SOUVENIR

20th Anniversary

Central Marine Fisheries Research Institute

(Government of India)

★

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THE ORGANISING COMMITTEE C. M. F. R. I. RECREATION CLUB

MANDAPAM CAMP

Reprinted from

Central Marine Fisheries Research Institute

20th Anniversary

February, 1967

SOUVENIR

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CITY PRINTERS, ERNAKULAM.

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Dr. S. Jones
Director (1957 -)

Dr. N. K. Panikkar
Chief Research Officer (1950–1957)

The Central Marine Fisheries Research Institute

Until the early forties of this Century fisheries has been a transferred subject, research and development being the concern of the then existing provinces and states. Except for the enactment of the "Indian Fisheries Act" of 1897 the Government of India had no direct interest in the fisheries of the country. The fisheries departments as they existed then were mainly revenue minded. However, studies on fishes and other aquatic fauna were being carried out by the Surgeon-Naturalists of the Marine Survey of India and the Officers of the Zoological Survey of India. Work on some aspects of aquatic sciences was being conducted in a number of Universities also.

Lack of supply of adequate quantities of good quality fish during the Second World War especially for the British, American and other Allied army personnel was mainly responsible for awakening the Government of India to the need for taking direct interest in the research, development and conservation of the fishery resources of the country. The immediate result of this was the initiation of some research schemes by the Indian Council of Agricultural Research.

The proposal for the establishment of a Central Fisheries Research Institute in India was first made in 1943 by Dr. Baini Prashad, who was then Director of the Zoological Survey of India, in his Memorandum on the "Post-war Development of Indian Fisheries". In the opening para of this historical document he has stated as follows:

> "I recommend that a central Fishery Research Institute be established by the Government of India on lines similar to those of the Agricultural Research Institute at New Delhi, the Veterinary Research Institute at Mukteswar and Izatnagar and the Forest Research Institute at Dehra Dun. Agriculture including veterinary work, and forestry are, like fisheries, transferred subjects; but the Government of India are maintaining fully equipped and well-staffed research institutes for the study of the problems connected with these subjects, and there seems to be no reason why the development of Indian fisheries, which in their importance are second only to agriculture and animal husbandry, should not be taken up along similar lines."

The proposals till then had been that the Central Government should promote studies on fish and fisheries by strengthening the staff of the Zoological Survey of India to give expert advice in fisheries to local governments and others as per the recommendations contained in the Report of the Industrial Commission of 1916-1918. The above view lingered for decades with some modifications till Dr. Baini Prashad in his Memorandum categorically and rightly stated he is "definitely of the opinion that it would be best if a separate central Research Department of Fisheries of the Government of India is constituted instead of tagging it on to the Zoological Survey of India", and that "it would not be in the best interests of fishery research in India to make it a subsidiary of the activities of the Zoological Survey of India."

The above recommendation first paved the way for considering the establishment of a central fisheries research institute and this was endorsed by the Fish Sub-Committee of the Policy Committee on Agriculture, Fishery and Fisheries in their Report in 1945.

Ultimately based on the "Memorandum on the proposed Fishery Research Institute" by the late Lt. Col. Dr. R. B. Seymour Sewell in 1946 the Central Marine Fisheries Research Station (as known then) came into existence in 1947.

The Central Marine Fisheries Research Institute of the Government of India under the then Ministry of Food and Agriculture, was established on the 3rd February, 1947 with temporary laboratory accommodation provided by the University of Madras at the Zoological Research Laboratories at Madras and was subsequently shifted to Mandapam Camp in 1949. Mandapam Camp is situated on the Madras-Rameswaram Railway route. It is 144 km south-east of Madurai which is also the nearest Airport. The distance from Mandapam Camp to Rameswaram is about 19 km. No motorable road existed then between Ramanathapuram and Mandapam Camp and the only mode of transport available was the rail. The buildings constructed originally for the Naval Hospital by the Defence Department during the World War II which were lying abandoned in a dilapidated condition overgrown with thorny jungles and infested by reptiles were acquired and converted into laboratories and temporary residences for the staff at considerable expense and effort. Subsequently, an aquarium was built and circulating sea-water facilities were provided for keeping marine fishes and other organisms for study. About a hundred acres of land adjoining the Institute has been acquired for expansion of the activities and for building permanent residences which were completed in 1958. About ninety acres of land and the road leading to the site have been acquired at Mandapam Camp on the Palk Bay side for setting up an experimental Marine Fish Farm which, however, suffered extensive damage during the cyclone and tidal wave which hit this part of the coast in December, 1964 with unprecedented fury. (Photographs showing the damage sustained by the Institute then are given in Plates in the Appendix). The experimental fish farm project had to be abandoned partly because of this and also because the results of the experiments carried out were not encouraging owing to the unsuitability of the area for any economic fish farming.

The head of the Institute is the Director. The Institute had as its first Director (then called Chief Research Officer) Dr. H. Srinivasa Rao, who was succeeded on his retirement by Dr. N. K. Panikkar towards the end of 1950. On the appointment of Dr. Panikkar as Fisheries Development Adviser to the Government of India in April 1957, Dr. S. Jones took over as the Chief Research Officer. In 1961 the designation was changed to Director and simultaneously the term "Station" was changed to "Institute". The staff consists of one Deputy Director, a number of Research Officers, Assistant Research Officers and other technical staff in addition to the normal administrative staff including one Administrative Officer and one Accounts Officer.

The scientific work of the Institute is broadly divided into three major divisions namely, Fishery Biology, Marine Biology & Oceanography and Fishery Survey and has a regionwise and subjectwise distribution. Since there is no fishery of any importance at Mandapam Camp the activities are necessarily decentralised. Apart from the Headquarters at Mandapam Camp, there are five Research Sub-stations located at Bombay, Karwar, Calicut, Ernakulam and Madras and a number of smaller establishments designated as Research Units at Veraval, Mangalore, Cannanore, Vizhingam, Tuticorin, Waltair, Port Blair (Andamans) and Minicoy. The units established at Calcutta and Kandla were closed down in 1962 and merged with those at Waltair and Veraval respectively. In addition, research and survey centres are functioning at a number of other places spread over the entire coastline of India, as illustrated in the appended map. In view of the fact that over three-fourths of the marine fish landings are from the west coast of India, the majority of the research establishments are concentrated there. The achievements of the Institute are dealt with in the next article.

The Technological wing which was functioning as part of this Institute was separated and merged with the Central Institute of Fisheries Technology, Ernakulam in 1958. In the year 1965, a Frog Research and Development Scheme was initiated at this Institute and a comprehensive report on all India basis was submitted to Government. It was later transferred to the Central Inland Fisheries Research Institute, Barrackpore.

The Institute has trained a batch of science graduates in 1949-50 [redacted] for taking up fishery work in the different States but the training programme was discontinued as a measure of economy. Facilities for work are, however, afforded at the Institute to specialists and scientists. Research training is being given by the Institute to Scholars under the Government of India Research Training Scheme from 1954. The Institute has also been recognised by the Inter-University Board of India as a centre for carrying out research in Marine Biological and allied subjects leading to Ph. D. and D. Sc. degrees and based on the work done here by the scholars doctorate degrees have been awarded by the Universities of Madras, Rajasthan, Punjab, Banaras and Aligarh. Scholars who have registered for their doctorate degrees in Bombay, Andhra and Kerala Universities are working here at present.

Under the Indo-German Industrial Co-operation Scheme 1956-57 two research Fellowship holders from Germany worked at this Institute from 1957 to 1960.

During the International Indian Ocean Expedition this Institute provided laboratory and guest house accommodation for a number of Scientists who participated in the Expedition under the U. S. Programme in Biology. This Institute has also been providing laboratory facilities to University Professors and teachers for research work under the University Grants Commission Project for training of teachers in research.

The Library for scientific staff of the Institute is one of the best in South East Asia for literature on fisheries in particular and aquatic sciences in general with extensive collection of essential books, periodicals, monographs and reports relating to all branches of the above sciences. The library facilities available here are availed of by a large number of Universities, fishery departments, zoologists and the Insdoc.

As regards other special facilities available at the Institute mention may be made of the General Museum and the Reference Collection with representative collections of identified marine fishes and other fauna and flora, an Aquarium with continuous supply of circulating sea and fresh water, motor launches specially built for carrying out inshore studies, and small canoes, catamarans and skiffs with outboard motors for shore work. A separate Machine and Wood shop is available.

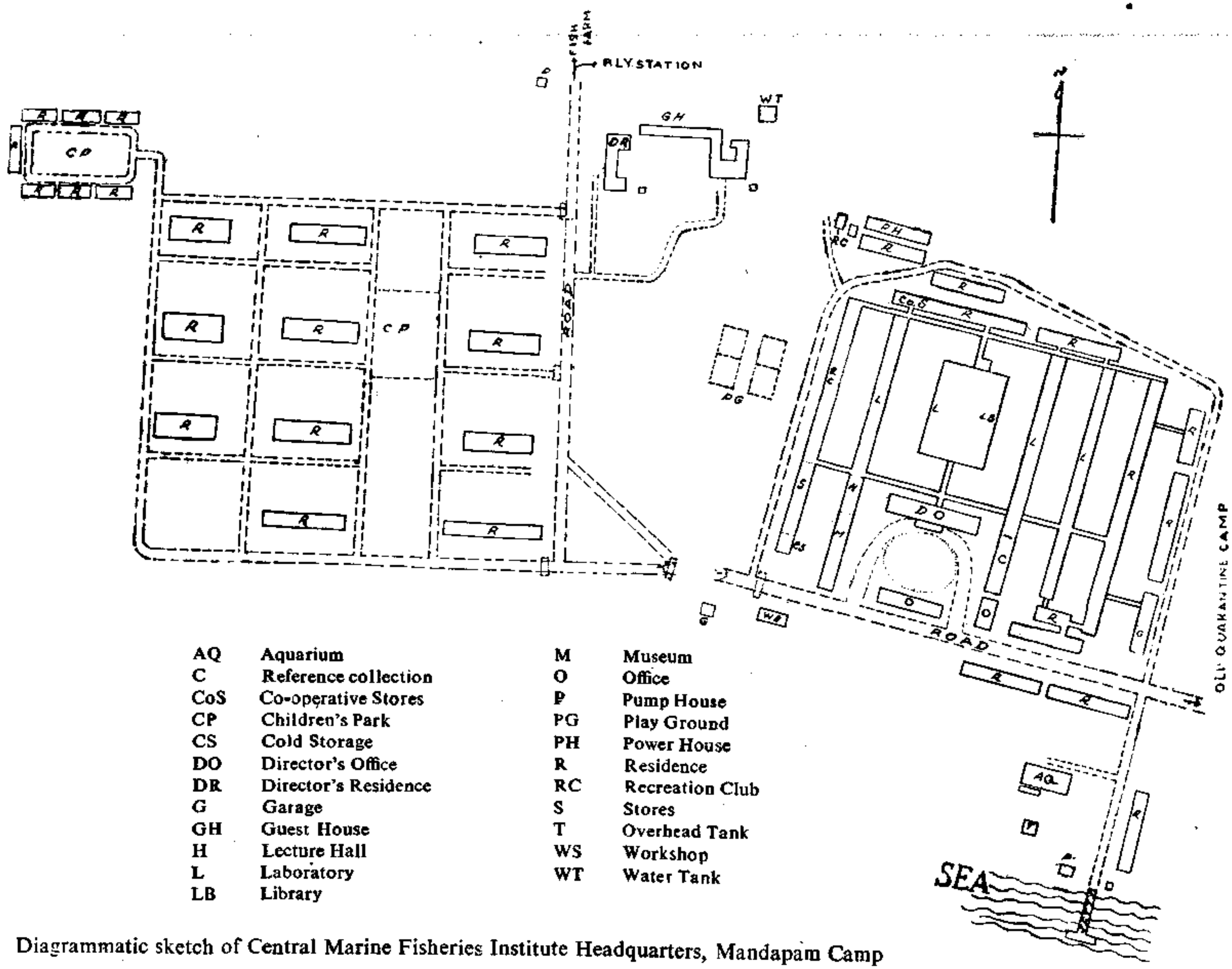
The Guest House of the Institute provides accommodation for visiting dignitaries and scientists. The staff of the Institute are provided family type quarters and bachelor accommodation. Recreation clubs are also run for the benefit of the staff members.

Numerous visiting parties and workers from Indian Universities, colleges and other Institutions have taken advantage of the facilities at the Institute and the value of the place as a centre for making studies on the rich marine fauna and flora in this part of the country is being appreciated also by workers abroad. The Museum, the largest of its kind in the entire region bordered by the Indian Ocean with a variety of exhibits pertaining to fish and fisheries and marine fauna and flora draws large crowds from far and near. A pair of dugongs or the so-called "Mermaids" has been living in the aquarium tank for the past seven years which is the longest period on record in the world for these animals in captivity. They are a great source of attraction to the visiting parties.

The need for a research vessel in connection with marine fisheries investigations in India was recognised from the very inception of the Institute but various practical difficulties stood in the way of procurement of one. In the early stages the investigations were confined mainly to the coastal belt availing of the existing types of craft. Gradually the work was extended wherever possible to areas further out with the help of trawlers of the Deep Sea Fishing Station. In 1957, oceanographic investigations were initiated in co-operation with the Indo-Norwegian Project and M. O. *KRISTENSEN*, one of the fishing vessels of the latter was made available for this purpose, with Cochin as the base of operations. Research cruises were started in September 1957 but due to the unsatisfactory condition of the vessel it was condemned and replaced by its sister vessel R. V. *KALAVA*. Since the end of 1957 the vessel has been making regular oceanographic cruises along the West Coast of India till 1961. Towards the end of 1961 a modern Research Vessel *VARUNA* specially built in Norway for oceanographic investigations was made available by the Indo-Norwegian Project and has been operating regularly since then.

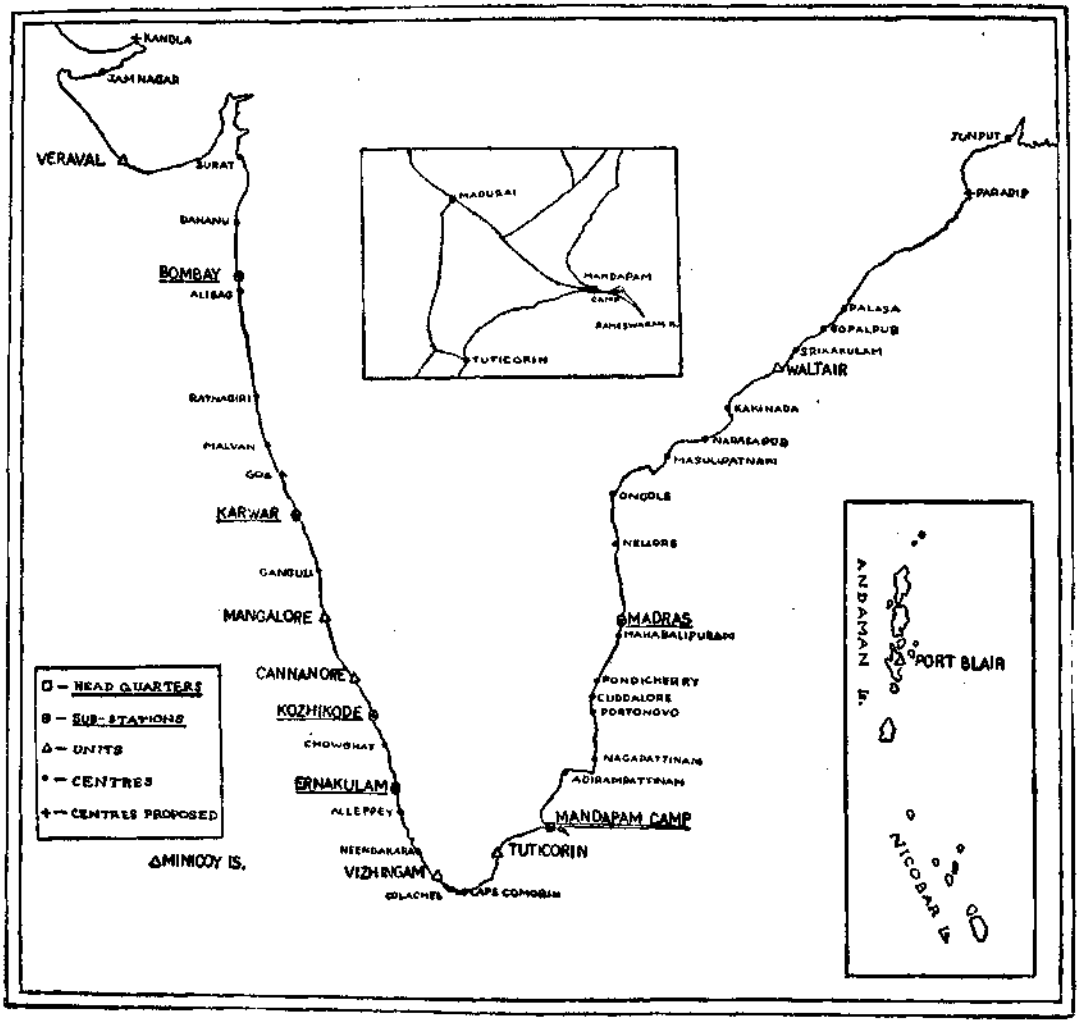
The Institute is providing since 1958 laboratory and other experimental facilities to the Central Electro-Chemical Research Institute, Karaikudi for locating a field Corrosion Testing Laboratory at Mandapam Camp which is all the year round subjected to severe saline atmospheric exposure consequent on the unique location of the place abutting the two seas, Gulf of Mannar and Palk Bay on either side.

The Institute is publishing the Indian Journal of Fisheries from 1954 on behalf of the Ministry of Food and Agriculture, the Director of the Institute being the Managing Editor of the Journal. The headquarters of the Marine Biological Association of India is located at Mandapam Camp and the scientific staff of the Institute have taken a great part in the formation of the Association which is publishing a journal devoted to marine sciences from 1959 and organising symposia on various aspects of the fisheries and marine biological sciences. Another periodical entitled "Advance Abstracts of Contributions on Fisheries and Aquatic Sciences in India" is being issued quarterly from the beginning of 1967. The periodicals have attained world wide recognition and by the publication of these journals, the activities of the Institute are known all over the world. A bibliography of scientific articles by the workers in this Institute since its inception is given elsewhere in the Souvenir.



