reported a surface temperature range of 22.5° to 29°C for Auxis and 23.5° to 29°C, for Euthynnus of the Dana collections from Pacific and Atlantic.

Jones and Kumaran (1963) observed that the maximum numbers of tuna larvae collected by the Dana Expedition from the Indian ocean, were from areas with a temperature range of 26°C to 29°C.

Klawe et al (1970) based on their studies in the Gulf of California area suggested an optimum temperature of 27°C for the occurrence of Auxis larvae. Richards et al

(1971) found *Auxis* larvae in water with temperatures as low as 21.6°C and as high as 30.5°C, the widest temperature range for any tuna larvae studied by them. They also observed that the larvae of yellowfin, bigeye and skipjack tunas were restricted to waters where surface temperature were higher than 24°C, in the Gulf of Guinea and off Sierra Leone.

In the present study the surface temperature and salinity values of the positive stations for the different larvae have been considered. Percentage frequencies of occurrence of the larvae of sardines, mackerel and tunas in different temperature and salinity ranges have been presented as histograms (Figs. 45, 47).

The larvae of *Sardinella* spp. and *Rastrelliger kanagurta* occurred in a wider range of temperature and salinity than those of tunas. The temperature range for *Sardinella* larvae was observed to be 24° to 31°C with their predominant occurrence in the 26° to 28°C range. The temperature range for the mackerel larvae was 25° to 30°C with their significant abundance in the warmer 27° to 29°C range. Stray occurrence of the larvae in waters with temperature as low as 23°C was also noticed.

Among the tunas, the larvae of *Auxis* sp. and those of *Euthynnus affinis* occurred in relatively wider range of temperature, 25° to 31°C in the case of *Auxis* and 25° to 30°C in the case of *E. affinis*. Dominant occurrence of *Auxis* larvae was found in the range of 27°C to 29°C and *E. affinis* from 29° to 30°C. Temperature range for skipjack larvae was 27° to 31°C with their predominant occurrence in the 28° to 30°C range.

Larvae of *Thunnus* spp. showed relatively restricted warmer temperature range for their occurrence, 28° to 30°C.

As regards the tolerance of salinity, it is seen that *Sardinella* larvae showed the widest range from 29‰ to 36‰ S, with their predominant occurrence in the range of 33‰ to 35‰ S (Fig. 46 and 47). The mackerel larvae showed a slightly smaller range than the sardines from 31‰ to 36‰ S, but with the same predominant occurrence range (33 - 35‰ S). All the tuna larvae showed a short range of 34‰ to 36‰ salinity for their dominant occurrence, with *Auxis* and *E. affinis* showing tolerance to less saline water down to 32‰ and 33‰ respectively.

Fig. 45

HISTOGRAMS SHOWING SURFACE TEMPERATURES AND OCCURRENCE OF THE LARVAE OF TUNAS, MACKEREL AND THE SARDINES. (Numbers in brackets indicate the numbers of positive tows considered.)