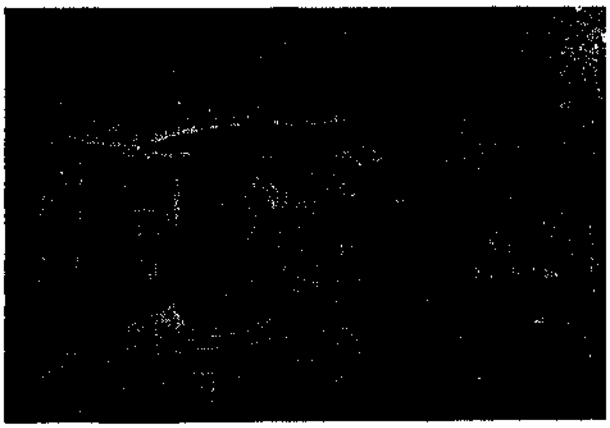
AQ	Aquarium	M	Museum
C	Reference collection	O	Office
CoS	Co-operative Stores	P	Pump House
CP	Children's Park	PG	Play Ground
CS	Cold Storage	PH	Power House
DO	Director's Office	R	Residence
DR	Director's Residence	RC	Recreation Club
G	Garage	S	Stores
GH	Guest House	T	Overhead Tank
H	Lecture Hall	WS	Workshop
L	Laboratory	WT	Water Tank
LB	Library		

Diagrammatic sketch of Central Marine Fisheries Institute Headquarters, Mandapam Camp



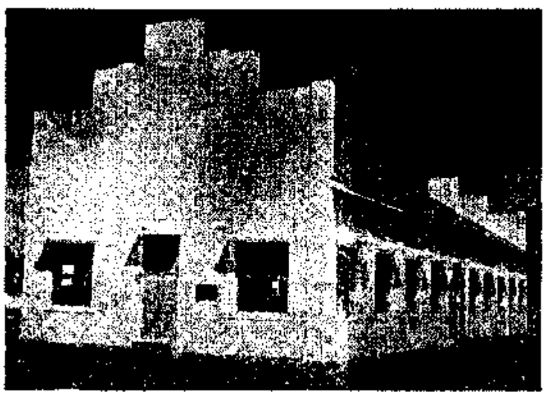
Map showing the location of the Central Marine Fisheries Research Institute Headquarters and Subordinate establishments

Aerial view of Headquarters of the Institute



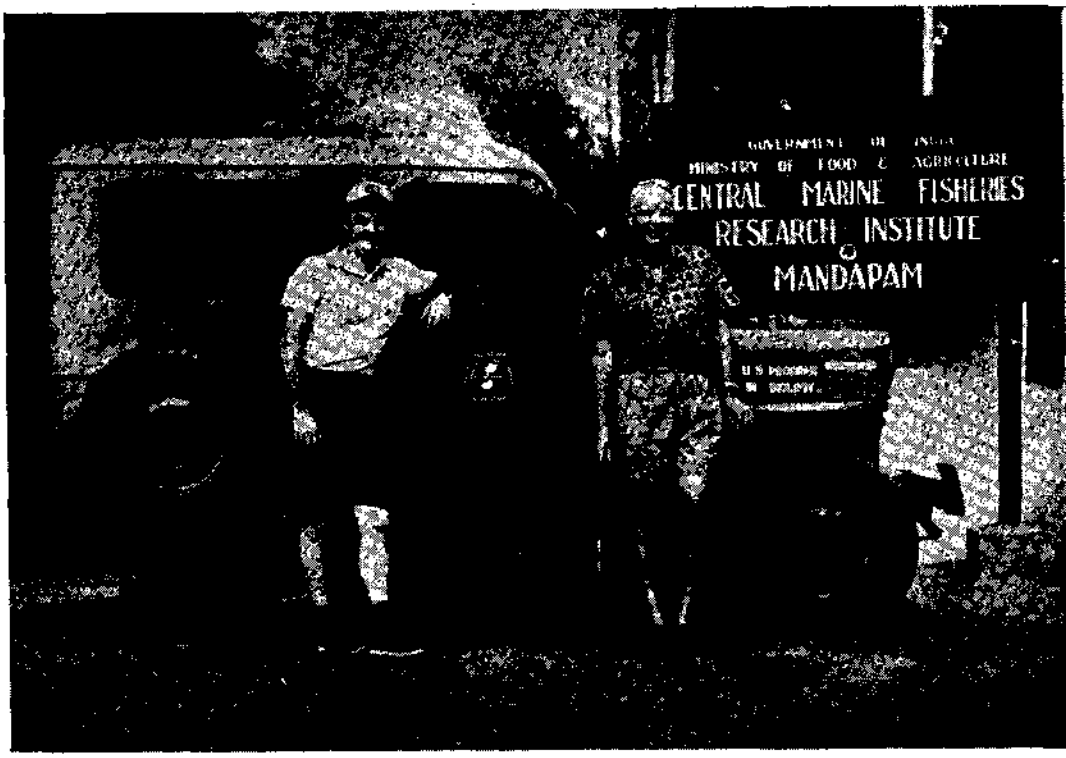
A view of the Museum

A section of the Library

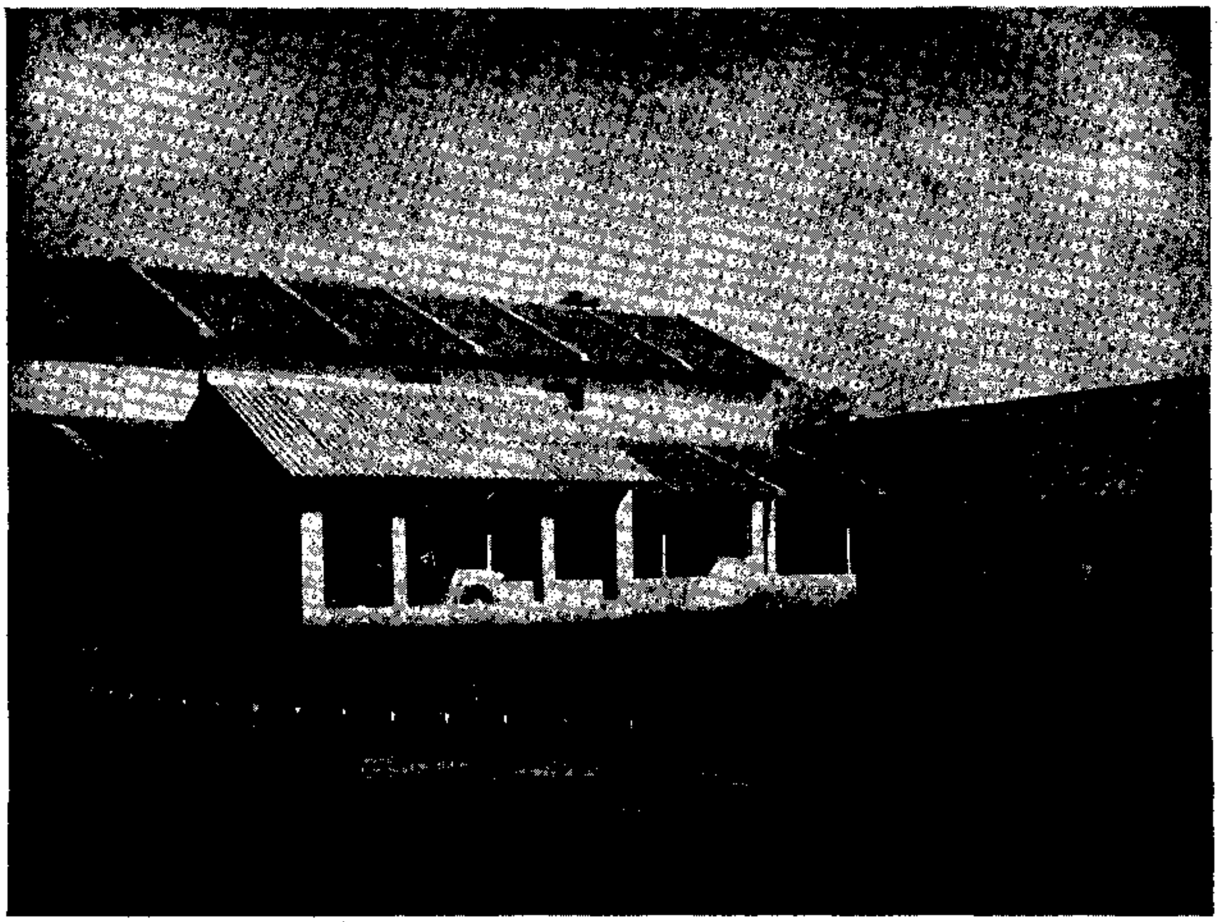


The Aquarium

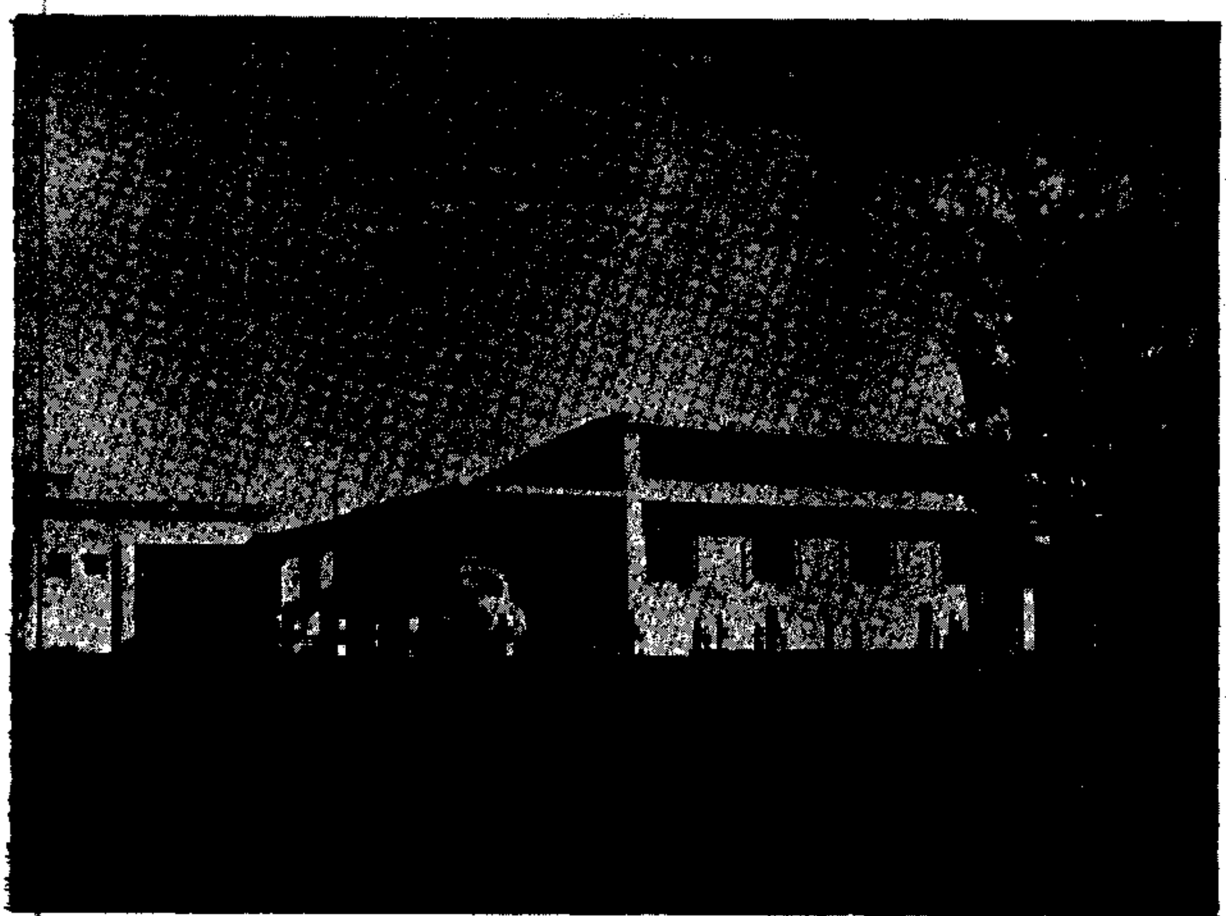
The Fish farm



Drs. McLaughlin & Karling, visiting scientists of the U. S. Program in Biology at the Institute

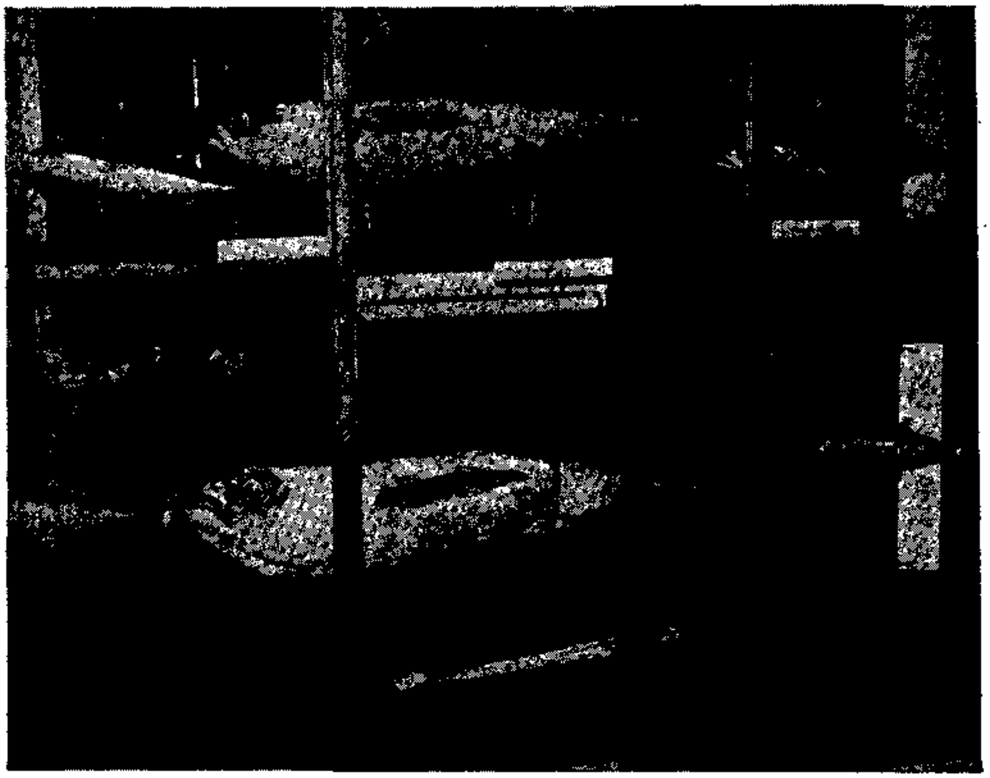


Director's office at Headquarters

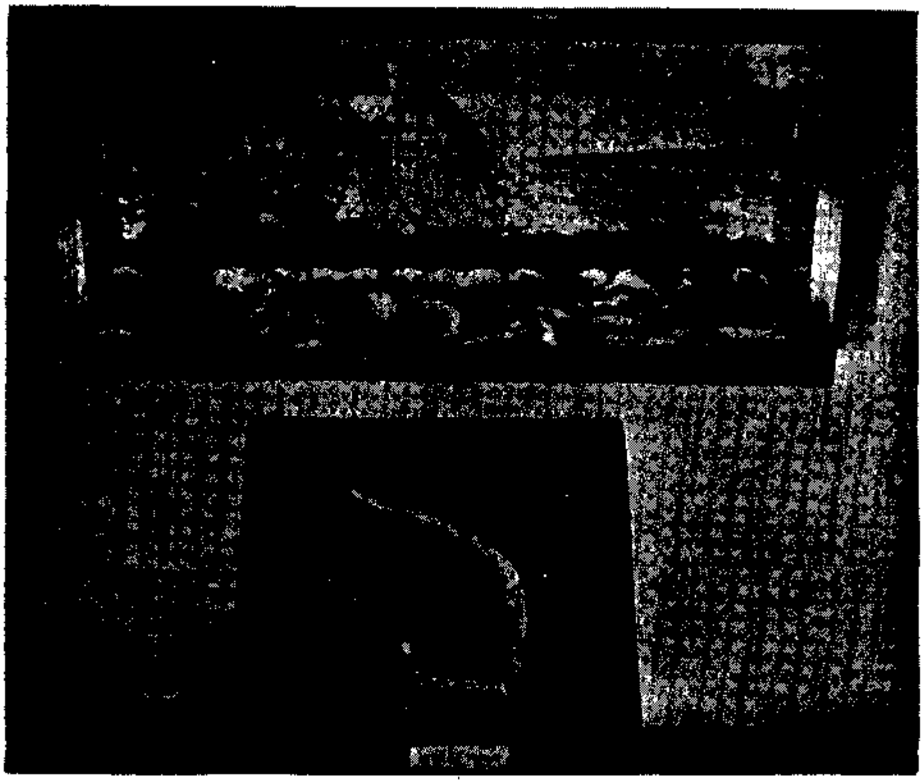


The Guest House at Headquarters

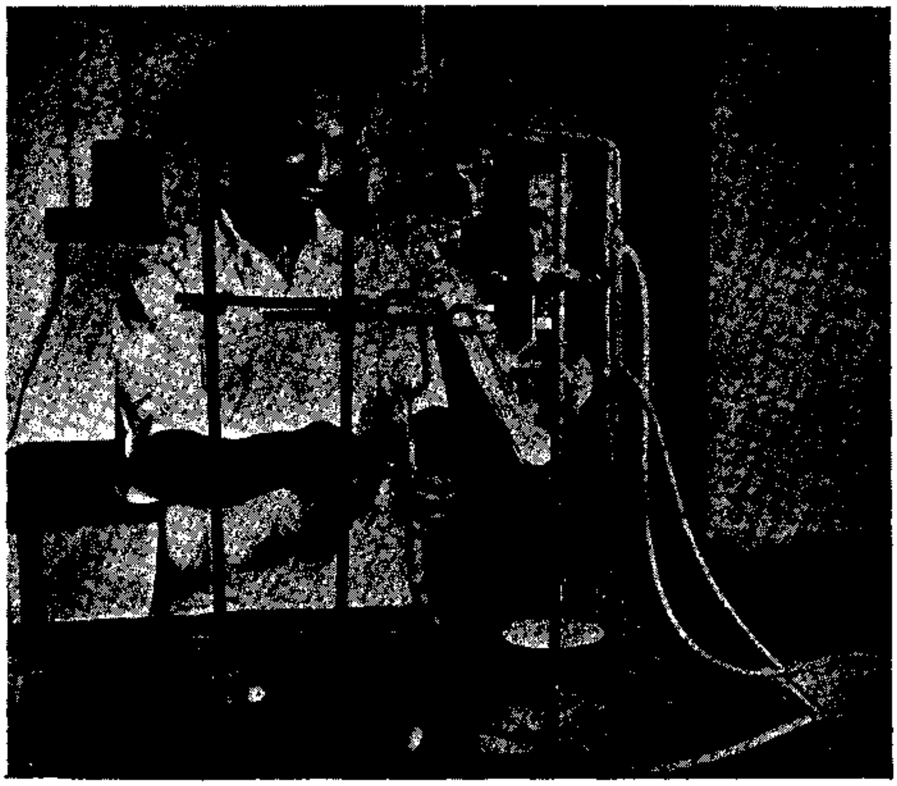
Part of the Reference Collection Museum at Headquarters



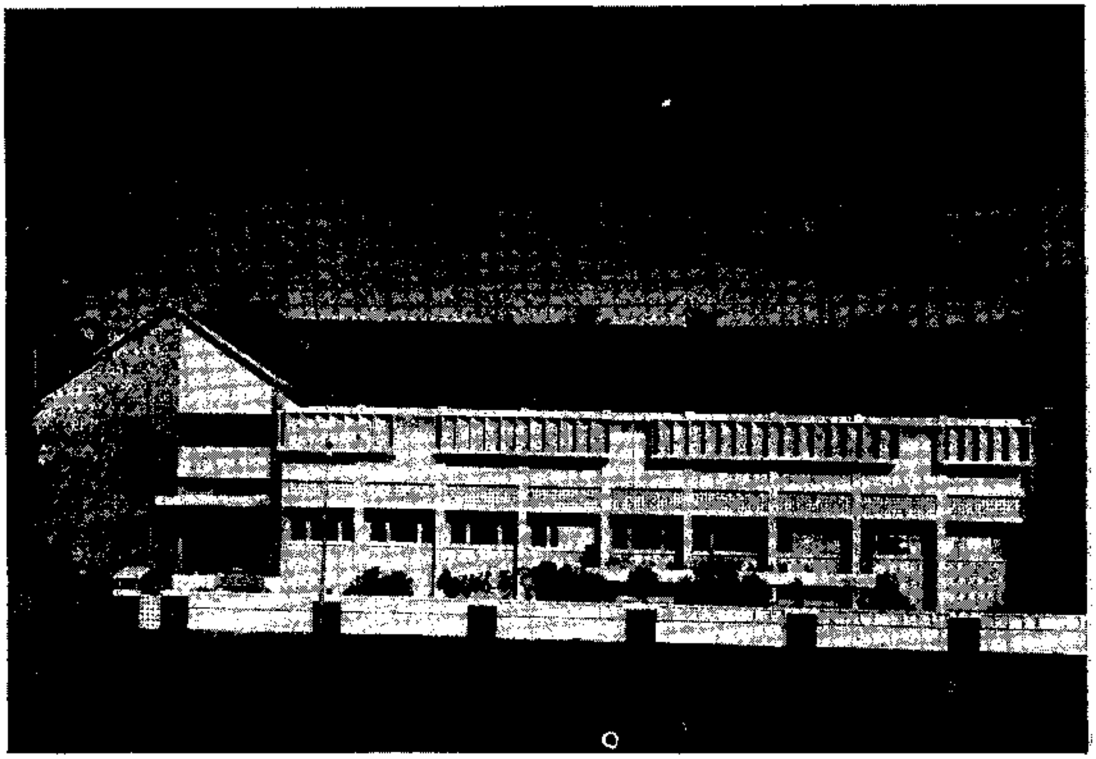
Part of general museum at Headquarters showing tunas and related fishes