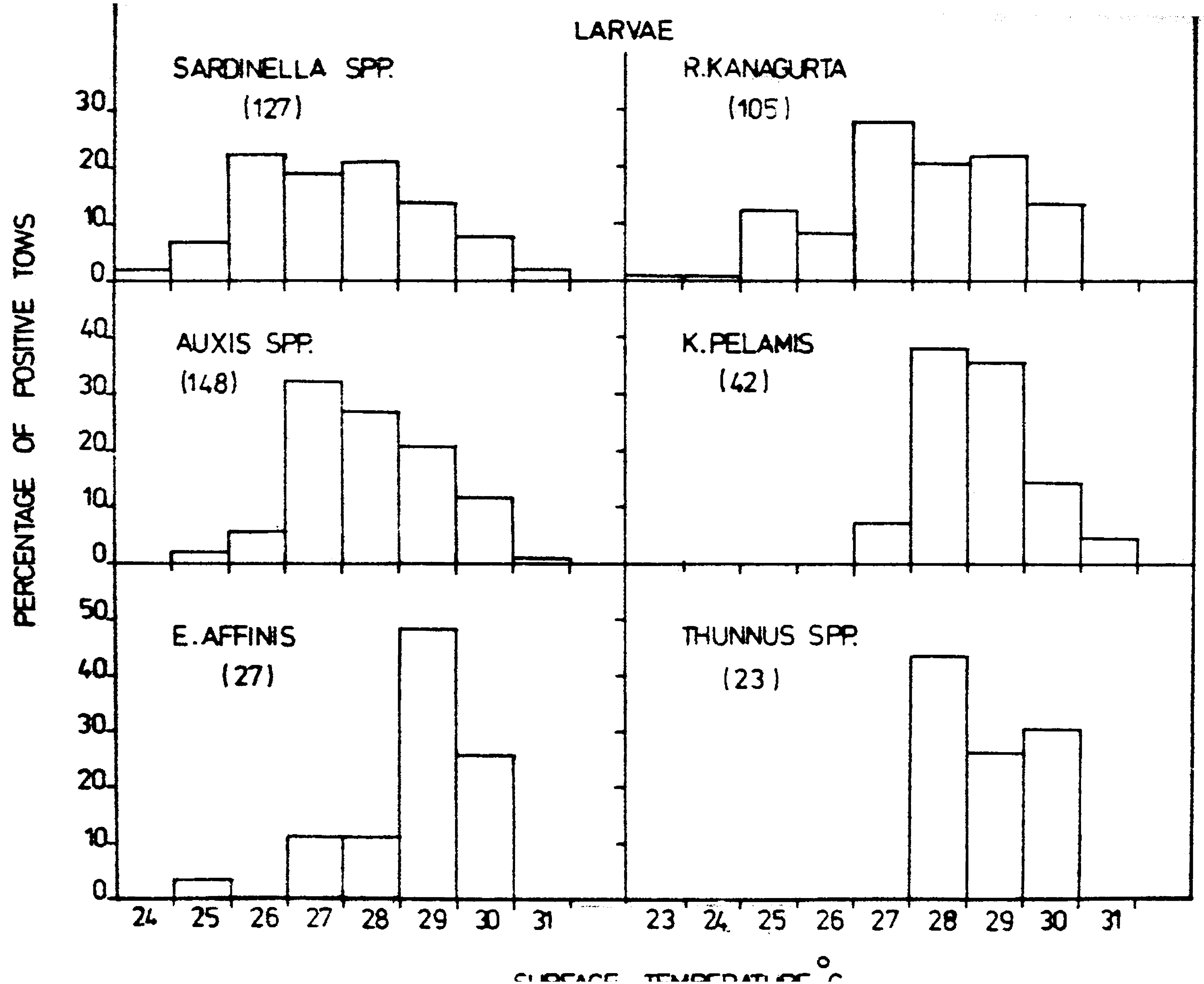
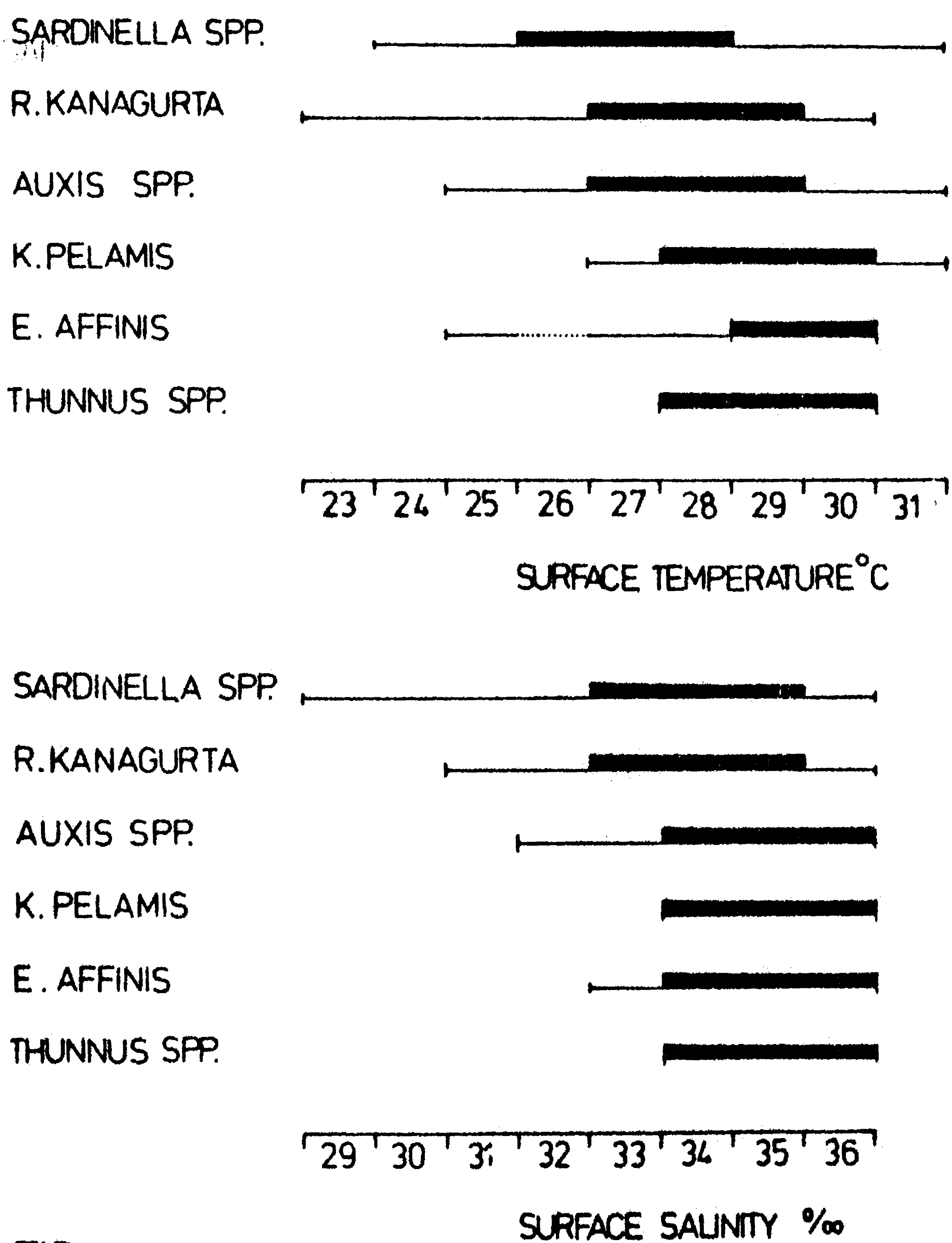

LARVAE
SARDINELLA SPP.
(127)
R.KANAGURTA
(105)
AUXIS SPP.
(148)
K.PELAMIS
(42)
E.AFFINIS
(27)
THUNNUS SPP.
(23)
PERCENTAGE OF POSITIVE TOWS
0
10
20
30
40
50
23
24
25
26
27
28
29
30
31

Fig. 47

COMPOSITE PICTURE OF THE SURFACE TEMPERATURE AND SALINITY RANGES IN WHICH DIFFERENT LARVAE OCCURRED. (The total range - entire bar - and the more favoured range - thick bar - are indicated).



SARDINELLA SPP.
R. KANAGURTA
AUXIS SPP.
K. PELAMIS
E. AFFINIS
THUNNUS SPP.
23 24 25 26 27 28 29 30 31
SURFACE TEMPERATURE °C
SARDINELLA SPP.
R. KANAGURTA
AUXIS SPP.
K. PELAMIS
E. AFFINIS
THUNNUS SPP.
29 30 31 32 33 34 35 36
SURFACE SALINITY ‰

FIG. 47

Fig. 48

BAR DIAGRAM SHOWING THE SPAWNING PERIODS OF DIFFERENT FISHES.

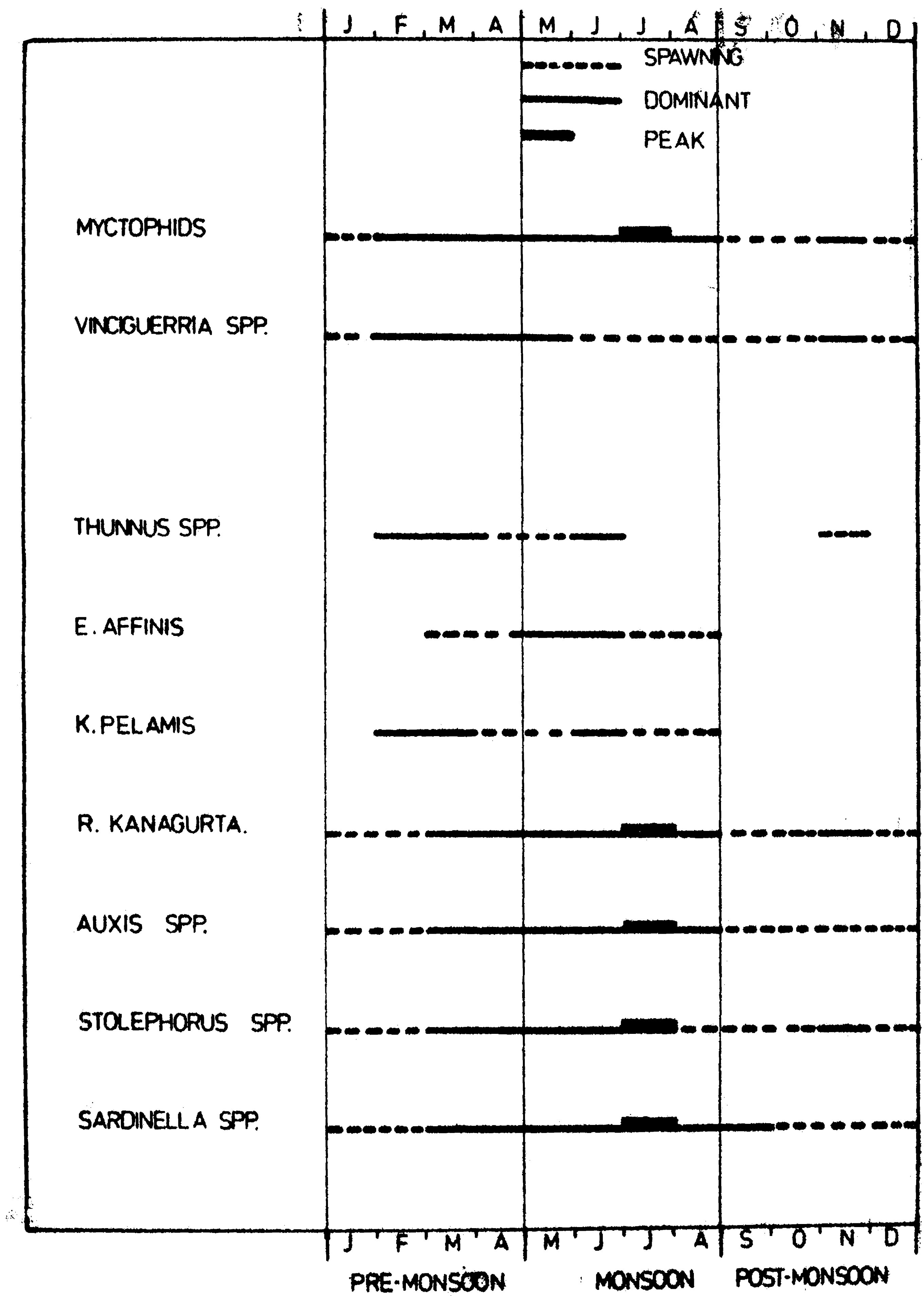

J F M A M J J A S O N D
SPAWNING
DOMINANT
PEAK
MYCTOPHIDS
VINCIGUERRIA SPP.
THUNNUS SPP.
E. AFFINIS
K. PELAMIS
R. KANAGURTA.
AUXIS SPP.
STOLEPHORUS SPP.
SARDINELLA SPP.
J F M A M J J A S O N D
PRE-MONSOON
MONSOON
POST-MONSOON

FIG.48

9. DISCUSSION

The International Indian Ocean Expedition (IIOE - 1960 - '65) and the Dana Expedition of the Carlesberg Foundation (1928 - '30) have made valuable contributions to our knowledge of the fish eggs and larvae of the Indian Ocean. But systematic ichthyoplankton surveys in an area, covering all the seasons have not been carried out in Indian waters till recently. In the late fifties and early sixties, the erstwhile Indo-Norwegian Project, in collaboration with the Central Marine Fisheries Research Institute played a vital role in the survey of ichthyoplankton, off the SW coast of India, particularly in the Laccadives Sea. The most intensive effort in ichthyoplankton surveys in recent times in Indian waters has been put in by the UNDP/FAO, Pelagic Fishery Project (1971 - '79), Cochin, mainly on the shelf waters off the SW coast of India, from Ratnagiri (17°N) to Tuticorin (08°48'N) on the SE coast. As an auxillary programme to acoustic surveys for fish resources, a grid of 7 plankton and hydrography sections with appropriately placed stations were worked in almost all the months during the first phase of the Project (September 1971 to December '75). The twin cone 'Bongo 20' net with a calibrated flow meter was the principal gear used. The continuous oblique hauls at a vessel speed of 2 - 3 knots, sampled the water column, when the net travelled down and up. The depth of collection was adjusted to ground depths in shallow waters and usually to 100 m in deeper areas. The volume of plankton and the number of fish eggs and larvae collected were standardised to number per m^2 on the basis of the volume of water filtered by the net. Volume of water filtered was determined from the flow meter reading and the calibration factor.

The surveyed area of the SW coast of India provides on an average over 50% of the marine fish catches of the country and the major pelagic fishery resources of oil sardine and the Indian mackerel are the most important exploited resources of the area.

The material dealt with in the present study pertains to the collections made during the first phase of the Project (September 1971 to December 1975). Samples from a total of 1409 stations were considered for this study. Nearly 70% of these stations were located over the shelf and the rest beyond.