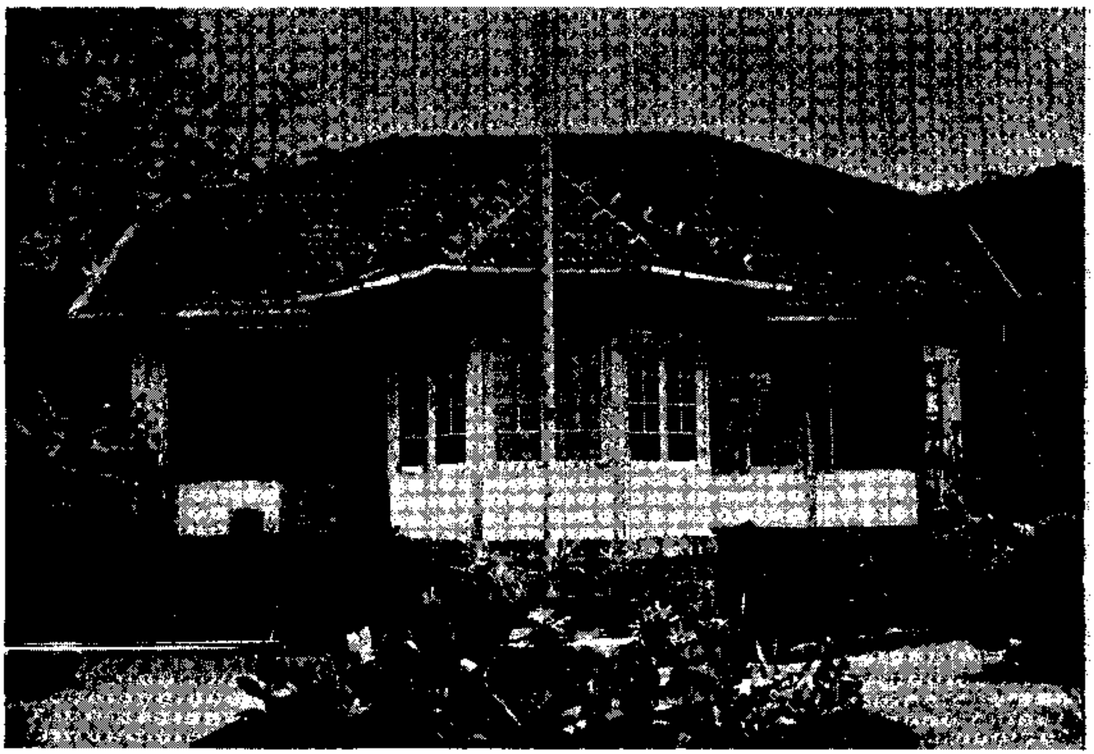
Diorama showing tuna fishing in Minicoy Island



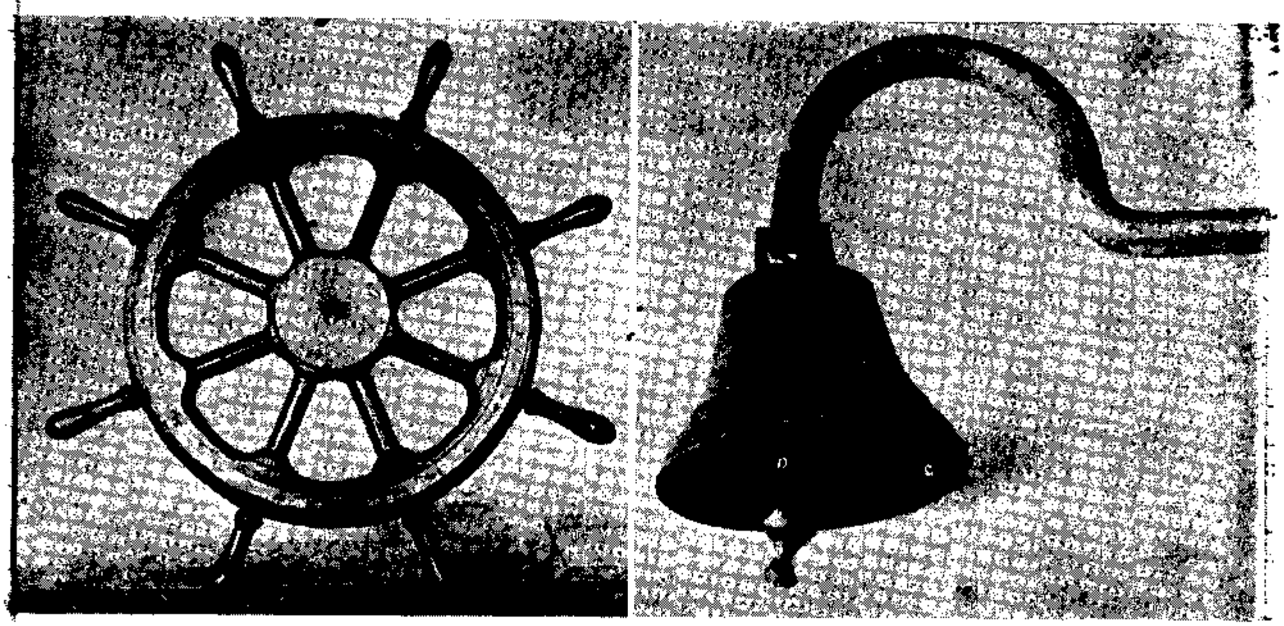
Part of the Marine Biology Laboratory at Headquarters



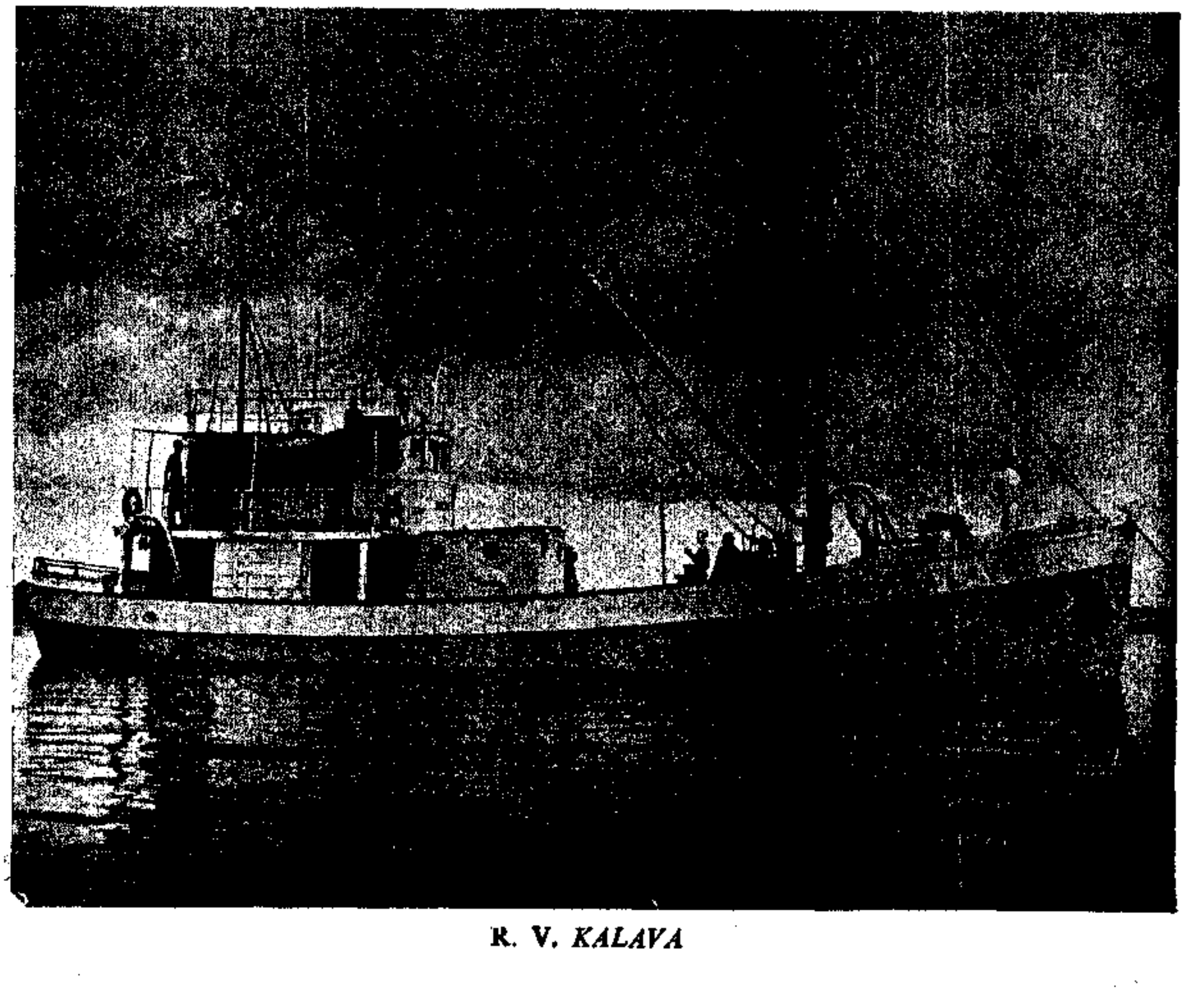
The Institute's substation at Kozhikode



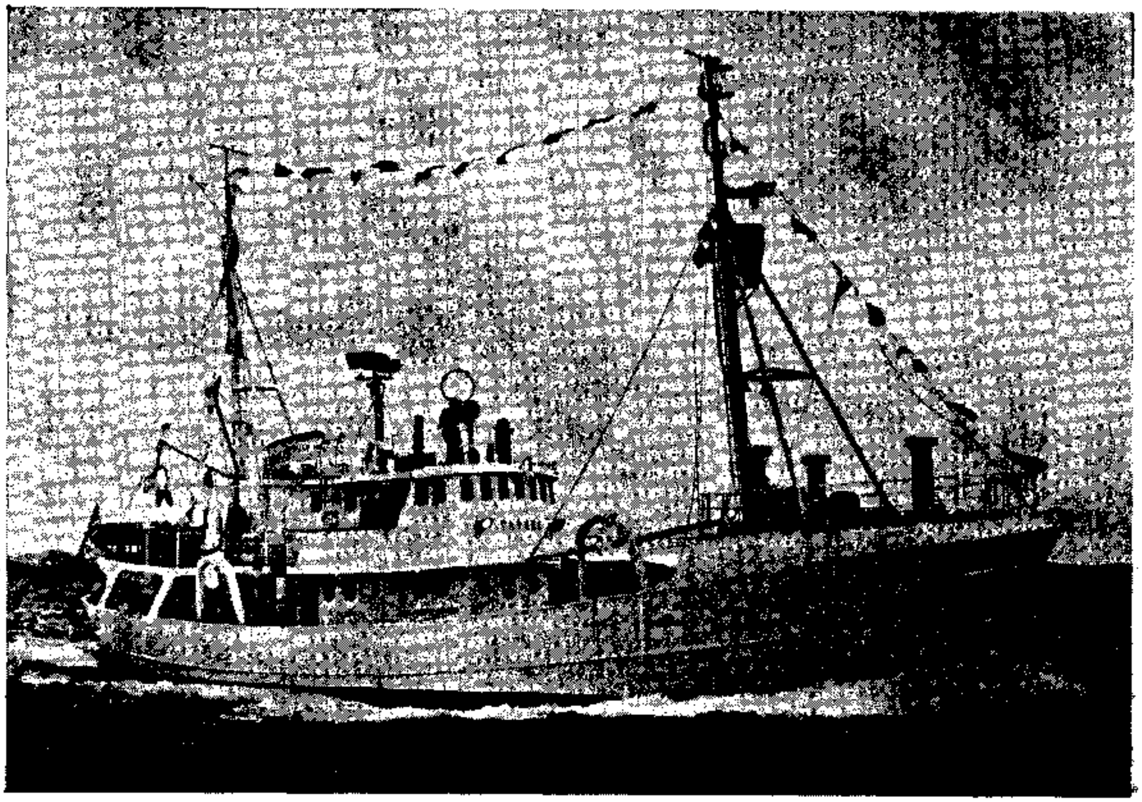
The Institute's substation at Karwar



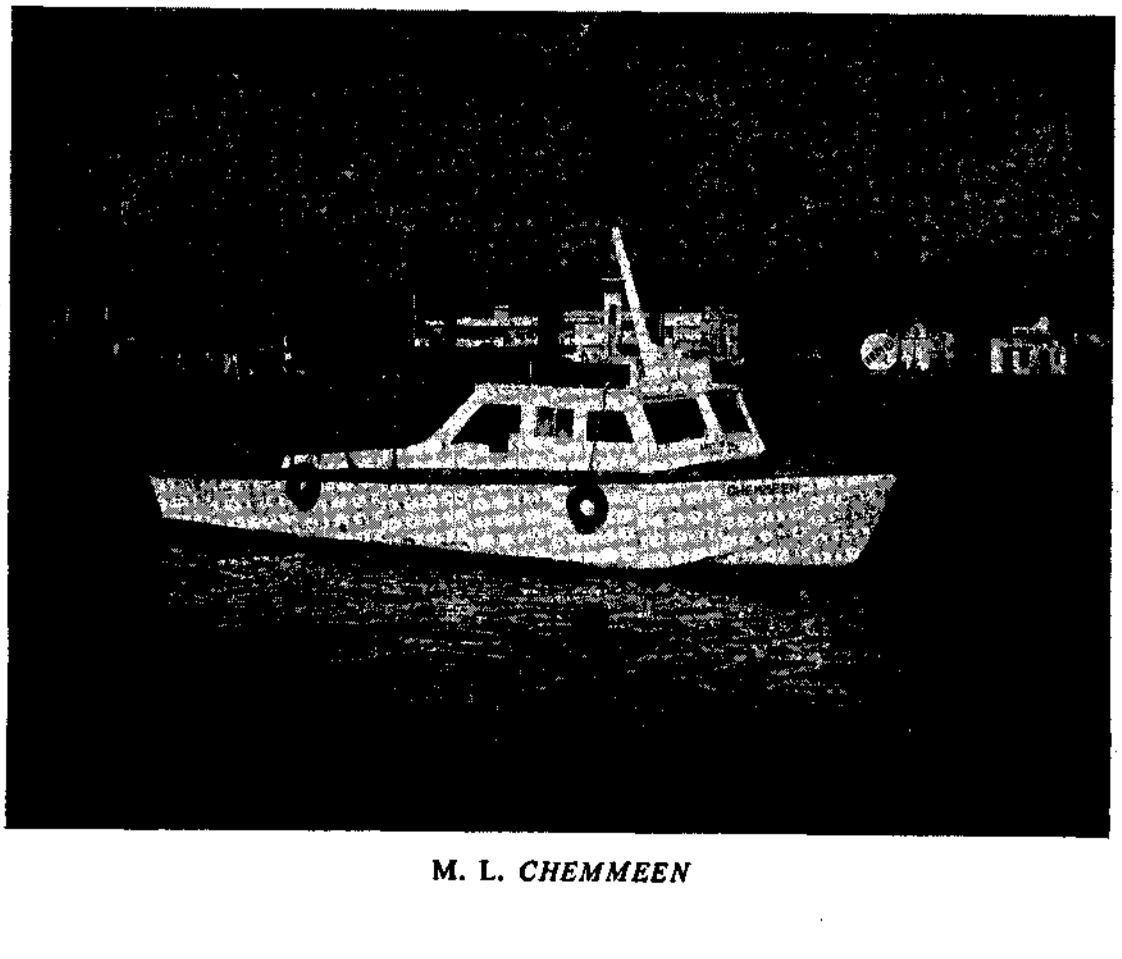
Wheel and Bell of M. O. *KRISTENSEN*



R. V. *KALAVA*



R. V. *VARUNA*



M. L. *CHEMMEEN*

Pair of captive dugongs "mermaids" in the Aquarium at Headquarters (as they rest at bottom of tank when water is drained off for cleaning the tank)

Two decades of Marine Fisheries Research

By S. Jones
Central Marine Fisheries Research Institute

The establishment of the Central Marine Fisheries Research Institute early in 1947 took place just before the dawn of independence, a most critical period in the history of our country which brought in its wake the partition, the stress and strains of which affected in one way or the other the entire Nation. However, the Institute continued to grow inevitably at a slow pace, mainly for want of adequate suitable technical personnel. Such difficulties in the early stages of any organisation are only natural even under normal conditions and could all the more be so in regard to an Institute of this kind as no set up for fisheries research or education existed then in the country from which experienced personnel could be drawn. The scientists required to shoulder the responsibilities were recruited mainly from Universities, Colleges and provincial or state fisheries departments and it necessarily took some time for many of them to get themselves acquainted and oriented to handle the problems that had to be tackled.

It may be stated that the broad lines on which the work had to be conducted were indicated in the various proposals made earlier for the establishment of the Institute but in the course of the actual implementation of these, problems which were not visualised earlier had to be faced by the investigators. The marine fisheries set-up in India being different from that existing in the most advanced countries, the scope for field co-operation in research was very limited. Fisheries occupied a comparatively low place in the economic complex of the country and the industry itself was in a much less organised state than at present. The Institute therefore had to rely on its own resources which especially in the early stages were not much and the scientific workers had to initiate work with very meagre facilities. It is gratifying that despite various handicaps the Institute continued to maintain steady progress.

Fisheries research being different from fish research and marine fisheries being essentially capture fisheries, it goes without saying that the requirements for marine fisheries research are quite different from those relating to some of the other disciplines. All the basic work will have to be carried out necessarily in the areas of occurrence of the fisheries and the fishes constituting them as a synoptic picture in relation to their environment is essential for proper assessment of stocks and their optimum exploitation. The research worker has therefore to be where the fish and fisheries are distributed. It is for this reason that in all countries marine fisheries research institutes are located nearest to important centres of fishing with provision for sea going research and exploratory vessels as a *sine qua non*.

Viewed from the above background it was painfully realised though rather late, that on account of the remoteness of the place and absence of any fishery or fishing industry of an appreciable magnitude, Mandapam Camp is not quite suited for the purpose for which it was selected and could serve mainly as the administrative headquarters only, incidentally tackling problems of local importance and giving the required preliminary training for the personnel recruited. This rightly called in for considerable decentralisation of the research activities which was implemented resulting in the establishment of a number of regional laboratories to tackle problems of all India importance.

The main need of the Institute, however, remained to be met and it continues to be so even after a lapse of twenty years. This is with regard to the provision of sea going research vessels which should form an indispensible complement of any marine fisheries research institute. The need for research vessels was adequately stressed from the very beginning even while recommending the establishment of the Institute but for some reason or the other the matter has remained deferred all along. Inspite of this handicap the scientific workers did their best by taking advantage of all available facilities such as country crafts, catamarans, outboard motor boats and launches for collection of specimens and scientific data. Facilities on board the fishing vessels of the Deep Sea Fishing Station of the Government of India were also utilised to the available extent. A great deal of information was thus collected on various aspects of fisheries to serve as basis for future work.

It could be said that a new chapter in the history of oceanographic investigations in this country was opened by the magnanimous co-operation extended by the Indo-Norwegian Project in 1957 by placing one of their fishing vessels at the disposal of the Institute for research purposes. This arrangement made by Prof. G. M. Gerhardsen, the then Director of the project has been maintained uninterruptedly ever since. In appreciation of the creditable way in which facilities made available on board the fishing vessels were utilised it was decided by the Project to replace the same with a modern, fully equipped oceanographic vessel and accordingly R. V. *VARUNA* was sent to India towards the end of 1961. What little this Institute could achieve in the field of oceanographic studies within the last decade has been mainly due to the above co-operation.

Twenty years is a reasonable period in the history of any organisation for the assessment of the work done. In the scientific field such an evaluation is not exactly based on the material returns or on the number of scientific contributions. While tackling problems of a long range nature as in marine fisheries research, identification of the problems on a priority basis, the method of approach in the investigations and the progressive trend in the accumulation of scientific data to stand the test of critical analysis and comparison ultimately are very important. Unlike in aquiculture, agriculture, etc., quick results are hardly possible, as in forecasting marine fisheries many variables beyond the control of man and their inter-relationship have to be reckoned with which call for data on the various aspects of the concerned fisheries for a long period.

From the very inception of the Institute its primary function has been to obtain detailed information on the distribution, abundance, habits and life histories, food, rate of growth, age and migrations of the commercial fishes and also to understand fully the relationship between environmental factors and concerned species, such information being very essential for developing the fisheries in a satisfactory manner so as to obtain maxium sustaining yields without detriment to the optimum levels of potential fish stocks. As a result of continuous efforts made in the past two decades by the scientific personnel of this Institute valuable information has been collected on various aspects viz., fishery survey, fishery biology, planktology, oceanography and related subjects investigated at the headquarters and regional laboratories. By far the more important groups like the sardines, mackerel and prawns contributing the bulk of marine fish landings have received special attention in the projects for investigation in the Pre-Plan and the First, Second and Third Five Year Plan periods, but other fishes, other shell-fish, sea weeds, etc , which have comparatively less scope for exploitation and utilization, yet playing an important role in local economy have also been taken up for investigation in detail during the entire period. The data now made available by this Institute in offshore and oceanic fisheries resources have paved the way for commercial exploitation, which in the earlier part of this century was considered uneconomical if not impracticable. The work carried out at this Institute is briefly reviewed below.

PRAWNS AND OTHER CRUSTACEANS

From the economic and industrial points of view prawns constitute the most important constituent of the commercial fish landings in the country at present. The export of canned and frozen prawns has been steadily going up in recent years and they form the most valuable foreign exchange earner among the fishery products.

Investigations on resources and biology of prawns and other crustaceans were initiated at the Institute in 1947 and since then valuable data have been collected. The distribution pattern and seasonal fluctuations of the commercial species of prawns and lobsters are now known. Factors, as growth rate, age, feeding habits, maturation and spawning of *Metapenaeus dobsoni*, *M. affinis*, *Solenocera indicus* and *Palaemon tenuipes* were studied. The larval life history of *M. dobsoni*, the most important prawn of the south west coast of India has been worked out in detail and some of the larval stages of *P. indicus* have been isolated from plankton and described. The investigations revealed that most of the penaeid prawns breed in the sea and that their young ones enter the estuaries, brackish-water lakes and backwaters where they feed and grow to re-enter the sea and attain sexual maturity. However, *Parapenaeopsis stylifera* is known to complete the life cycle in the sea. It has been estimated that prawns fished from the backwaters are four to ten months old and those from the sea are in the late 0-year and 1-year groups.