The broad objective of the study was to assess and present a synoptic picture of the distribution and abundance of fish eggs and the important groups of fish larvae along the SW coast and to delineate the spawning grounds and seasons of the major species. Fish eggs were treated on the whole on an unclassified basis and fish larvae, particularly of the important species were dealt with to the generic or specific levels.

Several records of fish eggs and larvae from coastal waters along the SW coast India are available. Gopinath (1942, 1946) studied the concentration of post-larval fishes along the Trivandrum coast during the November - March period. Menon (1945) found fish eggs and larvae most common off Trivandrum coast from September to November and May to July. George (1953) observed that fish eggs and larvae were scarce off Calicut coastal waters during the monsoon months. He collected eggs of Sardinella longiceps in August, that of Caranx spp., from September onwards, Anchoviella spp. during December to January and Kowala sp. during September to November. Mukundan (1967) found the abundance of fish eggs and larvae off Calicut from August to December. Information from IIOE collections showed significant abundance of fish larvae off the central part of the west coast of India, with catches upto 1600 larvae per haul, off the Malabar coast (11°00'N, 74°35'E), (Panikkar and Rao 1973). Peter (1974) observed that the June to August period was the best season for fish eggs and larvae in the Arabian sea, the peak being July. According to him December - February period was poor for eggs and April and September for larvae. The results of the present study largely corroborate the above observations. Ahlstrom (1968) after analysing representative samples from IIOE collections found that the intermediate zone was the richest in fish larvae, compared to the coastal and oceanic zones.

Nellen (1973) recorded an average of 42 larvae per m^2 off the west coast of India, which compared favourably with the average of 39 larvae per m^2 observed in the present studies from the SW coast. He also observed predominance of myctophid and gonostomatid larvae at the oceanic stations.

The distribution and abundance of fish eggs and larvae are illustrated by drawing density contour lines on the basis of standardised numbers (No/m^2).

During the pre-monsoon season there was relatively poor abundance of fish eggs and larvae than in the monsoon season, when high concentrations were seen in the area south of 12°N. The larvae showed wide seaward dispersal during the monsoon season, the nearshore areas showing low values. However, dense patches of eggs in nearshore as well as offshore waters were seen during this season. During the post-monsoon season, abundance of fish eggs were moderate to high over the shelf, decreasing steadily towards offshore and with pockets or narrow belts of high concentrations, near the shore or over mid-shelf. The larval densities were generally low during the post-monsoon season in the inshore areas while wide-spread and moderately dense distribution was seen in the offshore areas.

The present study gave special emphasis to the distribution and abundance of scombroid larvae. Over 20 scombroid fishes are recorded from the Indian waters, of which about 15 are found in waters off the SW and SE coasts of India. The scombroid fisheries of the area are sustained mainly by Rastrelliger kanagurta, Scomberomorus commerson, S. guttatus, Auxis thazard, A. rochei, Sarda orientalis, Euthynnus affinis, Katsuwonus pelamis, T. tonggol and Thunnus albacares.

The scombroid larval material in the present collections consisted predominantly of Auxis spp. followed by those of R. kanagurta. The larvae of K. pelamis, E. affinis and Thunnus spp. were also represented in lesser numbers. The larvae of Scomberomorus commerson, Xiphias gladius and and Istiophorus gladius were scarce.

The general picture of distribution of all scombroid larvae showed two areas of concentration, one south of Calicut to east of Cape Comorin and another smaller concentration off Ratnagiri. A dissimilar picture of this average pattern was seen in 1975, when the major concentration shifted to a large central patch, between 10°30' and 13°30'N in the offshore waters. An inshore belt, about 10 miles wide along the surveyed area was often devoid of larvae. Several records of larvae of tunas have been made from Indian waters, mainly from the Laccadives sea (Jones, 1959 b, 1960 a, b, 1963 a). The distribution of larval tunas in the Indian ocean has been dealt with by Jones and Kumaran, (1964 b) and Gorbunova, (1963).

In the present collections, the larvae of tunas were recorded from about 19% of the total plankton stations. The larvae of Auxis spp. the most abundant of all scombroid larvae were found over most part of the shelf and oceanic waters except in the nearshore belt, the major concentration being beyond 50 m depth, over the continental slope and oceanic waters in a belt of an average width of 30 miles from Kasaragod to Tuticorin. Jones (1960 b) collected Auxis larvae from the Laccadives sea in January and April and subsequently (1963 a) described two types of larvae A. thazard and A. tapeinosoma of the Dana collections from the Indian ocean (December 1929 - January, 1930).

Rao (1964) indicated April to September as the probable spawning period of *Auxis* spp. in Vishinjam waters on the basis of ovary studies. *Auxis* larvae were collected in the present study in all the months of the year, more abundantly from March to August with the peak in July. They were least available during the November to February period. The minimum size of larvae caught was 2.1 mm and the maximum size 13.6 mm, with the 3 to 6 mm length groups dominating in the catches. No significant day-night variation in the catches was noticed. The larvae occurred in a wide range of surface temperature (25°C to 31°C) but were more often caught in the 27°C to 29°C range. They were found in surface salinity range of 32 - 36 ‰, but the dominant occurrence was noticed in the 34 - 36 ‰ S.

Euthynnus affinis larvae occurred in the present collections from March to August, with their dominant occurrence in the May - June period. Though represented in all the sections, Karwar and Ratnagiri sections yielded more larvae. They were caught more in offshore waters beyond 50 m depth. Fifty percent more *E. affinis* larvae were caught in night hauls than in the day. The favourable surface temperature for occurrence of the larvae was however, 29°C to 30°C, they were found at temperature as low as 25°C. The larvae occurred in the 33 to 36 ‰ surface range with dominant occurrence in the 34 to 36‰ range. The minimum length of the larva caught was 3.0 mm and the maximum 12.8 mm, with the dominant length groups at 3 to 6 mm. The smallest specimen of E.affinis recorded from the west coast of India in the month of May measured 29.5 mm total length (Jones, 1960 a). None of the E.affinis larvae collected from the Indian ocean by the Dana Expedition were from the present area of investigation (Jones and Kumaran, 1963). The R.S.Vitiaz collection of E.affinis larvae from the Indian ocean also showed no positive stations in the Arabian sea (Gorbunova, 1963). Rao (1964) based on study of ripe ovaries indicated that E.affinis spawn probably from April to September off Vizhinjam.

The Katsuwonus pelamis larvae occurred during the February to August period, with dominant occurrence from February to April and in June. Raju (1963, 1964) observed that the peak spawning of K.pelamis in the Laccadives sea and Minicoy Island appeared to be from February to June or July. The present observations on the distribution and abundance of larvae from the SW coast of India fits well with the above conclusions based on study of ripe gonads.

Jones (1959 b) collected *K.pelamis* larvae from December to April from the Laccadives. A stray occurrence of *K.pelamis* larva was noticed during the present study in November. All these observations put together show that *K.pelamis* spawns throughout the year off the SW coast. During the present survey, more larvae were caught north of 12°N but were fairly well represented in the south also, particularly in the Cape Comorin region. The previous northern-most record of the larvae from the Arabian sea appears to be by Jones, 1959 b (11°70'N, 72°65'E) and from the Bay of Bengal by Gorbunova, 1963 (13°30'N), whereas the present collections extend the distribution of the larvae upto 16°40'N in the Arabian sea. *K.pelamis* larvae have been encountered in the nearshore, as well as oceanic waters, more of them having been caught beyond 75 m depth. The larvae showed a marginal increase in catch in the night hauls. The surface temperature range in which the larvae occurred was 27°C to 31°C with predominant occurrence in the 28°C to 30°C range. The favourable surface salinity range was 34 to 36‰. The smallest larva caught was 2.8 mm in total length and the largest 12.7 mm with the 3 to 6 mm length groups dominant in the catches.

Larvae of *Thunnus* spp. possibly containing those of *T.albacares*, *T.tonggol* and *T.obesus* were the least abundant of all tuna larvae, occurring in relatively restricted period from February to June. They were not observed in the Ratnagiri and Tuticorin sections, but recorded from Karwar to Cape Comorin with significant occurrence off Karwar as well as Cape. More of these larvae were caught in offshore waters beyond 100 m depth. The smallest larva caught was 3.2 mm in total length and the largest 10.4 mm. There was only marginal increase in the catches of *Thunnus* larvae at night. The larvae occurred in relatively restricted range of surface temperature (28°C to 30°C) and surface salinity (34 to 36‰ S).

The occurrence of *Thunnus* larvae in the present collections from February to June indicates a relatively shorter spawning period or it may be that the full range of the spawning area of this oceanic species was not accessible in the present survey.

Jones (1959 b) collected *T.albacares* larvae (3.88 to 9.54 mm) from the Laccadives sea in February - April period and one early juvenile (10.56 mm) from the Gulf of Mannar in February. Wade (1951) collected the larvae of *T.albacares* throughout the year from the Philippine seas and stated that the March to December period appears to be the season of intensive spawning with the maximum from May to September.

Larvae of Rastrelliger kanagurta occurred in about 9% of all stations worked. They were only next in abundance to larvae of Auxis spp. and occurred in all the months with dominance from March to August and in November. Relatively dense distribution of the larvae was found mostly over the mid shelf, beyond 30 m depth from 8° to 15° N, with maximum concentration south of 10°N. While the larval occurrence spilled beyond the shelf south of Mangalore it was restricted to the inner third of the shelf in areas north of Mangalore. Silas (1973) observed the distribution of R.kanagurta larvae mostly between 9° and 10°N in the 30 - 80 m depth zone in May. R.kanagurta larvae showed a marginal increase in catches at night. The more favourable surface temperature range for the larvae was found to be 27°C to 29°C. The larvae occurred in the surface salinity range of 31 to 36 ‰ with dominant occurrence in the 33 to 35 ‰ S range. Larvae of 2 to 4 mm length groups dominated in the catches.

One post-larva each of Xiphias gladius and Istiophorus gladius were collected during this study. Previous records of these larvae from Indian waters can be referred to

Jones (1958) who collected the X. gladius post-larva and a series of I. gladius larvae (Jones, 1959 a) from the Laccadives. Balasubrahmanyam (1973) recorded Istiophorus larvae from the Bay of Bengal.

One post-larva of Scomberomorus commerson (10.7 mm T.L) was identified from the present collections and described in Appendix-I.

Majority of the clupeoid larvae collected from the area were of Stolephorus spp. and Sardinella spp. The higher density of clupeoid larvae were on the shelf and seaward areas south of Kasaragod. In the areas north of Kasaragod clupeoid larval densities were generally less, with only pockets of high densities. The present study clearly indicated the prolonged spawning of the sardines along the SW coast of India. The sardine larvae with a predominance of Sardinella longiceps occurred throughout the year mainly from March to September, withthe maximum abundance from April to August and the peak in July. The lean months for sardine larvae were from December to February, as was the cast with most fish larvae in the area. Sardine larvae were practically restricted to the shelf areas, spilling beyond in any significant manner, only off Cape Comorin and in the Gulf of Mannar. However, in the Gulf of Mannar, the maximum concentration was seen over the narrow shelf. Best concentrations of sardine larvae were met with in the inshore shelf between Cannanore and Vengurla (11°30'N to 15°30'N). Fifty percent more sardine larvae were caught in night hauls than during the day. The larvae occurred in a wide range of surface temperature from 24°C to 31°C with their dominant occurrence in the 26° - 28°C range. Similarly a wide range in salinity toleration was also noticed from 29‰ to 36 ‰ S, with predominant occurrence in the 33‰ to 35‰ S range.

The larvae of *Stolephorus* spp. were much more abundant than *Sardinella* larvae, while the exploited fisheries showed much less *Stolephorus* spp. in the catches than *Sardinella* spp.