A study of the maturation process of *M. dobsoni*, *M. affinis*, *P. indicus* and *P. stylifera* has shown that all these species breed almost throughout the year with individually delineated peak periods, breeding occurring about five times in the life span, with intervals of two to three months between successive spawnings. Some spawning grounds off Cochin coast in 18 – 25 metre depths for *Parapenaeopsis stylifera* and in 50 – 60 metre depths for *Metapenaeus monoceros* have been noted.

Studies on postlarval abundance in Cochin backwaters have shown that the rate of recruitment is reflected in the subsequent prawn fisheries in the sea. Such an index can be used to predict the prawn catch in the trawl fishery in the region. Some statistically designed experiments in prawn farming have been carried out at Narakkal and Vaikom in Kerala. Preliminary work on the staining of prawns for growth and migration studies has shown that fast green (FCF) is best suited to local species.

Shrimp survey in the Gulf of Kutch resulted in the discovery of two new penaeid prawns viz., *Metapenaeus kutchensis* and *M. alcocki*, the former supporting a commercial fishery. In the south west coast, exploratory fishing has brought to light the existence of several deep water prawns and lobsters as *Aristaeus semidentatus*, *Heterocarpus woodmasoni*, *Parapandalus spinipes* and *Puerulus sewelli*. Nearly thirty new records have been reported from these collections. Some of them occurred in sufficiently large numbers to indicate the possibility of commercial exploitation.

Studies on *Macrobrachium rosenbergii*, the giant backwater prawn, have shown that the species breeds in slightly saline waters of the Vembanad Lake in Kerala and that the juveniles move up the river to the nursery ground in the Pamba River system. Tagging of the spiny lobster was initiated in Kanyakumari District and the recoveries were more than 30% in one year. The experiments have indicated a growth of about 200 - 220 mm in a period of two years. At present tagged lobsters are being released from several centres of this Institute.

The rapidly developing prawn fishing and processing industries call for intensification of research activities particularly on prawn and lobster fishery resources and management.

Oil Sardine

Of the clupeoid fishes which contribute to a third of the marine fish landings of India, the oil sardine, *Sardinella longiceps*, ranks first not only in the quantitative abundance on the west coast, especially from Quilon to Ratnagiri, but also from the point of view of its utilization as a much esteemed table fish and as a source of oil, fish meal and guano. The fishery is subjected to both annual and long term fluctuations. Its recovery since 1957 has been very remarkable and particularly in the last two years, 1964 and 1965 the annual landings were over two hundred and fifty thousand metric tons forming nearly 32% of the marine fish catches. The investigations on the oil sardine fisheries have been chiefly centered round the elucidation of factors responsible for the fluctuations in its fishery. The studies have indicated that the fishery is supported mainly by the first and the second year classes and that the intensity and availability of certain food organisms as also the prevailing physico-chemical factors, largely determine the extent of the fishery in any particular year. The spawning period appears to be much protracted extending from July to October or November. Divergent views have been expressed on the age and life span of the oil sardine. Some are of the view that the oil sardine attains 15, 17 and 19 cm. at the end of 1st, 2nd and 3rd year of its life respectively, while others are of the opinion that it attains 10, 15 and 19cm. respectively at the successive years of its life. Some information has been gathered on the life history of the oil sardine, but the details have still to be worked out and the extent of the spawning grounds to be ascertained. Experimental tagging was carried out in 1965 and a regular tagging programme has been initiated in 1966 and about 1500 of tagged oil sardines have been released on the west coast in order to obtain precise knowledge on the growth and migration of the species.

The rate of recruitment to the fishery depends on the extent of availability of spawners, the length of the spawning period, prevalence or otherwise of favourable environmental factors related to the survival/mortality of the eggs, larvae and juveniles. These aspects of study have received attention. The intensity of South West Monsoon has shown positive correlation with sardine abundance. It is difficult to fix any one factor as a causative factor determining this abundance, but the atmospheric pressure over the sea surface is known to bring about a series of environmental changes resulting in conditions of the sea responsible for fishery abundance.

MACKEREL

Among the pelagic fisheries, the mackerel fishery is as important as the sardine fishery. The annual average of landings in the period between 1958 and 1965 is over sixty five thousand metric tons and in some of the good years (1958 and 1960) the landings exceeded hundred thousand metric tons a year. Although over 80% of the catches come from the west coast, the species supports a minor fishery in certain places of the east coast also. The catches are high in Kerala and the Mysore States. The species supporting the fishery on both the coasts is *Rastrelliger kanagurta*. The occurrence of *R. brachysoma*, which is more deep bodied than *R. kanagurta*, in the Andaman Islands has been recently established. On the west coast of India the fishery starts in the southern centres in July-August and progressively later in the northern centres up to about December. Mostly the juveniles are known to constitute the fishery. The mackerel breeds over a prolonged period. Some spawning grounds are known to occur in the southern regions of the east and the west coasts. Some of the larval stages have been identified.

On the west coast, the peak of spawning season is July - August. While practically there is a diversity of opinion on this peak of spawning season, several observations are on record regarding the period of commencement and also the period of termination of spawning activity in any one year. It is known that the individual mackerel spawns in spurts, thus discharging the eggs, at some intervals. On the east coast of India spawning appears to be in October – November. There is indication that a brief supplementary spawning in about April – May also exists.

Tagged fish are being released since 1966 at important centres on the west coast to understand some aspects of the biology. Work relating to population studies and raciation of the species supporting the fishery, in comparison with mackerel species obtained from various places in the Indo-Pacific region is in progress.

TRAWL FISHES

The offshore catch data of the Government of India vessels operating from all bases since 1949, of the New India Fisheries Company's vessels at Bombay base since 1956, of the West Bengal cutters at Calcutta base for the period 1951–'63, of the Indo-Norwegian Project's vessels at various bases since 1956 and of a few commercial fishing vessels of Cochin base since 1965 have been analysed. This has helped in the assessment of regionwise and seasonwise catch abundance of different fish categories in the regions exploited.

The catch data for the period 1949–55 of the Government of India vessels especially "*ASHOK*" and "*PRATAP*" and the Japanese trawler "*TAIYO MARU* No. 17" fishing in the north western division have shown that of the five regions covered during the period viz., Bombay, Cambay, Veraval, Porbundar and Dwarka, the last named region is the best from the point of view of the catch abundance and also in the preponderance of quality fish. This region is considered to be comparable to some of the world's richest grounds.

Analysis of the catch data of the New India Fisheries Trawlers has furnished a good deal of additional information about the species distribution. The vessels had covered a 6th region also, viz., Kutch, the fishery potential of which was hitherto unknown. An important finding from the catch analysis is that Kutch is the best region for demersal fishes not only in the north western division, but of all regions so far fished on the continental shelf of India.

An exploratory fishing programme which involves repeated systematic linear bottom trawling along selected parallels of latitudes, passing through different depth ranges across the continental shelf to assess the potential demersal fish resources has been introduced at all bases of operations of the Government of India vessels since 1963 and the results are available in the as yet unpublished reports by the CMFRI staff at Veraval, Bombay, Mangalore, Cochin, Ernakulam and Visakhapatnam. These deal with areawise, specieswise catch per hour and catch per hour/horsepower returns separately for each one of the different vessels in different months. Similar reports are available for the vessels of the Indo-Norwegian Project operating at Karwar, Cochin and Mandapam and of the West Bengal cutters of Calcutta base.

A large number of very productive areas have been revealed by the exploratory and commercial fishing operations with catch rates exceeding even 1000 kg/hr of trawling.

From the analysis of catch data we are in a position to assess the total catch abundance and species of fishes that can reasonably be expected from known areas in any month of the year. This information is very valuable to the fishing industry.

TUNAS AND BILLFISHES

Intensive studies on the tunas and related fishes like sailfishes and marlins have been commenced in this Institute about a decade ago. *Auxis thazard*, *A. thynnoides* (= *A. tapeinosma*) from Indian waters were reported for the first time. In connection with the fishery resources of Minicoy Island the tunas and the tuna live bait fisheries have been surveyed. Accounts of eggs, larvae and juveniles of tunas and related groups have been given, including the material collected from the Indian Ocean by the Carlsberg Foundation's

DANA Expedition of 1928-30. Several new records of scombroid fishes from Andaman-Nicobar waters and the Laccadive Sea have been reported. *Spratelloides delicatulus*, *S. japonicus* and *Tilapia mossambica* have been studied as a source of tuna live bait. Tilapia was introduced there as a baitfish to be used as a substitute. The Indian tunas and other Scombroid fishes have been reviewed and suitable keys for their identification have been prepared. The food and feeding habits and other aspects of biology of *Euthynnus affinis affinis*, *Auxis thazard*, *A. thynnoides*, *Sarda orientalis*, *Katsuwonus pelamis*, *Thunnus albacares* (= *Neothunnus macropterus*) have been studied. The work done has been summarised in the Synopses of Biological Data in F. A. O. Fisheries Reports on *Katsuwonus pelamis*, *Auxis thynnoides*, *Grammatorcynus bicarinatus*, *Sarda orientalis*, *Kishionella tonggol* and *Gymnosarda unicolor*. Work on conservation of tuna and billfish resources of the Indian Ocean has been reviewed including the observations made at this Institute. The investigations have brought to light the rich and valuable resources of this group of fishes abounding in the seas around India, which hitherto have been little known and little exploited. Observations were conducted on tunas and other oceanic fishes during the V Cruise of *ANTON BRUUN* participating in the international Indian Ocean Expedition and very valuable information on the distribution of these fishes in the Central and Western sectors of the Indian Ocean were collected.

Clupeoid Fishes in general

Clupeoids other than the oil sardine have also received considerable attention. The fishery and biology of *Kowala coval*, *Thrissocles mystax* and *Ilisha filigera* have been studied. In the catches of the white bait, *Anchoviella baganensis* and *A. bataviensis* have been recorded for the first time along the Indian coasts. Maturation and spawning studies have been made on *Sardinella gibbosa*, *Anchoviella commersonii*, *A heterolobus*, *Thrissocles mystax*, *T. dussumieri* and *Dussumieria hasselti*. Studies on "choodai" fishery on the south eastern coast constituted mainly by *Sardinella albella* and *S. jussieu* have furnished information on length groups entering the catches and possible effects of the various types of gear employed on the fishable stocks. The annual fluctuations in the catches appear primarily due to the extent of replenishment by the O-year class. Key to the field identification of clupeoid fishes has been prepared covering exhaustively all the Indian species so far known. Eggs and larval stages of several species have been identified and described. The work done at this Institute has been summarised in the synopsis of the biology and fishery of the Indian Sardines in the FAO Proceedings of the world Scientific Meeting on the Biology of Sardines and Related Species.

Elasmobranchs

Keys to the identification of genera and species of elasmobranchs, which include sharks, skates and rays have been made for the use of fisheries field workers. Fairly thorough investigations of the species abundance, their distribution in inshore and offshore waters and the breeding periodicity in some of the forms have been made. Of the marine fish catch this group forms about 6%. In general, all species are highly predaceous and destructive to other fishes. Rays feed mostly on varieties of bivalves including the pearl oysters. Periodical incursions of *Rhinoptera javanica* in large numbers into the inshore regions of the Gulf of Mannar have recently been reported, these shoals mostly being composed of gravid females. Incidentally it may be stated that such shoals support fisheries of some magnitude.

FLAT FISHES

Among several species of flat fishes represented in Indian seas, the Malabar sole, *Cynoglossus semifasciatus* supports a commercially important fishery which is confined to the region between Moolki in the north and Nattika on the south of the west coast. The fishery is seasonal and the bulk of the catch is obtained in about September-October. The work at the Institute has shown that the fishery is supported entirely by one year old soles, older fish being rare. The adult size of 10-13 cm is attained in about a year. The fish spawn at the end of first year; spawning is protracted with the peak period between October and January; breeding is believed to take place further away from the fishing grounds and the young soles enter the inshore area in about March and are captured in large numbers. Soles being bottom feeders a close correlation between their food and the bottom fauna has been found. The matter which requires immediate attention is whether, and to what extent, capture of spawners and juveniles affects the fishable stocks.

RIBBON FISHES

The ribbon fishes are represented by four species in the Indian seas viz., *Trichiurus lepturus*, *Lepturacanthus savala*, *Eupleurogrammus muticus* and *E. intermedius*. Commercial fisheries of ribbon fish exist along the coasts of Andhra Pradesh, Madras and Kerala. In 1965 and 1955 when the landings were good, ribbon fishes amounted to forty thousand metric tons. In lean years the catches are known to dwindle to one half or even less. The fisheries are supported by all age groups which are caught mainly by the shore seines and the boat seines. The biology of some of the species, their length frequency distribution in commercial catches and their breeding habits have been studied in great detail. *Trichiurus lepturus* which is the dominant species attains a maximum length of over three feet and enter the inshore fishing grounds in large shoals generally between August and October.

SILVER-BELLIES

Silver-bellies support regional fisheries of much importance although the constituent species are rather small in size and consequently fetch low prices. There are about 16 species under three genera represented in Indian waters. Good fisheries exist along the coast of Andhra Pradesh, Madras and Kerala states. The silver-bellies are caught in shore seines, boat seines and otter trawls. The dominant species is *Leiognathus splendens*, the fishery and biology of which on the south eastern coast have been studied in detail. It spawns from March to September, individuals maturing at the end of first year. Its fecundity is high and the span of life about three years; one to two year old fish supporting the fishery. The biology of a few other species of this group is being studied.

MISCELLANEOUS GROUPS OF FISHES

Some aspects of the habitat, distribution, biology and fisheries of a large number of miscellaneous groups of fishes occurring in the commercial catches have been studied, they being the milk fish (*Chanos chanos*), the silver-bar (*Chirocentrus nudus* and *C. dorab*), the eels, (*Muraenesox talabanoides*, etc.,), Bombay Duck (*Harpodon nehereus*), the horse mackerels (*Caranx kalla* and *Selaroides leptolepis*), the thread-fins (*Polydactylus indicus* and *Polynemus heptadactylus*), the flying fishes (*Cypselurus spp., Exocoetus*), the sand-whiting (*Sillago sihama*), the seer fishes (*Scomberomorus guttatus, S. commerson, S. lineolatus* and *Acanthocybium solandri*), the jew fishes (*Pseudosciaena diacanthus, Otolithoides brunneus, etc.*), the grunters (*Pomadasys hasta*), some perches (*Psammoperca waigiensis, Lethrinus* spp.,etc), the goat-fishes (*Upeneus tragula, U. luzonius, U. vittatus, Parupeneus indicus*, etc.), the half beaks (*Hemirhamphus georgii, Hyporhamphus* spp.) the grey mullets, (*Liza macrolepis. Mugil cephalus*, etc.), the pomfrets *Parastromateus niger* and *Pampus argenteus*), and the hump-head (*Kurtus indicus*). Some of the studies are very comprehensive particularly those related to the Bombay Duck, polynemids, carangids, some perches, and half beaks which comprised theses submitted for post-graduate research degrees of different Universities in India by some technical staff and Research Scholars at this Institute.

Studies on some of the above groups include authentic systematic accounts. Area-wise distribution and regional abundance of groups like polynemids, sciaenids, eels and pomadasyids given in the above accounts have helped a great deal in exploitation of resources by trawl fishing in a more satisfactory manner than has hitherto been done.

Life History Studies

Studies on the life histories of fishes have an important bearing on the location of the spawning grounds, in understanding the nutritional and other requirements of the concerned species at different stages and the rate of recruitment of juveniles which ultimately aims at forecasting the fisheries. The material collected in the cruises of R. V. *KALAVA* and 'R. V. *VARUNA* has shown that the spawning grounds of tunas and the billfishes extend over a wide region in the Laccadive Sea where incidentally it may be stated that the productivity of the water is very high. General studies on the seasonal abundance of fish eggs, larvae and juveniles in the Gulf of Mannar, Palk Bay and other coasts of India has received much attention. In the following groups, eggs, larvae and juveniles and their distribution have been the subject of detailed investigations namely, sardines, (*Sardinella longiceps, S fimbriata, S. gibbosa* and *Kowala coval*), eels (a large number of species along the east and the west coasts, including distribution of *Leptocephali*, seerfishes (*Scomberomorus commerson, S. guttatus, S. lineolatus*), tunas (*Auxis* spp., *Euthynnus affiis affnis, Neothunnus macropterus, Katsuwonus pelamis* and *Sarda orientalis*), and billfishes (*Xiphias gladius* and *Istiophorus gladius*). Studies at the Institute on material collected from the Indian Ocean by Carlsberg Foundation's *DANA* Expedition (1928-30) have greatly helped to understand the extent of distribution of the species coming under the last three groups. The distribution pattern of the juveniles in particular and of the larvae to some extent, of the mackerel, *Rastrelliger kanagurta* in the east and west coasts of India has received fair attention. Other fish species covered are *Anchoviella* spp., *Caranx kalla, Chanos chanos, Gempylus serpens*, soles, halfbeaks, *Myripristis murdjan, Holocentrus* sp., *Dactyloptena orientalis* and a variety of other fishes. The description of eggs, larvae and juveniles have facilitated the identification of a number of early stages of marine fishes about which very little was known prior to the investigations carried out here.

Of the prawns, the life history of *Metapenaeus dobsoni* has been studied in detail. Breeding and recruitment of post larval penaeids have been investigated. Eggs and larval stages of *Hippolysmata encirostris* have been described. Post larval abundance as a possible index to the forthcoming fisheries has been studied in *Metapenaeus dobsoni*, which supports a major prawn fishery of the south west coast. The life histories of a very tiny shrimp *Periclimenus indicus* and the crab, *Neptunus pelagicus* have been studied. The phyllosoma of the lobster species have been described in detail. In connection with planktological and taxonomical studies, the life history of some of the other crustaceans and copepods have also received considerable attention.

Among the molluscs, the spawn, eggs and larval stages have been studied in detail in the prosobranchs (*Cerithium morus*, *C. fluviatilis*, *Cerithium* spp., *Ianthina* sp., *Natica* spp., *Cypraea* sp., *Erronea* sp., *Tonna dolium*, *Tonna* sp., *Murex spp.*, etc. *Thais* spp., *Pyrenae* sp, *Nassa* spp., *Ancilla* sp., *Xancus* sp., *Conus* spp., etc.) and ophistobranchs (*Pleurobranchus* sp., *Cuthona adyarensis*, *Stiliger* sp., etc.). In oysters, life history studies include tolerance to salinity, temperature and other environmental conditions which have a bearing on spawning, survival of eggs, larval development, setting and growth of spat, which are of much importance in oyster-culture.

Molluscan Fisheries

The biology and fisheries of the utilizable molluscan species especially for food, like clams, oysters and cephalopods have been studied in detail and information has been furnished on the growth rate, size at sexual maturity, breeding periodicity, sex reversal in some, the possible effects of environmental factors on breeding and growth, extent of resources, methods of exploitation and the possibilities for culture by employing suitable techniques. The species studied in detail are *Crassostrea madrasensis*, *Katelysia opima*, *Meretrix casta*, *Gafrarium tumidum*, *Donax cuneatus*, *Solen kempi* and *Sepioteuthis arctipinnis*. Observations on the brown and green mussel of the genus *Mytilus* occurring along the west coast of India has been initiated. Extensive under-water surveys of pearl and chank beds off Tuticorin have been made by the scientific staff using aqua lungs for diving purposes and regular charting and ecological survey of the fishing grounds has been made.

Physiology

Prawns have a high degree of tolerance to varying salinity conditions. The prawn fisheries in back waters depend upon the migrations of prawns from the sea into the former environment. The physiological processes involved in the chloride regulation in *Metapenaeus monoceros* have been studied in detail and this led to more intensive study of the adaptations of prawns in general to esturine and brackish water conditions The milk fish fry abound in certain coastal regions and as they can easily be acclimatised and grown in fresh waters, several aspects of physiology of *Chanos* fry have been studied. The more important of these studies is routine active oxygen consumption of the milk fish fry and fingerlings which has a bearing on their transport to nurseries and stocking ponds Basic metabolism etc. in *Plotosus unguillaris* and rate of filtration by clams under varying salinity conditions have also been studied. The phenomenon of 'red tide' and consequent fish mortality has also received attention. Work on brackish water fish farming was attempted and useful information on several aspects of *Chanos* and *Tilapia* culture has been gathered.

SEAWEEDS

Problems related to utilization of seaweeds for production of agar-agar, algin, seaweed meal and manure have been taken up for investigation and resources surveys have been conducted Extraction of agar and agaroids from *Gracilaria, Gelidiella, Hypnea* etc. and alginic acid from *Sargassum* have been worked out at a cottage industry level and the techniques perfected by the Institute have helped to establish government sponsored seaweed industry in the Madras state. Ecological factors conducive for algal growth have been studied and attempts have been made to culture some of the important species. Based on the advice given by the Institute, collection of agar producing seaweeds has started in a number of centres along the Gulf of Mannar and Palk Bay on a commercial scale and an export trade has been established Manufacture of agar within the country has also begun in places like Bombay, Ahamedabad, etc.

MARINE BIOLOGY AND OCEANOGRAPHY

Investigations in marine biology and oceanography have occupied a prominent place in the Research programmes of the Institute. Work on the standing crop of plankton, organisms in the food chain, their inter-relationships in the ecological niches, factors influencing production of organic matter and estimation of primary organic production using isotope ^{14}C was initiated and valuable results have been obtained. The studies have shown that the production of organic matter on the west coast is of a very high order comparable with some of the most highly productive regions of the world. Several species of plankters occur in greater quantitative abundance on the west coast than on the east coast and this is reflected in the composition of the fish catches in the respective regions.

The production of the plankton is closely related to the monsoon particularly the South West Monsoon on the west coast. Abundance of nutrients due to upwelling, river discharges and the lowering of temperature and salinity to optimum levels seem to promote rapid production of phytoplankters.

The magnitude of production of phytoplankters was assessed from several angles and compared with fish landings. This indicated that the harvest of fish could be increased to several times above the leval at 1955. Subsequent assessment in 1962 indicated that the increased exploitation by additional crafts have accounted for only a further small fraction of the total organic production.

Organic production studies by light and dark bottle techniques as well as using ^{14}C on the south east coast showed a high level of production equalling that of the Somali

Current region in the western Arabian Sea. The estimates of fishing potential indicates atleast a possible five fold increase.

Most of the floral elements occurring in the plankton have been identified. The nannoplankton has been estimated by pigment extraction; they constitute 30 to 50% of the total phytoplankters depending on the seasons. They are of great importance in the nutrition of larval forms on whose survival recruitment to fishery depends.

While the observations were mostly confined to the shallower inshore regions during the earlier period of investigations, with the availability of R. V. *VARUNA* of the Indo-Norwegian Project work has been extended to the offshore waters on the west coast from Cape Comorin to Karwar. In over 100 cruises covering about 3500 stations water samples for oxygen and salinity estimations were collected and the bathythermograph was operated to study temperature profiles. Samples have also been collected for studies on nutrients and the work is in progress. Displacement volumes of over 1560 zooplankton samples have been estimated, and fish eggs and larvae have been sorted out. The qualitative and quantitavtie studies of phytoplankton is in progress.

From the collections made on board R. V. *KALAVA*, Phyllosoma larvae of several species of lobsters have been described from off the west coast and the Laccadive Sea. The specific identity of these larvae is of significance to lobster fisheries.

The Euphausiacea, an important constituent of the offshore plankton and a forage item of pelagic fishes, have been studied. A useful guide for identification of common copepods of our waters has been published. The fish larvae, copepods, chaetognaths and the euphausids of the *VARUNA* collections are under detailed study.

The discovery and description of the larvae of tuna and related fishes have given an indication of the spawning grounds of these fishes. Data have been collected on the spawning of other pelagic fishes also.

A detailed study of the bottom fauna and bottom plankton off Calicut has been made; this would be valuable in connection with bottom fishery.

Simultaneously with exploratory fishing using different gears and echogram survey it has been possible to chart out and delimit areas suitable for perch ("kalava") fishing between Cape Comorin and Karwar. Useful trawling grounds in the depths beyond 200 m have been located and over 100 deep water and bathypelagic fishes have been identified.

Extensive work has been carried out on hydrological features of the offshore waters, mainly on salinity, oxygen content, temperature and total phosphorus. These studies indicate that there is regular upwelling of water prior to and during South West Monsoon and sinking after September; waters off Bombay are rich in phosphorus; and conditions around the Laccadives are conducive to high fertility and production of plankton. Oxygen content studies revealed the presence of an O_2 poor layer off the west coast which at times extends to the shelf region; this sometimes affects the fishery or may even cause fish mortality.

The general trend of circulation of the waters on the west coast, known since long, clockwise during the South West Monsoon and anti-clockwise during the North East Monsoon season, are confirmed. The development of the north heading current off the south west coast coincides with good catches of oil sardine; the year to year variations of sardine catch appear to be related to winter winds which strengthen the north heading current. The monsoon intensities occupying certain range appear to be favourable for fisheries by improving the nutrient and oxygen content of the waters bringing about high organic production.

Chemistry, Bacteriology and Technology

The section dealing with chemistry, bacteriology and fisheries technology had covered a wide field of fundamental and applied aspects before it was separated from this Institute and merged with the Central Institute of Fisheries Technology. Since more than 50% of the marine fish catch reaches the consumer in sun dried or otherwise cured state suitable standardisation of methods of fish curing were considered necessary. The quality and the hygienic standards of fish cured have been found to vary at different curing centres. Investigations were undertaken to ascertain the chemical standards that can reasonably be expected in the cured products. The work has covered the sun dried and salt cured products in the wet and dry condition. The extent of spoilage by bacterial action attendant on delay in commencement of curing has been studied. Besides biochemical studies organo-leptic-tests were also conducted to fix certain standards in the methods of fish curing. Extent of retardation of spoilage in frozen and chilled fish using aureomycin has also been studied.

The biochemical studies have been extended to other cured products as pickles, fish sauces, etc. In connection with the hydrological investigations the bacterial elements in the sea water have also been studied. Special techniques have been developed to prepare nitrogen free sulphuric acid for determination of ultra micro quantities of chloride, and in the chromatography of sugars by multiple development etc. In the ice stored prawns free amino acid nitrogen content is taken as an index of the quality. Chemical properties related to changes resulting in rancidity of ray liver oils have also been noted.

Highly proteinous and odourless fish flour for human consumption has been prepared employing the least expensive techniques and a pilot fish meal plant has been devised for use in small scale industry.

Survey and Statistics

One of the main achievements of the Institute has been the launching of a full-fledged all the year round sample survey to obtain monthly and annual estimates of total marine fish landings and their group-wise composition for each maritime State. Estimates of fishing effort in terms of manhours spent as well as in terms of number of operations of fishing units of different types are also obtained. The sample survey design is one of space-time stratification and was evolved after years of field trials and is probably one of the most suitable designs for Indian conditions where fish landings take place at innumerable landing centres at almost all hours throughout the year. The estimates obtained are reasonably accurate with a very low percentage error. At periodic intervals of about five years, census figures on the number of fishing villages, fishing population, craft and gear are also collected by the Institute on a complete enumeration basis. In fact, this Institute has been the only source for the supply of these basic figures to various organisations and industries in the country.

Considerable work has also been done on the quantitative assessment of the status of some of our important commercial fisheries like oil sardine and mackerel by estimating growth and mortality parameters. In the case of oil sardine, a relation between the abundance of spawners in one year with the catch next year has been obtained which may be useful for making short-term prediction of fishing success.

Some work on experimental designs has also been carried out in this Institute. For determining the optimum sizes of fields and the optimum number of sluice gates necessary for prawn culture practices in the paddy fields, statistically designed experiments were carried out and the analysed results gave valuable information. The Institute gave technical advice to the Central Inland Fisheries Research Institute, Calcutta by planning their designs of experiments in connection with various practices of carp culture. The Institute has also rendered statistical help to the Central Institute of Fisheries Technology, Ernakulam, in determining the criterion for the formation of lots of processed shrimps for quality control inspection. Other institutes in the country such as the Central Institute of Fisheries Education, Bombay, and Oceanographic Laboratory, Kerala University, have also from time to time asked for assistance in the shape of specialised lectures on Fisheries Statistics. The Statistical Schools organised by the F. A. O. in the Indo-Pacific Region have also invited assistance from this Institute in conducting their courses.

A perusal of the F. A. O. Year Book of Fisheries Statistics will reveal that India is the only country among the developing nations in the Indo-Pacific Region which has supplied diversified statistics, so necessary to understand the status of fishing industry and the fishery resources and the entire data relating to marine fisheries have emanated from this Institute.

Ichthyological and Faunistic Studies

From the resources point of view it is essential that we should know qualitatively and quantitatively in space and time the fauna and flora constituting the biological complex in the marine environment. An area within the Indian Union, the ichthyofauna of which was least known was the sea around the Laccadive Archipelago. An intensive collection was made from this interesting region and over 500 species were recorded as against a few dozens known previously. This study is expected to turn out to be the most important contribution to our knowledge of the fishes of the Indian Region since the monumental work of Francis Day.

In the course of routine biological studies quite a good number of marine animals and algae were recorded for the first time in our waters. Several were new to science and these have been described. A list of the new records and new species already published is given in the Appendix.

Frog Research and Development

Frog leg export from the country has been going up steadily in recent years in close association with the marine fish and prawn freezing and canning industry on the west coast of India. With a view to survey the frog resources of the country, the present condition of the frog leg industry and its effect on the stock in areas of intensive exploitation, explore the possibilities of development in areas with potential resources and recommend steps for conservation, work was initiated in 1965 and carried out in this Institute until the scheme was transferred to the Central Inland Fisheries Research Intitute in August 1966. An exhaustive survey was carried out and a detailed report on the future work to be done has been submitted to the Government.

General

Along with the applied research carried out investigations of a fundamental nature were also conducted, especially by some of the research scholars working for their degrees. Many of these have applied value also either directly or indirectly. Special mention may be made in this connection of the studies conducted on trematodes, molluscan eggs, crabs, echinoderms, nudibranchs and copepods. Studies on corals, sponges, stomatopods and polychaets are in progress.

Quite a large number of educational and research institutions in the country have been benefited in one way or the other in educational and scientific matters by this Institute. The contributions from the Institute and the contact with the workers have greatly helped to create and promote general interest in fisheries and marine biological researches. While in the early stages the Institute had to draw in the required technical personnel from other organisations, in about a decade's time the position reversed and a number of experienced persons started going over to other institutions such as the Central Institute of Fisheries Technology, Central Institute of Fisheries Education, Central Inland Fisheries Research Institute, Central Institute of Fisheries Operatives, Deep Sea fishing Station, National Institute of Oceanography, Atomic Energy Establishment, Zoological Survey of India, Central Food Technological Research Institute, Central Salt Research Institute, Botanical Survey of India and Universities.

A matter in which the scientific personnel of this Institute could claim justifiable credit is for organising the Marine Biological Association of India in 1958 which has been regularly publishing since 1959 the Journal of the Marine Biological Association of India and conducting periodically Symposia on fisheries and marine sciences. The Journal and the Proceedings of the Symposia have been well received all over the world and in no small measure have helped to promote the cause of marine sciences in this country.

The Institute actively collaborated in scientific matters with various international and national bodies like the Food and Agricultural Organisation of the United Nations, Indo-Pacific Fisheries Council, the former Central Board of Geophysics, National Institute of Oceanography, etc., and the State Fisheries departments and Central Fisheries Institutes.

Under a special scheme sanctioned by the then Ministry of Scientific Research and Cultural affairs and funds provided by them, collection and study of seawater samples and oceanographic data from different parts of the Arabian Sea and Bay of Bengal were made. Research training and facilities for research have been given to a number of Indian and foreign research workers. The Institute gave the necessary residential accommodation and laboratory facilities for locating the U. S. Programme in Biology during the International Indian Ocean Expedition. This Institute also actively participated in the Expedition and R. V. *VARUNA* undertook several cruises with our scientists on board. The Deputy Director of this Institute in his capacity as the Chief Scientist-in-charge of the Indian Ocean Biological Centre has been guiding the researches carried out there.

An attempt has been made to review briefly the different aspects of marine fisheries research carried out at this Institute during the last two decades. It is obvious that in view of the extensive nature of the work done adequate coverage would not be possible in an account of this kind. All the contributions from the Institute are listed in the Bibliography and those pending publication are given in Appendix. In addition to the above, several scientific contributions are in various stages of finalisation.

It may be said in short that as a single organisation this Institute has been mainly responsible for the greater part of marine fisheries research work carried out in the Indian Region within the last twenty years and that the contributions from the Institute have helped to place India in the map of marine fisheries science.

It would only be appropriate that the actual evaluation of the work done is made by others but it could be said that the scientific workers have done their best inspite of various handicaps and there is no doubt that with additional facilities they will do much better. The *Ad-Hoc* Committee that assessed the work in 1954 and the Foreign Expert assigned for similar purpose in 1962 have spoken only in appreciative terms about the work carried out at the Institute. The scientific workers are fully seized of their duties and responsibilities. They are at the same time conscious of the fact that in research as in any other field there is always scope for improvement which only can ensure progress.

It is a recognised fact that spectacular results are hardly possible in marine fisheries research and that accumulated data based on years of uninterrupted studies spread over a wide area are necessary to arrive at any positive conclusions that would help to forecast fisheries and maintain them at optimum level of exploitation. In the marine environment with changing conditions, the problems confronting the research worker are vast and varied. The conditions under which he has to work also has to be appreciated and no premium could be considered too high for facilitating research on proper lines. The foreign exchange earned by the export of marine fishery products has been steadily going up during the recent years and has reached a record figure of 135 million rupees in 1966 from 61 million in 1959. As the above does not include the value of marine fish and fish products consumed within the country the cumulative value of the industry to the nation can well be imagined. It is therefore imperative that a fair proportion of the same should be set apart for research purposes.

The greatest asset of any research institute and for that matter of any organisation is the personnel therein on whom depends mainly the success of any programme of work or enterprise. Whatever may be the other assets like buildings, equipments etc. and however essential they may be, the deciding factor is the man and as such without the right type of men good results can never be obtained. It is therefore absolutely essential that in our planning for the future the greatest priority has to be given to the proper selection, training and conditioning to research of the younger generation on whom ultimately would depend the future of the research Institute. The ancient oriental proverb suggests to grow rice if one plans for one year, to grow trees if for twenty years, and to grow men if for hundred years. This saying is equally applicable in fisheries research as in any other. Regular drain of scientific personnel is natural in any organisation and it is therefore essential that conditions of service should be sufficiently attractive to draw in the best talent for replacement. The basic requirement of scientific workers and their conditions of service have to be regularly reviewed and steps taken to rectify the handicaps so that the efficiency of the rank and file is maintained at a high level and a chain of trained workers are available to shoulder the increased responsibilites as and when occasion demands. The Central Marine Fisheries Research Institute is particularly fortunate in having a band of devoted scientists of a high order. Their present efficiency has to be maintained at all costs. The future is in the hands of the planners and administrators.

Organic Production in Indian Waters

R. Raghu Prasad

Central Marine Fisheries Research Institute

Studies on the quantitative and qualitative distribution of the standing crop of plankton in the Indian coastal waters have been fairly extensive. But investigations on the production of organic matter which enable us to assess the relative fertility of the various regions of the sea are of recent development. Systematic measurements on the production of matter in the southeast coast of India and recent measurements from the west coast together with the information already available on the nutrient salts enable us to draw a general picture of the productivity of the Indian waters.

Taking all seas as a whole it may be mentioned that the replenishment of nutrient salts in the productive layers is normally the most important factor governing the magnitude of the annual organic production, other factors being light, temperature and grazing by zooplankton. However, temperature and light are never limiting factors in these waters as in the temperate seas.

Nature has established an equilibrium between all factors influencing production. Any change in one of the factors will normally influence the other factors as well and establish a new equilibrium. It is only occasionally possible at any given time to describe one of the factors as the absolutely limiting one. The most important elements thus becoming limiting in the sea are nitrogen and phosphorus In water masses located below a depth of about 500 – 1000 metres the concentration of inorganic phosphate and nitrate are relatively high. The ratio between nitrogen and phosphorus (N:P) is about 16 in phytoplankton when the contents are expressed in mg. atom and is generally the same in deeper waters. Therefore when deep water is brought up to the surface and used for phytoplankton growth the two elements are exhausted simultaneously. So it is the rate of replenishment of the nutrients in the euphotic zone and not the concentration observed at a given time which determines the productivity. This replenishment is provided by the two processes of decomposition and water circulation.

Regeneration of the nutrients from organic matter may be either due to the excretion by the zooplankton feeding on phytoplankton or indirectly by microbiological regeneration of organic compounds originating from digested plants and animals. This indirect regeneration takes place both in the water masses and in the top layer of sediments. In the free water masses this process is generally slow. In shallow areas the regeneration in the sediments constitutes the most important part of total regeneration. The influence of temperature on the regeneration of nutrient salts is considerable. So in coastal areas where the water masses of the photic zone comes in direct contact with the bottom a striking correlation will be found though temperature has only a limited significance on the rate of organic production. On the other hand in the open part of the sea, water circulation is necessary for the replenishment of the nutrient salts in the photic zone. The water circulation may be horizontal, whereby nutrient-rich water is brought in from neighbouring areas, or vertical. It is the vertical circulation that is more important. Vertical circulation may be due to upwelling or due to turbulence. In typical upwelling deeper water masses ascend to replace surface water carried away by wind. In typical vertical turbulence there is more or less a complete mixing of the surface water masses with deeper water masses The rate of production is thus high in the "new" surface water and low in "old" surface water.

The shallow coastal regions show that they are very productive. This is a general feature of tropical waters. As mentioned before the main cause for this high rate is the regeneration of the nutrient salts due to the high temperature A strong positive correlation was observed between temperature and organic production in the shallow coastal waters of Mandapam. There are two peaks of production, one in April–May and another in October. The annual gross production in the surface waters as estimated by the light and dark bottle method comes to 75 g C/m^3. Carbon-14 experiments conducted off Tuticorin in the Gulf of Mannar also indicated a very high rate of production. In regions where the depth of the photic zone was about 45 metres, production rate exceeded 5gC/m^2/day. This is comparable with the highest rates so far observed, for example in the western part of the Arabian Sea and in the Gulf of Oman by the Indian Ocean Expedition research vessels.

On the west coast of India the hydrographic features governing production show pronounced seasonal variations. Four seasons can arbitrarily be postulated viz., monsoon (June, July, August), post–monsoon (September, October, November), winter (December, January, February) and summer (March, April, May). The summer months exhibit stagnant conditions. During monsoon and immediate post-monsoon periods upwelling occurs along the entire west coast with regional variations in intensity. This brings up nutrients from the deeper layers and thus enrich the surface layers The open part of the Arabian Sea, especially the regions of deep water ascent, has the highest concentration of nutrients at or near the base of the photic zone which is a potentially productive condition.

Near the shelf the lower boundary of photic zone as determined by light penetration is about 60 metres. The rate of production is high in the surface waters towards the coast (more than 10 mg C/m^3/hour) suggesting a constant supply of nutrients. The rate of production amounts to 2.0 – 4.5 gC/m^2/day near the coast off Cape Comorin. Outside the shelf the rate of production is only moderate, being less than 0.5 gC/m^2/day. In the open part of the Ocean the Expedition ships have observed high production in the zones of deep water ascent. In the equatorial part of the Indian Ocean the production rate is found to be significantly higher than tropical waters in general.

It is also seen that a high rate of production takes place in the shallow waters at the coasts of isolated oceanic islands. This is mainly because the ocean currents sweeping an isolated island may induce some vertical mixing. Investigations conducted around the Laccadive Islands have shown that there is an anticyclonic motion from surface down to the thermocline and down below the circulation is reversed. These circulatory movements help to maintain the highly productive water in the vicinity of the Islands for a longer time. Carbon-14 experiments conducted in the waters around the Islands show that compared to the other islands the waters around Minicoy are having the highest production rates with 50.0 mgC/m^3/day in the surface waters. In the deeper regions in the vicinity of the Island, though the rate per unit volume is lower, the column production is about 0.3 gC/m^2/day which is only a little more than the rate usually found in tropical oceanic waters. On the shelf where there is no turbidity the rate of production is found to be high – upto 0.6 gC/m/day. Hence it may be seen that the productivity in the coastal regions of Indian waters is high practically anywhere on the shelf. Outside the shelf it is wholly dependent on the ascent of 'new' water rich in nutrients from below.

Thus organic production studies conducted extensively both on a spatial and temporal basis can provide valuable information on the possibilities of large scale fishing. Investigations conducted by the Central Marine Fisheries Research Institue for the first time in India have revealed that in some of the regions like the southeast coast of India, the rate of production is very high and comparable to the most productive regions of the world. Exploratory fishing carried out subsequently have substantiated that some of the areas like the inshore waters of the Gulf of Mannar and Palk Bay could sustain a much higher yield than at present exploited.