Stolephorus spp. larvae, mainly those of *S.heterolobus*, *S.zollingeri* and *S.bataviensis* occurred in all the months with their major occurrence in the March to July period and with a secondary dominance around November. The distribution of these larvae showed relatively dense concentration in the area south of Kasaragod to the Gulf of Mannar, with the high value core mostly over the outer shelf. A northern concentration was noticed over the seaward half of the shelf, approximately between 13°30' N and 15°30' N.

Carangid larvae occurred in the plankton almost throughout the year. Maximum numbers of larvae, with a predominance of Decapterus spp. were noticed over the shelf waters in the May-June period. A secondary abundance was seen around the month of October. The carangid larval concentration was seen mostly in the area between Cochin and Cape Comorin.

Flat-fish larvae, mostly Bothidae and Cynoglossidae occurred from Ratnagiri to Tuticorin in all the months, dominantly from March to November with the maximum numbers in March to July period. The major areas of distribution were the shelf waters from Quilon to Karwar.

Myctophid larvae were most common and widespread than all other fish larvae in the collection, occurring in about 45% of all stations sampled. Major concentration of the larvae were found in a belt 30 - 40 miles wide outside the shelf, south of 9°30' N. Another narrow belt of concentration over the outer shelf and continental slope was seen from north of Coondapur to Ratnagiri. They were collected throughout the year, but mostly in the February to August period with the peak abundance. A secondary abundance was also seen around November.

Gonostomatid larvae commonly met with were those of *Vinciguerria* spp. They were widely distributed in the entire area in a rather diffuse manner, without patchy concentrations. The oceanic regions off the Karwar - Ratnagiri coast and off the Quilon - Cape Comorin coast were relatively richer in these larvae. They showed seaward increase in their numbers, upto about 100 miles but showed a decline farther off. Inshore areas upto about 20 miles from the shore were almost devoid of these larvae. More larvae were collected in February to May and least in September - October period. Silas and George (1971) found the larvae of *V. nimbaria* more in the open sea, that in neritic waters off the SW coast of India, during November to January and April - May periods.

The larvae of *Bregmaceros* occurred throughout the year, mostly over the mid-shelf, in the Quilon - Ratnagiri stretch with best concentrations off the Karwar - Ratnagiri coast. Nearly 70% of all positive stations for *Bregmaceros* were located over the mid-shelf between 30 - 150 m depths. More larvae were collected during February - August period, particularly in July and August. December - January was the lean period for the larvae.

Balakrishnan (1971) recorded larvae of *Bregmaceros* sp. in the months of March, April, November and January from the SW coast of India. These larvae were collected mostly over the shelf between 9°10'N and 10°40'N.

The larvae of Saurida spp. and Saurus spp. occurred in all months, more abundantly during February - March and November - December periods and least in July and August.

Observations on day and night larval catches showed in most cases, marginal increase in number of larvae caught at night than in the day. The larvae of Vinciguerria, showed 100% increase in the catch at night, while an increase of 50% was noticed in Sardinella spp. and Euthynnus affinis. Larvae of Rastrelliger kanagurta and all other tunas dealt with showed only marginal increase of catch at night.

Alikhan (1972), Peter (1977) and Silas (1974) noticed increased catches of fish larvae at night in the Indian ocean, while Boonprakob and Debtaranon (1974) found positive phototaxis reaction in Rastrelliger neglectus larvae, large number of the larvae congregating at 5 - 10 metres during day time and sinking to greater depths from dusk through night. While Klawe (1963) observed lesser catches of Auxis larvae at night time, Richards et al (1971) found no difference in catches of Auxis larvae between day and night. Ahlstrom (1959) found no consistant difference in the day and night catches of *Trachurus symmetricus* larvae of California and Baja California.

Observations on the relationship between volume of plankton and the number of eggs and larvae collected showed that there was in general a positive relationship. However, preceding peaks of eggs and larval numbers to those of plankton volumes were also seen. Peter (1969) observed no close or uniform volumetric relationship between plankton and fish larvae in the IIOE samples from the Indian ocean. Alikhan (1972) found an inverse relationship between number of larvae and zooplankton volumes in the Gulf of Aden. Nakamura and Matsumoto (1966) found on an average a positive correlation between abundance of plankton and larval tunas, but in individual samples no significant correlations were found. Strasberg (1960) reported high catches of larval tunas in samples with low and moderate volumes of plankton. In the present study, it could be pointed out that maximum spawning activity of fishes in the area took place during the monsoon period when there was also maximum of plankton and hence positive relations between plankton volume and eggs and larval numbers could also be expected.

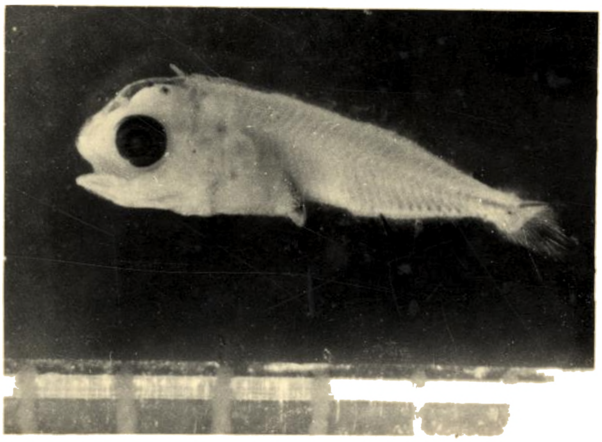
In the past, indications of spawning seasons and spawning grounds of fishes in Indian seas have been based mainly on the occasional collections of eggs and larvae from coastal regions and on the basis of gonad studies. In the first case, the concept of fairly well defined spawning ground and seasons often seen in temperate region fishes influenced the surmises based on mostly partial coverage of the range of distribution and spawning of the fishes in Indian waters. More recently Indian workers studied gonads and ova diameter from mature and ripe fish for indicating the spawning periods of different fishes (Karandikar and Palekar, 1951, Prabhu, 1956, Dharmamba, 1959, Annigiri, 1963, Antony Raja, 1964, Radhakrishnan, 1963, Raju, 1963 & 1964, Rao, 1964 and Kagwade, 1968). A comprehensive review of information on spawning periods of several marine teleosts was made by Qasim (1973). He came to the conclusion that "fishes along the west coast of India largely spawn during the monsoon (June to September) and post-monsoon months (October to January). Many species appear to be continuous breeders with prolonged spawning, lasting 7 - 9 months during the year - the restriction imposed in some months appears to be simply because of the lack of proper observation".