Exploratory Fishing

By K. VIRABHADRA RAO
Central Marine Fisheries Research Institute

While the exploitation of the inshore fisheries with the help of indigenous non-mechanised craft and gear is being carried out fairly intensively from very ancient times, combing of the depths of the high seas in India using power driven vessels operating trawls and other types of gear has come into vogue only within the last few decades. Different organisations at present are conducting large scale exploratory and commercial offshore fishing operations from different bases viz., Bombay (Government of India Deep Sea Fishing Station, Directorate of Fisheries of Maharashtra State and the New India Fisheries Company Ltd.), Goa (Directorate of Fisheries, Government of Goa), Karwar (Indo-Norwegian Project), Cannanore (Indo-Norwegian Project), Cochin (Government of India Offshore-Fishing Station, Indo-Norwegian Project, The Cochin Company, New India Fisheries Ltd., Island Seafood Private Ltd.), Tuticorin (Government of India Offshore Fishing Station), Mandapam (Indo-Norwegian Project) and Visakhapatnam (Government of India Offshore Fishing Station).

The fishing base at Calcutta of the West Bengal Government which was functioning since 1950 had been closed down in 1963 and some of the vessels had been transferred to the Deep Sea and the Offshore Fisheries Establishments of the Government of India. For want of suitable vessels the Government of India fishing bases at Veraval and Mangalore also had to be closed in 1966. Besides the medium and the large trawlers operating from the aforesaid bases, there are over 3000 mechanised indigenous craft spread over the country and fishing in waters a little beyond the narrow, appoximately the seven mile inshore zone where the local fishermen use their non-powered craft and gear.

The catch data of exploratory and commercial fishing vessel are being analysed by the Central marine Fisheries Research Institute of the Government of India and an outline of results so far obtained is given in the following account for different divisions.

1. NORTH WESTERN DIVISION (Ratnagiri to Kutch)

This division includes areas lying on the continental shelf approximately between latitudes 16° to 23° N and between longitudes 67°–73° E which have been very intensively fished for demersal fishes by a large number of vessels. Especially, the northern areas have revealed excellent trawling grounds for quality fishes like "Ghol" (*Pseudosclanea diacanthus*), "Karkara" (*Pomadasys hasta*), "Dara" (*Polydactylus indicus*), and "Koth" (*Otolithoides brunneus*) which along with other fishes as "Wam" (*Muraenesox talabonoides*), "Doma" (small sciaenids), catfishes, elasmobranchs and miscellaneous fishes contribute to very high catch per hour returns. Although the initial attempts by some of the vessels were not fruitful, subsequent operations proved that high and sustaining yields could be obtained by trawling in these grounds. Of the earlier trawling operations which are on record namely those of S. T. *WILLIAM CARRICK* and S. T. *MEENA* the catch rates obtained were low but they provided some useful information on the fish distribution pattern on this division.

The catch data of the Government of India vessels *ASHOK* and *PRATAP* and the Japanese fishing vessel *TAIYO MARU* 17 for the period 1949-56 has brought to light much valuable information on the regionwise distribution pattern of the important categories of fish and the environmental factors influencing the fisheries. Five main regions viz., Bombay, Cambay, Veraval, Porbundar and Dwarka have been covered of which the last one was found to be the most productive and the first the least. Dwarka was recognised to be the best at the time when the potential resources of the Kutch region were little understood. While "Ghol" was observed in considerable quantities in all regions, "Dara" and "Koth" were best obtained from Dwarka, "Wam" from Cambay and Veraval, "Karkara" from Porbundar and Dwarka and catfishes and elasmobranchs from Bombay and Cambay. In relation to depth zones, it was observed that the bulk of the catches came from the 20 fathoms line with "Dara" and "Koth" relatively in greater abundance to landward side and "Ghol," "Karkara" and "Wam" to seaward side of this line. The day catches were better than those of the night catches and the neap tide yields higher than the spring tide yields. In the different graded patterns of temperature distribution, within a limited range, "Dara" and "Koth" showed preference to colder regions. It was also found that bull trawling resulted in far better yields than otter trawling in the same grounds.

Following operations of the Government of India vessels, the New India Fisheries Company's bull trawlers, *ARNALA* cum *PAJ* and *SATPATI* cum *PILOTON* very successfully carried out commercial fishing from Bombay base during 1956-'63. In addition to five regions covered by *ASHOK* and *PRATAP*, these vessels covered a sixth region viz., Kutch, which has been found to be far better than any other region on the continental shelf in the Indian territory from the point of view of extremely high catch returns for all fish with preponderance of quality fishes. For the period 1957-62 in which the vessels fished continuously in all months, the annual regional averages of catch, effort in hours and the catch per hour returns (per two vessels) have been worked out along with species composition and seasonal abundance and presented in Figs. 1 & 2. The monetary returns for the period 1956-'63 exceeded over Rs. 1.6 crores for an overall catch, of 26304 tons for an effort of 34953 hours at a catch rate of about 753 kilogrammes per hour of trawling.

The *AKASHI-MARUS* 23 and 25 of the same fishing Company operating from Bombay base since 1964 have also been yielding high catch returns.

Areas (Fig. 1) 43, 48, 10, 11, 17, 18 24, 2, 3, A, D, E, H, K, L, M, N, P, Q, R, S, T, U, V, X and Y have given over 1000 kg/hr of fish in bull trawling in some months. Of these, 11, 18, 48, A, N, R, S and T have yielded more than 1,500 kg/hr. but below 2000 kg/hr The highest catch rate was from area 2 for a catch of 2914 kg/hr. in January 1961.

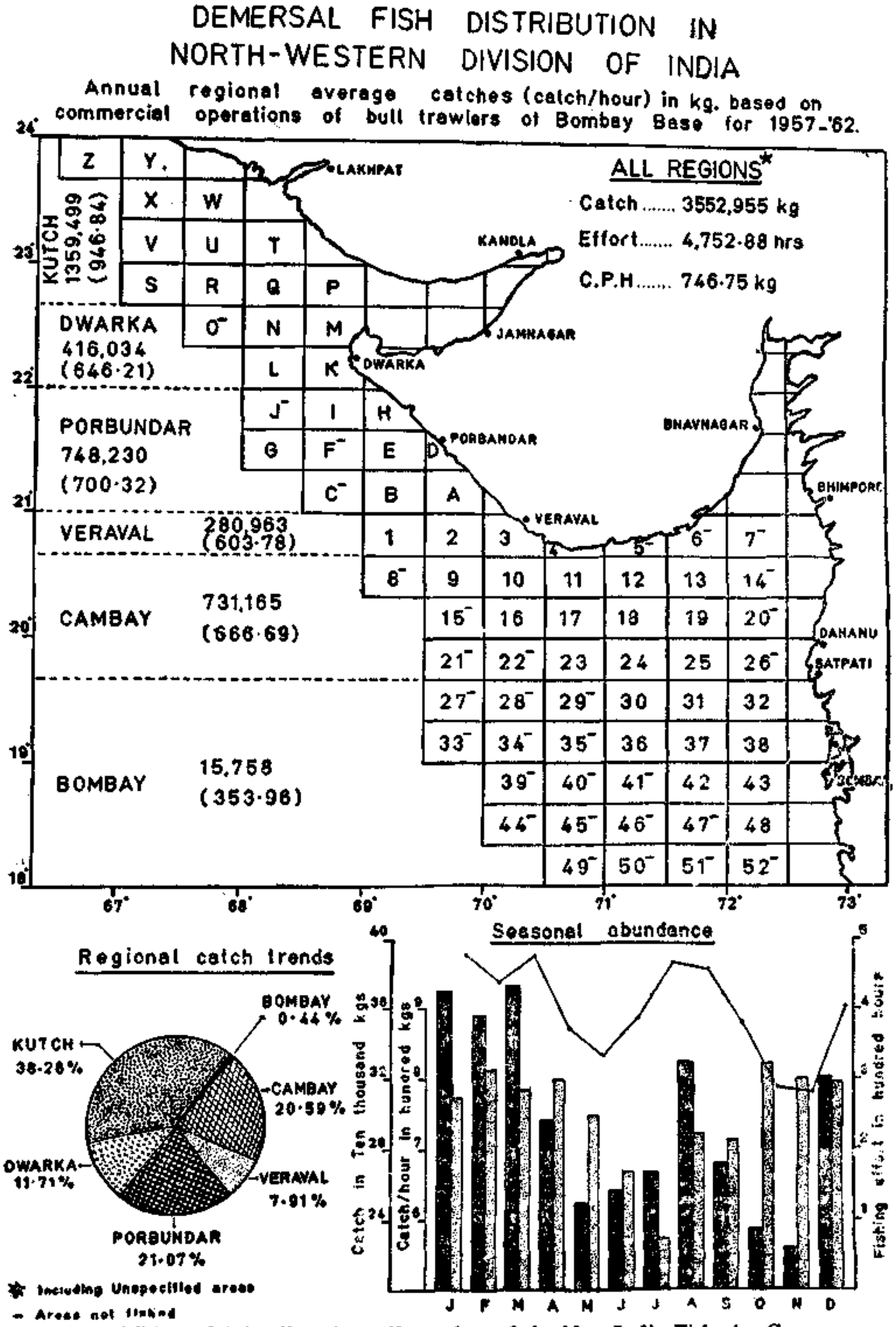


Fig. 1. Offshore fish landings by bull trawlers of the New India Fisheries Company, Bombay with some catch particulars.

During the period 1961 to 1965, very intensive trawling operations were carried out from Bombay base by the Government of India vessels also. The areas covered, the annual catch returns and the catch composition are shown in Fig. 3. Areas 18-72/5D, 19-71/1D, 20-70/1B, 5C, 6A, 20/72/5D, 21-69/3D and 21-70/1A gave at times 1000 kg or more of fish per hour of trawling; similarly 18-72/1D, 19-72/1D, 3A, 20-70/3D, 4C, 5A, 5B, 6B, 21-69/4C, 6A and 22-68/5F gave yields between 750 kg and 999 kg/hr, 17-72/4F, 18-72/5C, 5E, 6E, 19-72/1B, 1C, 20-70/5D, 6C, 21-69/2E, 5B, 5C, 6B, 22-68/4D, 4E, and 5E gave

COMPOSITION OF CATCH
BY BULL TRAWLERS, BOMBAY BASE
1957 -'62

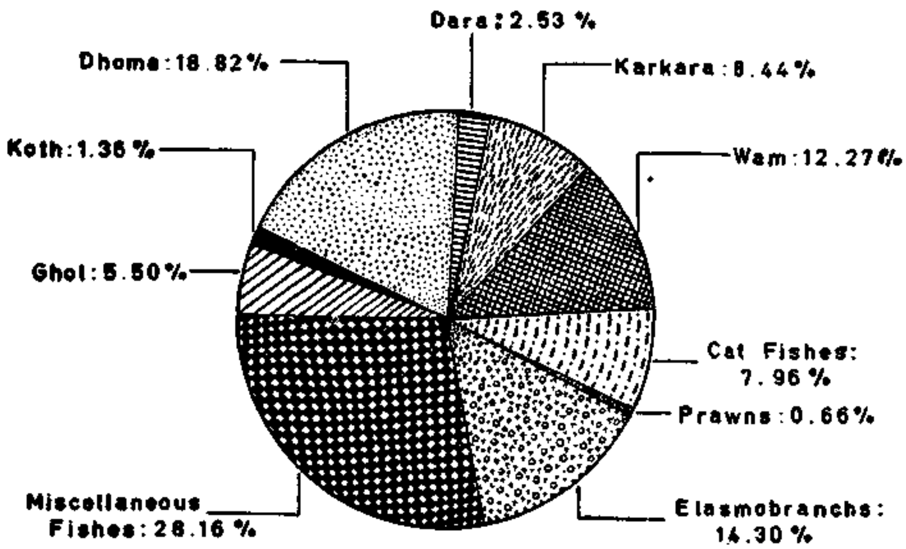


Fig. 2. Species composition of the catches by bull trawlers of Bombay Base: Miscellaneous fishes include Pomfrets-1.39%, Kati-3.33%, Shende-3.26% and other 20-18%.

catch rates between 500 kg and 749 kg/hr. A large number of other squares gave more than 200 kg. but below 499 kg/hr in major area 16-72, 16-73, 17-72, 17-73, 18-72, 19-70, 19-71, 19-72, 20-69, 20-70, 20-71, 20-72, 21-69 and 22-68.

SOUTH - WESTERN DIVISION (Karwar to Cochin)

This division is well-known for the oil sardine and mackerel which together constitute the bulk of the inshore catches. The best of shrimp fishing grounds are also located in

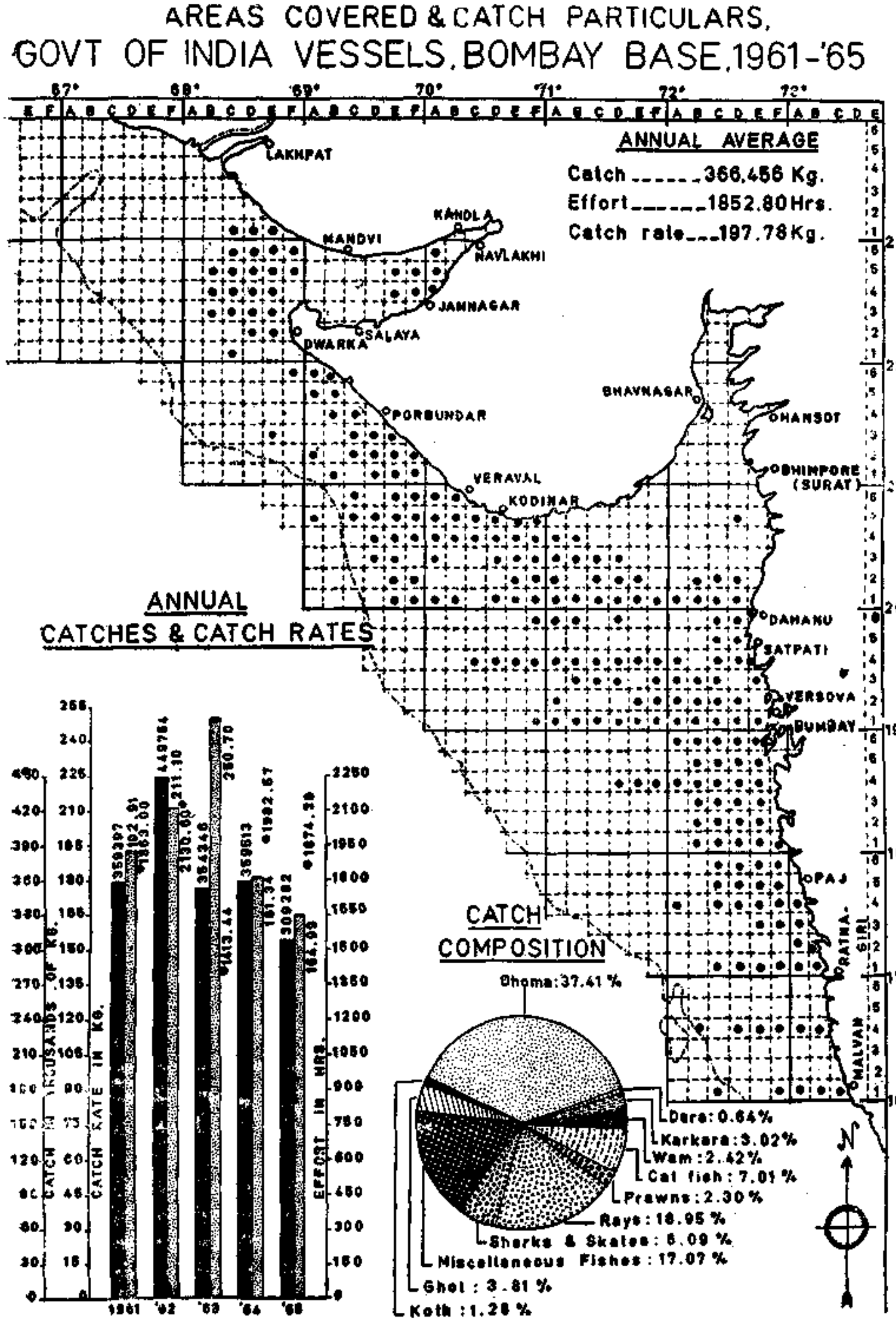


Fig. 3. Landings by Government of India vessels of the Deep Sea Fishing Station, Bombay for 1961-'65 with catch particulars and areas covered.

the southern part of this division. However, the demersal fisheries potential is not yet fully understood. During 1928–'45 some of the Governmental and commercial vessels of Ceylon viz. *BULBUL*, *TONGKOL*, *RAGLAN CASTLE* and *ARINGA* and later in 1949-'50 other vessels, *KANYAKUMARI*, *SAGAR KUMARI* and *ASHOK KUMARI* of the West Coast Fisheries Company of the erstwhile state of Travancore, and *CHANDRIKA* of the Department of Marine Biology and Fisheries, University of Travancore were engaged in deep sea fishing operations in areas around the 'Wadge Bank' but the results were not encouraging.

Subsequently the INP schooners surveyed the coast from Cape Comorin to Kozhikode from 7 miles limit to the edge of the continental shelf, a distance of 240 miles long and 30 miles wide; during 1956-'57 the schooners caught 117 tons of fish at 52.6 kg per fishing hour. Several types of gear were used; they obtained 291.7 kg of fish per trip for purse-seining. On the edge of the continental shelf the rock cod, *Epinephelus* was obtained in considerable quantities by hooks and lines. The Medium boats in 1957 had given better yields of 512.1 kg per trip in shrimp trawling, 249.5 kg per hour in pair trawling, 458.6 kg per trip for purse-seining and 233.1 kg per trip for hooks and lines.

Within the scope of the available information, the results of operations of the offshore fishing vessels at different bases in recent years is given below.

a) *Karwar:* (Approximately between latitudes 14° and 15°N and long. 73°30' and 74°30' E): Some of the vessels of the Indo-Norwegian Project have been exploring the nearby grounds upto 20 fathoms using shrimp trawls and purse seines since September 1963.

During 1963–'64, three vessels netted a total of 167,092 kg of all fish for an effort of 846 hrs. at 197.51 kg/hr. Fish constituted 155,961 kg. and prawn 11,131 kg. The highest monthly catch rate for all fish was 417.3 kg. for the vessel *KARWAR*-I in December '63.

In 1964–'65 the vessels had landed 164,103 kg. of all fish for an effort of 749 hrs. at a catch rate of 219 10 kg/hr. The monthly catch rates for individual vessels varied from 116.21 kg. to 315.62 kg/hr. of trawling. Purse-seining operations have proved in the year a failure with a low catch and a catch rate (102.70 kg/hr.).

In 1965-'66 the vessels obtained by trawling and purse-seining a total of 130,912 kg. of fish for 822.83 hrs. of fishing. The quantity of fish obtained by trawling was 114,585 kg. for an effort of 764.42 hrs. at 149.90 kg/hr; by purse-seining (restricted to October-December) a catch of 16,327 kg. for 58.42 hrs. at a catch rate of 279 48 kg/hr. was obtained.

The trawler catches in the year consisted of miscellaneous fishes 39.99%, *Opisthopterus* 21.35%, *Leiognathus* spp., 24.78%, sciaenids 5.03%, *Lactarius* 2.52%, sharks 3%, rays 2.04 and prawns 1.29%. The purseseine catches consisted of *Rastrelliger kanagurta* 36.09%, *Sardinella longiceps* 29.74%, *S. fimbriata* 21.55% and miscellaneous fishes 12.62%.

b) *Cannanore*: (Lat. 11° to 12° N and long. 74°.30' to 76°E) In 1964–'65 the INP vessels landed 92,099 kg. of fish and 18,107 kg of prawns. The fish catch consisted of *Opisthopterus tardoore*, *Lactarius*, *Leiognathus*, *Johnius*, *Stromateus* and *Cynoglossus* and the prawn catch of *Metapenaeus dobsoni*, *M. affinis* and *Parapenaeopsis stylifera*.

In 1965–'66 M. V. *NORIND* obtained by trawling a catch of 24,111 kg of fish in 75 trips in 289 hauls in 292 fishing hours at 82.56 kg of fish per hour of trawling and M4 by purse-seining a meagre catch of 254 kg. of sardines.

c) *Mangalore*: (from lat. 12° to 14°N and long. 73°.30' to 75°E): Off Mangalore and Malpe in 1964-'65 at total of 3206 metric tons of all fish were landed by the mechanised boats and the Government of India trawlers, M. V *TARPON*, M V. *SAGARVIHARI* and M. V. *SAMUDRA*. The major part of the catch was obtained by the mechanised boats of ex-trainees of the Department of Fisheries, Government of Mysore. Of the total catch, fish were 589.4 metric tons and prawns 2616.6 metric tons The latter formed 18% of the catches. In 1965–'66 the same vessels landed 3976.7 metric tons of all fish. Fish formed 2833.3 metric tons and prawns 1143.4 metric tons (28.75%).

d) *Cochin*: (Lat. 8° to 12°N and long. 75° to 77°30' E): In 1957 the Offshore Fishing Station of the Government of India was opened at Cochin. The trawlers *ASHOK* and *PRATAP* were shifted from Bombay to this base during that year. Subsequently a few other vessels were added. Besides the Government of India vessels, of Indo-Norwegian Project and commercial fishing companies are regularly fishing especially for prawns.

During 1964 March to 1965 March a total of 168,053.5 kg. of fish were landed by the Government of India vessels for an effort of 1482.04 hrs at catch rates of 19.39 kg/hr. for prawn and 94.0 kg/hr. for fish. Prawns formed 17.1% of the total catches. In 1965-'66 the vessels landed 131562 kg. at a catch rate of 111.84 kg/hr. for all fish. Prawns formed 14.13%.

The Indo-Norwegian Project vessels landed 32,445 kg. of all fish during March to June, '64 and September to November '64 for 282.83 hrs. at a catch rate of 114.72 kg/hr. of trawling. The catch included prawns of 4170 kg. at a catch rate of 14.73 kg/hr.

The same vessels in 1965–'66 landed by trawling 29621 kg. of all fish, of which prawns formed 15.16%. The catch rate for all fish was 106.04 kg/hr. *KALAVA* did hand lining in the deeper waters with rocky bottom and obtained large perches etc. to the extent of 28956 kg

The Cochin Company's vessels during January to March '65 landed 54,044 kg of all fish for an approximate fishing effort of 768 hrs. The prawn catch consisted of 1411.75 kg at a catch rate of 18.37 kg/hr During 1965–'66 a catch of 197,714 kg. of fish and prawns was landed for an effort of 2666 hrs. at an average of 74.16 kg/hr. Prawns formed 27.90%. The first catches were generally composed of *Leiognathus*, *Opisthopterus*, *Anchoviella*, *Cynoglossus*, *Trichiurus*, *Pseudosciaena* etc. Among the prawns the dominant species was *Parapaenaeopsis stylifera*.

The region is extremely good for prawns, where large sized species suitable for canning and freezing abound, but very poor for general fish categories which are chiefly small sized uneconomic varieties, occurring sparsely and yielding low catch per hour returns in almost all grounds explored in trawling operations. The landings of shrimp from areas around Cochin by the New India Fisheries Company's vessels and other commercial vessels are high but the actual catch data are not available.

Some of the Government of India vessels operating from Cochin have been doing exploratory fishing for tunas in the region upto the Laccadive Islands. During 1965–'66 the monthly hooking rates for big eyed tuna ranged from 0.07% to 0 34%, yellow fin tuna 0.14% to 0.37%, marlin 0 05% to 0 28%, sailfish 0.06% to 0.15%, sword fish 0.03% to 0.14%, sharks, 0.78% to 2.30% and other 0.05% to 0.16%, rather very low and unimpressive figures from the practical point of view.

SOUTH-EASTERN DIVISION (Pondicherry, Tuticorin, Mandapam)

Of the total marine fish production of India only 20% of the catches are obtained from the east coast. The demersal fisheries like the pelagic fisheries, are much poorer in the grounds of the east coast than those on the west coast. Nevertheless, some important trawling grounds have been located in the recent exploratory fishing operations by the Government of India vessels, the Indo-Norwegian Project's vessels and the West Bengal cutters.

a) *Pondicherry - Tuticorin:* The Government of India vessels started fishing operations with Tuticorin as the base since 1959 in Madras State. The vessels surveyed a very wide region for grounds suitable for trawling and for operating bottom and surface gill nets. The gill net operations were not encouraging.

During 1963–'64 off Tuticorin M. V. *MEENAKSHI* operated in all 153 sets of gill nets in area 8–78 at a depth of 12–55 metres with a total catch of 7800 kg of fish at a catch rate of 47.14 kg per set. Off Pondicherry the same vessel operated 74 sets of gill nets in 15–78 metres depth in areas 12–79 and 12–80 with a catch of 3292 kg of fish at 44.5 kg of fish per set.

Trawling operation off Tuticorin by two of the vessels in 1963–'64 resulted in a catch of 124,810 kg of fish at 152.64 kg per hour of trawling in area 8–78. The sub-area 4B proved to be good with a catch rate of 245.30 kg/hr. In 1964–'65 two vessels trawled for 352.92 hrs in 8–78 and 9–78 obtaining a catch of 43081.5 kg at a catch rate of 122.07 kg/hr 8–78/1F gave a fairly high catch rate of 177.51 kg per hour. In 1965–'66 one vessel trawled in the same major area with a catch of 83526.5 kg for an effort of 568.50 hrs at a catch rate of 146.64 kg/hr 8–78/2A and 4B gave catch rate of 170.15 kg/hr and 155.29 kg/hr respectively. Trawling off Pondicherry in 11–79 resulted in a catch of 13,589 kg of fish with a catch rate of 75.60 kg per hour. The gill net catch was dominated by sharks and catfish and the trawl net catches by leiognathids, sciaenids, *Drepane* etc.

Tuna long lines were tried in areas 8–79, 8–80, 7–79 which gave low catch rates of 38.63 kg of fish per 100 hooks (June 1965).

b) *Mandapam*: With Mandapam as the base of operations, some medium boats of the Indo-Norwegian Project have been fishing with shrimp trawl in the Gulf of Mannar and the Palk Bay since 1964. During August 1965 to February 1966 two of the boats landed 110,109 kg of fish at a catch rate of 233.18 kg/hr. In some of the months the catch rates for individual vessels were as high as 806 kg and 915 kg of fish per hour of trawling. In 1965-'66 two of the boats from this base landed 175, 663 kg of fish for an effort of 788.83 hrs. at a catch rate of 222.69 kg/hr. The monthly catch rates for individual vessels ranged from 155.40 kg/hr. to 385.90 kg/hr. The catch in the region consisted of silver bellies which amounted to over 90%, along with catfishes, *Lactarius*, rays, prawns and mixed fish.

Central and North-Eastern Divisions

These include the demersal fisheries in the Andhra, Orissa and West Bengal States.

a) *Visakhapatnam*: Since the establishment of the Offshore Fishing Station at Visakhapatnam in 1959 several vessels operating from the base surveyed the continental shelf between the river mouths of Godavari and Mahanadi along the coast line of Andhra and Orissa States for a distance of 359 nautical miles. Several types of gear were designed and tried. During 1959-'60, 131,170 kg of fish with an overall catch rate of 89.8 kg of fish per hour of trawling was landed. During 1964-'65, 233,670 kg of fish at a catch rate of 114.66 kg/hr was landed. In 1965-'66 the catch was 109,290 kg at 78.23 kg per trawling hour.

The areas between Visakhapatnam and Bimlipatnam have been intensively fished because of their proximity to the base. However, the catch rates here were only moderate. In grounds south of Visakhapatnam, the catch rates were generally low. Near the False Point in the north as also in the grounds near the mouth of Chilka Lake, the catch rates have been observed to be high. In general, it may be stated that the catch per hour returns increase from south to north. Catfishes, sharks, rays and miscellaneous fishes comprise the catches and the prawns in the region as a whole constitute 2% to 4%.

b) *West Bengal*: Subsequent to the preliminary survey of fishing grounds made by *GOLDEN CROWN* in 1908, systematic exploration in the region was started by the Department of Fisheries of the West Bengal with two Danish cutters in 1950. Three more Japanese trawlers were added in 1965. As a result of continuous fishing by these vessels (*KALYANIS* I to V), some important fishing grounds in the Western Channel, Eastern Channel, Sand Heads, near Baitarni River mouth, off Debi and Prachi Rivers, near Black Pagoda (Konark), off Puri, Chilka Lake and Gopalpur in depth ranges of 10 to 30 fathoms have been located. In 1960 a new fishing ground "Swatch of no grounds" noted for quality fishes has been found. The major groups contributing to the fish catches in the region as a whole were sciaenids, *Kurtus indicus*, eels, *Scomberomorus* spp., *Pomadasys hasta*, *Pampus argenteus*, prawns, sharks and rays, catfishes etc. The catches were sorted into A, B and C classes based on the high, moderate and low prices prevailing in the markets.

These trawlers for the period of 1951 to 1960 had landed 3726.06 metric tons of fish In the year 1961 the catches were excellent for two vessels being 603.5 metric tons; the number of voyages were 36; the catch per voyage worked out to 16.8 m tons and catch per day's absence from port 2.45 m. tons. The A, B and C categories landed in the year as a whole were 318.2, 274.9 and 10.4 metric tons respectively.

Fishery biological research:- Various aspects of fishery biology of the species contributing to the offshore catches have been under investigation at the Central Marine Fisheries Research Institute's establishments at Veraval, Bombay, Karwar, Mangalore, Ernakulam, Tuticorin and Visakhapatnam. A good deal of useful information on *Polydactylus indicus*, eels, *Otolithoides brunneus*, *Pseudosciaena diacanthus*, *Polynemus heptadactylus*, *Ilisha filigera*, *Parastromateus niger*, *Nemipterus japonicus*, food of trawl fishes of Visakhapatnam Coast, *Decapterus*, bathy-pelagic fishes, plankton in relation to trawl catches, relative fishing powers of the Government of India fishing vessels of Bombay base, some new records of fishes, mackerel catches by trawlers etc.

It may not be out of place to mention here some of the more important observations on the component fish species of the offshore trawling grounds. These are not different from the species caught by non-mechanised craft and gear in the inshore region, but their relative abundance in the two environments may vary and in some there may be periodical migrations from one environment to the other for the purpose of breeding or feeding. The regionwise abundance of fish categories detailed here is determined on the basis of annual average catch rates by bull trawlers for the period 1957-1962 for Bombay to Kutch.

Polydactylus indicus: The "Dara" is a prime fish the landings of which have much dwindled in recent years. It grows to over a metre in length and is carnivorous, feeding mostly on crustaceans, but also on fair amounts of juvenile fishes and molluscs. The catches show about five major size groups. Some maturing "Dara" are known from Bombay and Cambay regions and one with oozing gonads from the Gulf of Kutch. Spawning appears to be twice in a year i. e. in April-June and October-November. There is evidence to show that the species breeds in shallow inshore waters, particularly in the Gulf of Kutch and that the juvenile "Dara", known as "Chelna" enter the offshore grounds in Dwarka and Porbandar, which appear to form the nursery grounds. "Dara" from all regions together forms about 2.5%. The catch rates are the highest from Dwaraka; Kutch and Porbundar rank next.

Otolithoides brunneus: The "Koth", has been showing declining trends in the inshore and offshore catches as "Dara". Sexual maturity is reached at about 120 cm. and the adults grow to over 150 cm. The O-year class dominates the inshore catch and the I and II year classes the offshore catches. It has a very high rate of fecundity and a prolonged spawning commencing about the end of South West Monsoon and extending over several months. The juveniles enter the creeks and other inshore water inlets where they are caught at times in large numbers. The growth checks on scales which are upto 9 in full grown adults, seem to be reliable indicators of the different age groups. The food consists of fishes, crustaceans, stomatopods and squids.

Dwarka registered highest catch rates for this species, Kutch ranking next.

Pseudosciaena diacanthus: The "Ghol" is also one of the prime fishes. The annual fluctuations not being marked, "Ghol" catches have been steady in recent years contributing, on the average, 5% of the total landings. The fish attains sexual maturity at a total length of 800 to 850 mm. and the adults grow to about 1200 mm. Growth checks are upto eight, which have been found useful in determining the age of the fish at different lengths. Most of the fish in the landings are with extroverted stomachs indicating, disgorging of food. Fishes and crustaceans form the food. Spawning appears to take place over a prolonged period of June-September or a still longer period. Spent ones appear in large numbers in October. Juveniles in large numbers are found in the inshore catches from March on. Kutch has been found to give the highest catch rates to this species, Porbundar and Dwarka ranking next. However, it may be stated that fair amounts of "Ghol" are obtained from all other regions also.

The "Wam", (Eels) are highly predaceous feeding on a variety of teleostean fishes, including young eels, and crustaceans as prawns and crabs. *Muraenesox talabonoides*, which grows to about 2 metres in length supports a fishery of much important, on the north western coast of India. Sexual maturity is attained at 120 cm. The rate of fecundity is high and mature individuals are obtained from April onwards. Some with oozing gonads have been met with in July-August. Peak of the landing is in August and the major part of the catch consists of individuals ranging from 120 to 170 cm. Eels form about 12% of the total catches. The catch rates have been the highest form Cambay; Veraval ranks next in catch rates but first in abundance of catches. The systematics of a large number of eels has been studied and the *leptocephali* of several eel species have been described.

The "Karkara", *Pomadasys hasta* is a high quality fish with steady annual catches amounting on the average to over 8% of the total catches from Bombay to Kutch. It grows to a little over 60 cm. in total length. Sexually mature individuals are not met with in fish below 40 cm. Spawning is soon after the South West Monsoon. Juveniles of 5 cm. onwards occur in January-February in the inshore region.

The fish is a bottom feeder both in the adult and juvenile stages, feeding on amphipods, polychaetes, shrimp, small mud crabs, hermit crabs, stompatodods and molluscs. Upto a maximum of five growth checks have been observed in the otoliths. Kutch has given the highest catch rates, Dwarka and Porbundar ranking next. Also fair quantities are caught by trawlers from Bombay, Cambay and Veraval on the west coast and in Andhra and West Bengal along the east coast.

The "Shende", *Polynemus heptadactylus* a small sized fish, which occurs both on the east and the west coasts, is fairly abundant from Bombay to Kutch consisting about 3% of the total catches. The juveniles prefer the surface waters, feeding on *Acetes indicus* and a variety of zooplankton; the adults are more abundant in deeper waters and feed on crustaceans, fishes, polychaetes, molluscs and echinoderms. The third and the fourth year groups viz. fish between 136 mm and 165 mm dominate the trawler catches. Growth checks on scales and otoliths have been found useful in determining the growth and age of the fish. Breeding seems to take place almost all round the year, with two spawning peaks, in about March-June and August-November. A fair proportion of the adult exhibits hermaphroditism. Catch rates by trawlers have been found to be almost equally high from Kutch-Dwarka and Cambay.

In respect of other groups, the regional abundance may be stated briefly as follows based upon the catch per hour returns: catfish (about 8%) in Kutch followed by Porbundar; "Kati" (*Ilisha filigera* about 3%) in Porbundar and Dwarka followed by Kutch; pomfrets (about 1.39%) in Porbundar followed by Kutch and Dwarka; prawns (about 1%) in Cambay followed by Bombay and Veraval; Elasmobranchs (about 14% in Kutch followed by Cambay and Veraval; "Doma" (mixed uneconomic small sciaenids about 19%) in Porbundar followed by Cambay and Veraval; and miscellaneous fishes in Kutch and Porbundar.

Work is in progress on the fishery biology of "Ghol", other sciaenids, "Karkara", catfishes, *Saurida*, *Ilisha*, carangids, prawns, silver-bellies and prey-predator relationship in trawl fishes.

The research schemes of the Central Marine Fisheries Research Institue in the Fourth Five Year Plan period include 1) continuation of the present programmes on catch analysis of fishing vessels and biological studies of fish species with a view to understanding the causes behind the annual fluctuations and 2) taking up fresh programmes on (a) tagging, (b) determination of inter-relationships between offshore and inshore fisheries (c) study of ecology, including planktology and hydrology of fishing grounds (d) statistical estimation of relative richness of different fishing areas (a) determination of relative fishing efficiency of different types of vessels and (f) standardisation of fishing effort.

It may now be concluded that fishing in deeper offshore regions mostly by trawling and to a limited extent by other types of gear like gill netting, long lining, purse-seining, etc., has come to stay and the activities in this direction are expanding. The expansion of the export trade in frozen and canned marine products, like the shrimps has given a further impetus to mechanised fishing to obtain better catches from known grounds and to look for as yet unexploited grounds. The non-availability of fully equipped ocean going vessels and the lack of adequate fishing harbour and on-shore cold-storage, processing and other facilities are the main factors retarding the progress of the offshore fishing industry in spite of fairly adequate information now available in regard to the exploitable resources of the different fishing grounds explored in the past two decades. The long felt need for suitable research vessels at the Central Marine Fisheries Research Institute for systematic exploration of the fishing grounds, particularly in offshore waters which have not hitherto been covered and for collection of biotic and abiotic environmental data in relation to fish catches requires immediate attention in the Fourth Plan period.

Fish Population Studies

By S. K. Banerji
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Generally, we hear such questions as "what is the magnitude of our oil sardine or mackerel resources?" "Can we get more catch from these resources?" It is, therefore, proper that we carefully examine what is meant by a fishery resource e. g., oil sardine or mackerel resource. A fishery resource is just like any other natural resource (e. g., mineral resource, hydro-electric resource etc.) which is exploited by man. But at the same time, it differs considerably in character from other types like mineral resources. The coal resource in a region is limited in magnitude, even though sometimes we do not know the magnitude. From this fixed resource we can exploit at any desired rate. The resource will be completely exhausted after a period of time depending on the rate of exploitation. In this sense a mineral resource can be described as a non-renewable natural resource which is liable to get exhausted after some period of time. It is also a static resource because we always know how much of the resource remains, once we know how much has been removed. A fishery resource is very much different in character. It is a self-regulating renewable natural resource. Consider a fish population occupying a certain area of the sea. Now when a certain portion of the population is removed, the remaining portion in the habitat gets better food, more area to move about, and this results in faster growth rate, lesser mortality rates and also the spawns get better chance of survival. The result is that the resource resusciates itself quickly. Apart from fishing, the population is also affected by many other fishery-independent environmental factors such as available food supply, change in salinity, temperature of the water, change in ocean-currents etc. Thus the fishery resource is a dynamic resource, ever changing due to impact of fishing and other fishery-independent factors.

Though it is possible to estimate the absolute magnitude of this dynamic resource by tagging experiments and other methods, it is easier to construct simple index which measures the relative abundance of the resource. This index is given by the catch per unit effort. This index however will be a valid measure of the dynamic fishery resources only if our fishing efforts are spread over the entire range of the resource. The term unit effort requires some explanation. If it could be assumed that boats of the same type and size employing the same gear of more or less same dimensions exploit the fishery, then the number of operations of such boats in a year can be taken as the magnitude of effort, or even the total number of fishing hours by all these boats could also be taken as a measure of effort. If, however, a fishery resource is exploited by various types of boats employing diverse types of gear, the measurement of the magnitude of effort poses a problem. In this case, the relative efficiencies of the various types of fishing units have to be first found out, so that the efforts expended by various fishing units can all be expressed in terms of a standard fishing unit. One of the commonest method of estimating the total effort generated by diverse fishing units in terms of a standard fishing unit is to divide the total catch obtained by all fishing units by the catch per unit effort of the commonest or standard fishing unit.

Though the catch per unit effort gives a relative index of abundance of the fishery resource in different years, the information as such is not of much use to fishery scientists. For example, let us assume that catch per unit effort of mackerel in 1964–65 season is 1000 kg and that in 1965–66 season is 900 kg. The above information only tells us that in 1965-66 the abundance of mackerel was less than that in 1964-65. But such changes in a dynamic resource is inevitable. Thus neither a knowledge of the absolute magnitude nor the relative indices of abundance are of any gainful use to us. We have to use a different and meaningful yardstick for measuring the fishery resource. In fact the present catch and effort should be the most appropriate yardstick. Can we get more catch out of the available resource by increasing fishing effort, so that the available resource can regenerate itself to the original level? Or are we catching more than what the resource can yield and the fishing intensity has to be restricted? An answer to these questions will furnish more information on the status of the fishery resource than a mere knowledge of absolute magnitude of the resource which is variable and dynamic. In fact, the knowledge of these types constitute the crux of the problem of fish population studies.

The problem can be studied in two ways. The first method uses the population growth law derived by Schaeffer and others. Any population in the sea will grow i. e., increase in weight due to growth of the existing number and recruitment of new ones and decrease due to natural mortality taking place. The growth rate however will depend on the magnitude of the population in the sea. This growth rate will be obviously zero when the population is zero and again it will be zero when the population is at its maximum. The maximum growth of the population will take place when the population is at some intermediate level. If our catch is equivalent to this growth of population, the population will remain unaltered, that is, in equilibrium, and continue to yield the maximum catch. This is called optimum sustainable yield or equilibrium yield. Several empirical growth laws of the population can be assumed, the simplest of which is a parabolic law of population growth. Based on this, equilibrium level of catch can be worked out. A corollary of this approach states that if the population is in equilibrium, the relation between abundance (i.e., catch per unit effort) and effort is linear and abundance decreases with effort. Thus if we have several years' data, a simple plot will show the relationship between abundance and effort. If this is linear, abundance decreasing with effort, we can be sure that fishing is affecting the population and then determine the level corresponding to the maximum equilibrium yield. If on the other hand, no such linear relation is observed we should say that fishery-independent factors are the predominant factors. Thus the relationship between fishing effort and abundance is a diagnostic character of the status of fishery resource.