It was seen from the present studies that the major species of pelagic fishes along the SW coast of India namely *Sardinella* spp., *Rastrelliger kanagurta*, *Stolephorus* spp., and *Auxis* spp. spawned throughout the year, but predominantly from the latter part of the pre-monsoon period (February - March) through the monsoon to the earlier part of the post-monsoon period (September) with maximum spawning activity in the monsoon period. This agreed by and large with the information given by Qasim (1973). The tunas, other than *Auxis* spp. appeared to have shorter spawning period from February to August. *Stolephorus* spp. and *R. kanagurta* larvae were found to occur in significant numbers in November also, indicating spawning of a secondary magnitude. Larval abundance of myctophids, gonostomatids, and *Bregmaceros* sp. also showed a spurt in abundance around November. Post-monsoon period in general was a slack season for the spawning of most of the pelagic fishes.

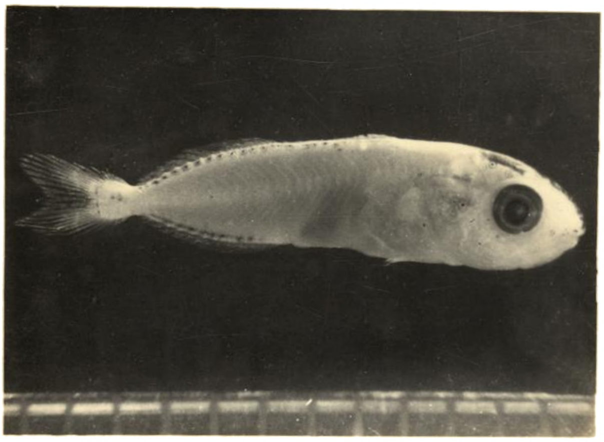
Most of the fishes dealt with spawned on the shelf, in the entire range of their distribution. However, a concentration of larvae over the shelf and oceanic waters south of 12°N. was seen, which in all probability was due to the southward surface drift along the SW coast of India during the late pre-monsoon to early post-monsoon period with maximum speed of current in the monsoon months, which caused some translocation of the young planktonic larvae. The oceanic distribution of the larvae were seen more in the southern sector.

From the above, it may be seen that the present survey has in a reasonable measure achieved the delineation of the spawning seasons and areas of the important commercial fishes of the SW coast of India, on the basis of their larval distribution in time and space.

1.



2.



3.

RASTRELLIGER KANAGURTA

10. SUMMARY

1. The major objective of the present study was to assess the distribution and abundance of fish eggs and larvae along the SW coast of India and to delineate the spawning grounds and seasons for important commercial fishes, with particular reference to scombroids. The ichthyoplankton collected by the UNDP/FAO, Pelagic Fishery Project, Cochin, from 1409 stations, mostly located on the shelf waters of the area from Ratnagiri (17°N, SW coast) to Tuticorin (08°48' N, SE coast), during the period from September 1971 to December 1975 formed the basis of the study.

2. The background information on the physical, biological and oceanographical environment of the area are reviewed. The overall picture of abundance of fish eggs and larvae with special reference to scombroids are presented. The study indicated the highest spawning activity of most of the commercial species, especially the pelagic ones during the SW monsoon season. Short periods immediately prior to and after the monsoon season also showed significant spawning. December - January period recorded least

spawning activity. Maximum spawning activity and larval life of the fishes were seen in the areas south of 12° N, extending from about February to November. Some amount of drifting of the fish larvae to the southern sector of the SW coast appeared to occur due to the southward surface current during the major part of the spawning period indicated.

3. Two areas of concentration of scombroid larvae, one south of Calicut to east of Cape Comorin and a smaller concentration off Ratnagiri were seen. The larvae were present in all the months of the year, but were more abundant in the March - August period.

4. Auxis larvae, the most abundant of all scombroid larvae were met with in all the months, but more from March to August, with the peak abundance in July. September to February was a very lean period for these larvae. The concentration of the larvae were seen over the outershelf and continental slope and even beyond, in a belt of an average width of 30 miles from Kasaragod to Tuticorin with high core values between 10°00' and 11°30' N and also off Quilon in the south.

5. The larvae of <u>Rastrelliger</u> <u>kanagurta</u>, second in order of abundance among the scombroids, occurred in about 9% of all stations. They were found throughout the year, with abundance in March to August and in November and the peak in July. The average picture indicated relatively denser distribution of the larvae over areas 30 - 75 m depth from 8° to 15° N, with the maximum concentration between 8° N and 10° N.

6. The larvae of <u>Katsuwonus</u> <u>pelamis</u> showed a relatively more northern distribution, from Kasaragod to Ratnagiri, the northern limit of the survey. The larvae were collected from nearshore as well as oceanic waters. More larvae were caught in waters beyond the 75 m depth. Significant abundance was noticed during February to April and in June.

7. <u>Euthynnus</u> <u>affinis</u> larvae occurred more frequently off Ratnagiri, but their numerical abundance was more in the Karwar, Kasaragod and Quilon sections. More larvae were caught beyond the 50 m depth. Though the larvae were seen in the March to August period, their occurrence was significant only in May and June.

8. Larvae of Thunnus spp. occurred in small numbers more frequently off Karwar and Cape Comorin and were caught mostly over the deeper shelf, beyond the 100 m depth zone. The larvae occurred from February to June, but their availability was more in February - March period and in June.

9. Size distribution of the larvae showed dominance of 2 - 4 mm length group for Rastrelliger kanagurta; 3 - 6 mm group for Auxis, Euthynnus affinis and Katsuwonus pelamis. The 4 - 7 mm group was dominant in the case of Thunnus spp. In all cases larger larvae were caught at night. All tuna larvae showed marginal increase in the catches at night, particularly those of E.affinis, where a 50 percent increase was noticed. Surface temperature range of 27° C to 29° C for the larvae of R.kanagurta and Auxis spp., 28° C to 30° C for K.pelamis and Thunnus spp. and 29° C to 30° C for E.affinis were observed to be the more favourable temperature conditions for their occurrence. All tuna larvae showed a short range of 34 ‰ to 36 ‰ salinity for their dominant occurrence, with Auxis spp. and E.affinis showing tolerance to less saline waters down to 32 ‰ and 33 ‰ S

respectively. Predominant occurrence of mackerel was noticed in the 33 to 35 ‰ S range, while their occurrence was noted from 31 to 36 ‰ S.

10. One post larva each of Scomberomorus commerson, Xiphias gladius and Istiophorus gladius were collected during the survey. S.commerson post larva was caught off Cochin in December, X.gladius, off Ratnagiri, in April, and I.gladius, off Kasaragod, in April.

11. Clupeoid larvae were distributed more densely in the areas south of Kasaragod (12° 30'N) and showed considerably high abundance during the SW monsoon period.

12. Larvae of Stolephorus spp. were the most numerous of the clupeoids and occurred throughout the year, with abundance in March to July and November. Relatively dense concentration of the larvae was seen in the area south of Kasaragod to Gulf of Mannar with high core values over the outer shelf.

13. Sporadic large collections of eggs of Sardinella longiceps (sometimes more than 5000 Nos./m^2) were made during the present survey in July and August between 9°30' N - 12°30' N, within 25 m depth zone.

Larvae of *Sardinella* spp. dominated by *S. longiceps* occurred throughout the year, but predominantly during March to September period, with the peak abundance in July; the larvae being restricted to the shelf area, with denser concentration in the region north of Calicut to Vengurla (11°30' N to 15°30' N), Wadge Bank and eastwards, in the offshore waters and also in the coastal waters from Cape Comorin to Tuticorin. The larvae were collected under surface temperature conditions of 24° to 31° C, with their predominant occurrence in the 26° to 28° C range. They showed a wide salinity tolerance, from 29‰ to 36 ‰, with predominant occurrence in the 33‰ to 35‰ S range.

14. Carangid larvae occurred throughout the year, with a predominance of *Decapterus* spp., more abundantly during May - June and October. The larvae were mostly concentrated in the area between Cochin and Cape Comorin.

15. The larvae of flat-fishes, mainly Bothidae and Cynoglossidae occurred significantly from March to November with the maximum numbers in March - July period. The major areas of distribution were the shelf waters from Quilon to Karwar.

16. Myctophid larvae were the most abundant of all larvae collected during the survey, with the major concentration in a belt of 30 - 40 miles width, outside the shelf, south of 09°30' N. The larvae occurred in all the months, but significantly from February to August with the peak abundance in July.

17. Gonostomatid larvae, mostly *Vinciguerria* spp. occurred in a diffuse manner all over the surveyed area, with gradual increase towards oceanic waters upto about 100 miles outward from the shore. The oceanic region off the Karwar - Ratnagiri coast and the Quilon - Cape Comorin coast were relatively richer in these larvae, they being abundant from February to May and least during September - October.

18. Larvae of *Bregmaceros* sp. occurred throughout the year, mainly over the mid-shelf, in the Quilon - Ratnagiri area with the best concentration off the Karwar - Ratnagiri coast. More larvae were collected during the February - August period.

19. Larvae of lizard-fishes mainly *Saurida* spp. and *Saurus* spp. occurred throughout the year, more

abundantly during February - March and November - December periods and least in July and August. The larvae of *Saurida tumbil* were more common in areas south of Kasaragod.

20. The major pelagic fishes of the SW coast of India, namely *Sardinella longiceps*, *Rastrelliger kanagurta*, *Auxis* spp. *Stolephorus* spp. spawned throughout the year, in the entire range of their distribution, mostly on the shelf. The larvae showed in general a southward drift and concentration in areas south of 12° N spreading over the oceanic water in this sector. Lizard fishes showed active post-monsoon and pre-monsoon spawning. The dominant period of spawning was March to August or September, with the peak in July. The myctophids showed active spawning more or less in the same period as the major pelagic species, while the gonostomatids showed active pre-monsoon spawning. Larvae of both groups showed wide oceanic distribution.

21. *Katsuwonus pelamis*, *Euthynnus affinis* and *Thunnus* spp. showed shorter spawning periods, from February to June, the major areas of larval distribution being over the mid-shelf and beyond, with relatively more larvae occurring in the northern and southern sectors of the SW coast.

11. ACKNOWLEDGEMENTS

I am indebted to Professor C.V.Kurian, D.Sc., Head of the Department of Marine Sciences, University of Cochin, for guiding me in this work and for the critical reading and correction of the thesis.

This work was carried out by me during my service on deputation from the Central Marine Fisheries Research Institute at the UNDP/FAO, Pelagic Fishery Project, Cochin.

I thank Messrs. M.Devidas Menon and Dr.M.S.Prabhu, Directors, of the Project and Mr.Steinar Olsen, FAO-Project Manager for their special interest in this work and for the facilities and encouragement given to study in detail part of the Project's eggs and larvae collections, for preparing this thesis.

While the material studied was collected with the active participation of the author in several cruises, the considerable effort put in by other participating staff and the ship's staff in this connection is gratefully acknowledged.

I am particularly grateful to my colleague Mrs.Geetha Antony for the help rendered in preparing the figures. Thanks are due to my colleagues Messrs. K.V.Raghavan and M.A.Nizar for various help while preparing this thesis.

I thank the Government of India, Ministry of Agriculture and Irrigation, Department of Fisheries and the Director, Central Marine Fisheries Research Institute for granting me permission to register for the Ph.D. degree, as a part-time Research Scholar, with the University of Cochin.

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