The problem can be viewed in another way. The commercial fishery begins to exploit the fish from a certain age, which we may call the minimum age of capture. The period of exploitation will depend on how long the fish lives. The weight of a fish will be more if we catch it when it is older than when it is young. But natural mortality operates throughout the life of the fish and sometimes it increases with age. Thus though an older fish will be bulkier, there may not be many fish left in a population, to catch at that old age. Hence we should better start catching the fish at an age when the growth rate equals natural mortality rate. Thus the catch depends on the minimun age of capture. The catch will also depend on the number of fish of capturable age entering into the fishery every year. The subsequent growth rate of the fish, natural and fishing mortality rates and also the longevity of the fish will influence catch. Thus if we can estimate the rate of growth, the age of capture, the longevity of the fish and natural mortality rate it is possible to determine the magnitudes of catch corresponding to various rates of fishing mortality, that is, fishing effort, and determine the level of fishing effort which will yield optimum catch. This is most important in relation to fishery management in the sense that a decision can always be taken as to whether the fishing intensity is to be expanded or restricted. Similarly at the current level of fishing effort, we can determine the magnitude of catch that can be derived if we vary the minimum age of capture. This will enable us to determine the most profitable minimum age at which we should begin to catch the fish so that we get the maximum weight of catch per fish. The problem of fish population studies thus reduces to the one of estimating the various vital statistics of the fish population, namely, the growth rate, natural mortality rate and the fishing mortality rate.

The growth rate of a fish can easily be ascertained if we know the sizes of the fish at different ages. Various methods are available for the determination of the age of a fish. The most popular method is by identifying the modal positions of the length frequency distribution obtained by taking samples from the commercial catch. This method does not furnish the age of individual fish but only indicates the average size of the fish at the end of successive ages. It has various limitations and needs careful handling. The second method of age determination is based on counting growth checks on scales, otoliths etc , brought about by periodic disturbances in environmental or physiological conditions. This is a very widely used method in temperate climate, where during the extreme rigours of cold season the growth ceases and it leaves its imprint in the harder structures like scales, otoliths etc. This method has been successfully employed for the determination of age in the case of some of the Indian fish but has not given any results in the case of many others. The third method of determining growth rate is by tagging fish and noting down the size of the fish at the time of release and again its size at the time of recapture. This method has so far not been tried in India because of many difficulties associated with the problem but very recently lobsters have been tagged and from the recaptures valuable information have been obtained. A programme to tag mackerel and oil sardine has already been initiated. The mortality rates can be determined either by comparing the relative abundance of a brood of fish at its successive ages or again from tagging.

Once the necessary estimates of the required vital statistics are obtained, it has already been mentioned that the status of a fishery can be determined.

The mackerel and oil sardine form two of our most important fisheries in India and the two together form nearly 25% of the total landings of marine fish in India. The two fisheries are characterized by high fluctuations in their annual catch. No relation has been found out between abundance and fishing effort. Hence it is obvious that the fluctuations in the fishing success of these two fisheries are not due to fishing but are most probably brought about by fishery-independent factors. Both these fish are very fast growing in the initial period of their life and then the growth slows down considerably. Both have very short life span with a high natural mortality and a relatively low fishing mortality rate. In such a fishery, the fishing success will depend on the strength of the incoming group (recruits) in the fishery. In fact in both the fisheries, the major portion of the catch comes from the O-year class (i. e., fish less than one year old) and the fluctuations in the catch have varied along with fluctuations of the O-year class. It is necessary to search for the fishery-independent factors which cause such wide fluctuations in the yearly recruits and bring about wide fluctuations in the annual catch of these fisheries.

The Oil Sardine

By M. S. Prabhu
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In the marine fisheries map of India pelagic fishes dominated by clupeoids undoubtedly occupy an important place by virtue of the relative magnitude of their fishery. Clupeoids, in general, constitute about a third of the marine fish caught in India and within this group oil sardine (*Sardinella longiceps* Valenciennes) known as "Mathi" in Malayalam "Boothai" in Kannada and "Tarali" or "Haid" in Marathi, ranks first. Out of a total of 815,120 tonnes of marine fishes landed in 1965, oil sardine alone accounted for 253,302 tonnes forming 31. 69%.

The oil sardine fishery is known for the worst set backs it has suffered for over two or three decades from the twenties to the forties except for certain slight improvements in the catches during the 1922–24, 1925–26 and 1933–34 seasons. That the oil sardine fishery has had a phenomenal revival during the last decade is apparent from the high percentage it has been constituting in the total marine fish production from 1957 onwards (Table I). During the last 15 years, the average oil sardine catch of about 30,200 tonnes in the 1950–55 period appears to have had almost a fourfold increase during the 1956–60 and a sixfold increase in the 1960-65 periods. Such an improvement in this fishery which is practically the mainstay of economy of the fishermen along the Kerala and Mysore coasts sounds a very encouraging note especially during these years of critical shortage of food in general and protein rich food in particular.

Table I

Year	Total oil sardine landings in India. (in tonnes)	Percentage of oil sardine in the total.
1950	34,420	5.9
1951	17,240	3.4
1952	13,895	2.5
1953	51,831	8.9
1954	33,952	5.8
1955	30,447	5.1
1956	7,412	0.1
1957	1,91,467	21.9
1958	1,23,730	16.4
1959	69,234	11.8
1960	1,89,016	21.5
1961	1,67,884	24.6
1962	1,10,229	17.1
1963	63,647	9.6
1964	2,74,333	31.9
1965	2,53,302	31.7

The oil sardine, known to occur along the coasts of Arabia, Iran, Pakistan, Ceylon, Andamans and Java and in Bali straits, is one of the important species of commercial importance occurring extensively in the inshore waters along the west coast of India, the region of maximum abundance being from Ratnagiri in the north to Quilon in the south. However, during certain years stray catches of oil sardine have also been made along the coasts of Madras and Andhra states in the east coast. From very early times this fishery has been exploited by the indigenous craft and gear which naturally set a limitation on the region fished and the duration of fishing. This fishery, without having any impact of mechanisation on it so far, continues to be restricted to a narrow coastal belt within the 25 fathom line. Generally, the gears employed in this fishery are boat-seines called *Mothikolli vala*, *Pattenkolli valu*, *Thattum vala*, *Paithu vala* and *Nona vala* in the Kerala region, beach-seines known as *Rampani*, *Kairampani* and *Yendi* along the Mysore Coast, cast-nets and gill-nets. Certain types of specialised small-meshed cast-nets called *Koori bale* are operated in the Mangalore zone from July to September when small-sized oil sardine abound in the coastal waters. Similarly, another specialised type of net employed in the above region is *Ida bale* which is actually a big-meshed gill-net operated for large-sized oil sardine. During July to September, a type of small-meshed boat-seine called *Nethel-vala*, mainly used for catching white baits, is operated for small-sized oil sardine in the Calicut zone. Comparing the catching efficiency of all these gears, the boat-seines of Kerala and *Rampanis* of Mysore with their catch-per-unit exceeding one and ten tonnes respectively, seem to account for the major part of the oil sardine catch in these regions.

In addition to the importance of oil sardine as food both in the fresh and cured conditions, its oil has several uses as in the jute, leather and soap industries, and guano as fertiliser in the coconut, coffee, tea and other plantations. With the growing demand for fresh fish in the interior places and also because of the availabilty of ice from a chain of ice factories set up at some of the important fish landing centres, good quantities of oil sardine are now transported to the interior places and marketed in fresh condition. In addition to this, carrier launches also transport oil sardine to Bombay from the *Rampani* operating centres along the Mysore Coast. Judged from the magnitude of the catches made during the peak season particularly in the *Rampani* operating centres along Kanara Coast where glut conditions seem to prevail at times following extraordinarily heavy landings of oil sardine, it appears that there is further scope for extending more cold storage and transport facilities so that more fresh fish, now converted into manure, could be made available to the needy consumers in the remote areas. Because of the extreme fluctuations in the oil sardine fishery, the establishment of dependent industries, particularly canning, has not progressed at the expected pace although a very limited number of them has come up along the Mysore and Kerala coasts.

The oil sardine fishery generally commences on the west coast soon after the outbreak of the South West Monsoon. The beginning of the fishery is marked by the entry of big-sized fish in advanced stages of maturity. In certain years small-sized oil sardine belonging to the 0-year class, i. e., not yet one year old, and measuring 4 to 5 cm in length also occur in large numbers during August-October. Such an occurrence of small-sized fish over several months is suggestive of the protracted nature of spawning in the oil sardine. With

PLATE I. Fig. 1. Oil sardine (17.8 cm) with opercular tag.

Fig. 2. Oil sardine belonging to different size groups supporting the fishery. Length of fish (top to bottom) 17.8, 15.4, 11.8, 8.6 and 4.2 cm.

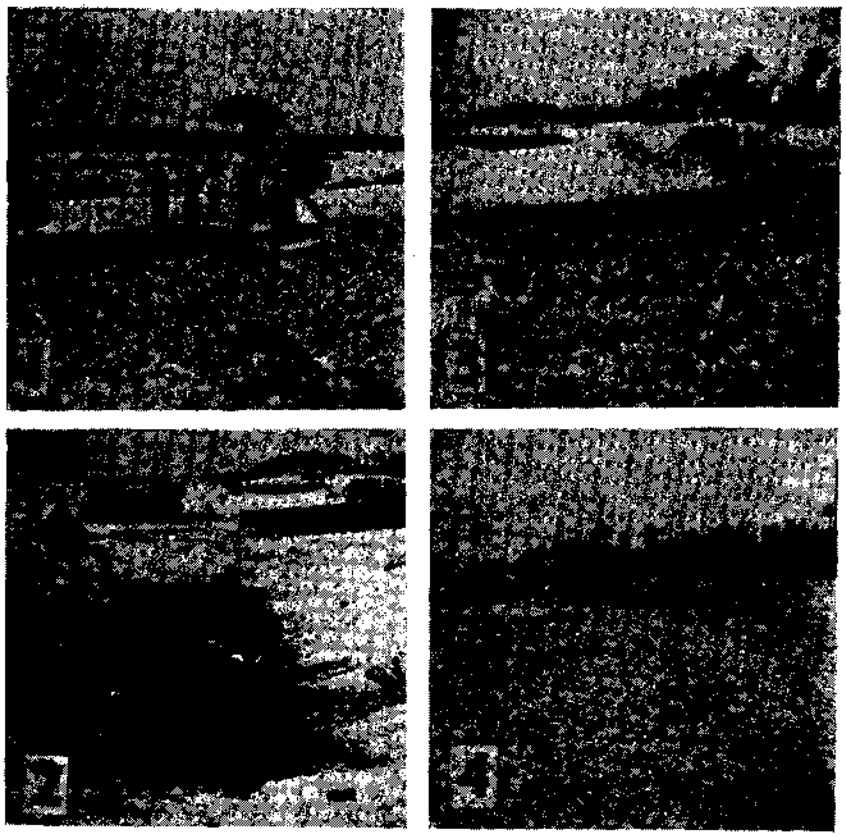

PLATE II. Fig. 1. Oil sardine from *Rampani* being dumped into the pit for preparing manure.

Fig. 2. Crude oil emanating from the pit.

Fig. 3. Manure from the pit spread out for drying.

Fig. 4. Fresh oil sardine spread out for sun drying.

—Photos by courtesy of Mr. M. H. Dhulkhed.

the disappearance of these size groups, the medium sized fish ranging in size from 12 to 15 cm dominate the catches and support the fishery during the peak period which generally extends from September to January after which the fishery dwindles and comes to a close by about April-May coinciding with the summer months. During the period of peak abundance of oil sardine, temperature has been observed to vary from 27° to 29°C and salinity from 33 to 35‰. Divergent views have been expressed on the age and life span of the oil sardine. Some are of the view that the oil sardine attains 15, 17 and 19 cm at the end of 1st, 2nd and 3rd year of its life respectively, while others are of the opinion that it attains 10, 15 and 19 cm respectively at the successive years of its life. Thus, considering the composition of the oil sardine catches during the peak periods in different years, it can be stated that the fishery is dependent to a great extent on the availability of 0-and 1-year old fish in the inshore waters. The present belief that the sardines spawn only once in their lifetime may have to be revised in view of the occurrence of big-sized fish above 17-18 cm with rematuring gonads in November and December. Regarding the spawning behaviour in oil sardine, indications are that it may be protracted over a period extending from July to October or even November. Since individuals in advanced stages of maturity frequent the inshore waters during the commencement of the fishery in July, followed by the entry of juveniles of 4-5 cm in size, the possibility of the spawning grounds being not far away from the coastal region is not ruled out. However, the exact spawning grounds of oil sardine are yet to be located for which a more concerted vigil may have to be kept along the entire coast of Kerala and Mysore and the search for eggs and larvae intensified particularly during the South West Monsoon months.

For the first time in India, an attempt to release oil sardine tagged with opercular plastic tags (see Plate I, Fig. 1) is being made for studying the growth and migration among this species. As pointed out earlier the oil sardine fishery is supported by different size groups (see plate I, Fig. 2) but where from they come and where they go, the route of their migration–whether it is from the offshore to inshore waters or whether they move along the coastal waters from south to north or *vice versa* are certain vital aspects which still remain to be investigated in detail. It is with a view to elucidating information on such important aspects concerning the Indian oil sardine that a programme for tagging this species has been initiated along the west coast of India at four important centres, namely, Karwar, Mangalore, Calicut and Cochin. It is proposed to tag on a large scale oil sardine in different size groups depending upon their availability at the above centres and a beginning has already been made off Narakkal near Cochin. It may be mentioned here that oil sardine tagged on an experimental basis at Mangalore in 1964 and 1965 and released in cages anchored in the open sea had survived for over 8 days without any ill effects whatsoever on them, thus showing that the opercular tags are quite suitable for this species. In order to make this venture a succes, wide publicity is being given through hand bills and posters in different languages and also through press soliciting the co-operation of the public who are also paid for the fish with or tag alone recovered and returned to any of the establishments of the Central Marine Fisheries Research Institute or its survey staff. A good beginning has already been made and the results are being watched with great interest by all concerned in this pioneer attempt in tagging one of the important marine migratory shoaling species in India.

The Indian Mackerel

By G. Venkataraman
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The Indian mackerel *Rastrelliger kanagurta* (Cuvier), forms one of the two commercially important pelagic fisheries of the west coast of India, the other being the oil sardine. On an average 65,342 tonnes of this fish were landed annually during 1958–65 period and in the years 1958 and 1960 the total catch exceeded one lakh tonnes. This fish is widely distributed in the Indo-Pacific areas extending from the African coast north of Durban to the Polynesian group of Islands. Therefore, the problems facing the mackerel fishery are being tackled on an international basis as recommended by the Indo-Pacific Fisheries council.

Valuable knowledge on the fishery and biology of the Indian mackerel have been obtained as a result of the Investigations carried out by the Central Marine Fisheries Research Institute on the west and east coasts of India. Some of the aspects on which information have been obtained relate to annual fluctuations in the fishery, age and rate of growth, spawning habits and environmental conditions. Further investigations along these lines are being continued.

The mackerel fishery along the Indian coast comprises of a single species viz., *Rastrelliger kanagurta* (Cuvier), while one more species, a deep-bodied from *R. brachysoma* (Bleeker), occurs in the Andaman waters. The Indian mackerel is mostly caught on the west coast which accounts for as much as 9% of the total catch. It is fished from Ratnagiri to Cape Comorin on the west coast, but the bulk of the fishery is concentrated between Ratnagiri and Quilon. It appears rather erratically in some parts of the east coast forming local fisheries near Madras, Kakinada, Visakhapatnam and some places off Orissa. In the Mandapam area, the fishing season extends from December to March and the best catches are obtained in January-February.

Even in the region of the main fishery along the west coast, variations are noticed in the total catch landed. The largest catches are usually recorded in the region between Ratnagiri (in Bombay State) and Ponnani (in Kerala State), while only moderate to poor catches are obtained south of Ponnani up to the Cape. The fishery as a whole is in vogue from August to March. While in the Mangalore-Ponnani region the fishery starts early (August-September) and lasts longer (terminating in March-April), in Mangalore-Ratnagiri region it is of shorter duration commencing later (October-November) and terminating earlier (February-March). In the Karwar and S. Kanara coast two peaks are noticed, one at the beginning and the other at the end of the fishing season.

The most common net used in the capture of mackerel along Southern Bombay and Mysore coasts is known as the *Rampani*. It is a shore seine consisting 400 to 600 pieces made of hemp or cotton yarn, joined together and operated by about 80 men with the help of five outrigger boats. In very few other shore seines in the world such large quantities of fish are caught as in the *Rampani* net and in a good fishing season it is not unusual to get in one operation alone over two million fish. One advantage in operating this net is that surplus mackerel can be impounded and kept alive for about a week, so that they can be sold later at favourable prices. Gillnets known locally as *Pattabolae* are also used. The nets commonly employed along the Malabar coast (North Kerala) are boat seines such as *Pattenkolli, Ayila kolli*. and *Paithu vala* and the gillnet, *Ayila cholavala*; both operated from dugout canoes. Further south, boat seines are used from dugout canoes.

It is the juvenile mackerel of size 18 to 22 cm. that contribute most to the commercial catches in the post South West Monsoon months. But during the monsoon months irregular catches of both juvenile and adult mackerel of size range 7 to 24 cm usually occur. Towards the close of the season the fishery is mostly supported by large ones of length 21 – 22 cm.

Mackerel are normally surface feeders feeding both on phyto and zoo-plankton. Correlations between the food of the mackerel and the plankton organisms found in the environment have been noticed and it is felt that one of the causes for the movement of mackerel in dense shoals during the post monsoon months in inshore waters is the availability of plankton in the highest densities during that period. The intensity of feeding varies depending upon the state of maturity of the fish. There seems to be some selectivity in the feeding and some plankters such as *Sagitta*, stomatopods and spionid larvae are avoided. Though some workers have found no difference between the food of the adults and juveniles, some others have observed carnivorous habits in the juveniles.

The spawning season of mackerel along the west coast is a prolonged one. extending from April to September. Observations on the spawing habits of this fish made at Vizhingam near Trivandrum indicated the possibility of two spawning periods, one in November–March and another in May–August. Off the Madras coast, this fish breeds during or after the North–East Monsoon as evidenced by the occurrence of young mackerel in March–April. About the same time this fish is presumed to breed off the Vizag coast also where there are indications that it spawns twice in the spawning season.

Sex differentiation takes place when it is about 12cm and the minimum size at which mackerel matures is 21–22 cm. The ova are released in batches. Observations made at Porto Novo suggest that the spawning takes place at night. Mackerel are believed to spawn in slightly deeper waters outside the usual range of our fishermen, but not far off from the coast. There appears to be good spawning grounds of this fish off Vizhingam and Madras coasts as judged by the occurrence of post larvae and young ones in these two areas.

In regard to age of mackerel, it has been deduced from length frequency studies that the normal modal size of one year old mackerel is 12 to 15 cm and it reaches a length of 21–23 cm at the end of the second year of its life. The determination of the age of mackerel by length frequency analysis is rendered difficult due to the prolonged spawning and recruitment of mackerel broods in batches into the fishery. A view is held that the mackerel grows much faster (2–3 cm per month) while it is young and 10–14 cm fish may actually belong to 0 year class and the fish attains 21-22 cm at the end of first year of its life. Growth checks or rings have been observed in the scales of mackerel of over 23 cm (in some between 22 to 23 cm also) and they have been interpreted as spawning marks. But if the latter view is accepted, these may even be considered as age rings.

Mackerel move in shoals and each shoal comprises of individuals of uniform size. They approach the near shore waters at a time when the salinity and temperature show a rising trend after the minimum values. Though mackerels are pelagic fishes, the possibility of a dispersed and demersal phase in their life history is not ruled out as they have been caught in trawl nets and bottom set gill nets. Observations made on the west coast show that the bigger size groups show high tolerance towards the increase in the temperature and salinity in contrast to the smaller size groups which usually occur in good numbers only at a certain time (June-September) when the salinity values and temperature are low.

The highly fluctuating nature of the mackerel fishery may be seen from the following table wherein figures of annual mackerel landings from 1958–'65 are given.

TABLE

Landings of mackerel during 1958–'65 (in metric tons)

Year	Mackerel	Percentage of Mackerel to total catch
1958	1,23,282	16.31
1959	62,198	10.65
1960	1,33,655	15.22
1961	34,485	5.04
1962	29,103	4.52
1963	76,980	11.74
1964	23,863	2.78
1965	39,169	4.80
Average	65,342	8.90

During this period the mackerel on an average constituted 8.90% of the tatal marine fish catch. The highest catch was in 1960 and the lowest in 1964. An interesting feature noticed during the period was that whenever there was a good mackerel fishery there was correspondingly a good oil sardine fishery. However, a steep rise in the oil sardine catches was noticed during the years when the mackerel fishery failed. Though the reasons for such marked fluctuations cannot be adequately given, some of the factors generally attributed to poor catches are spawning failure resulting in the poor recruitment to the fishery, lack of food and adverse environmental conditions.

During the time of glut due to lack of transport and cold storage facilities, only small part of mackerel catch is consumed in fresh state, the rest being cured either by dry or wet process or pickled according to Colombo method. In the wet process, the required quantity of salt is split up and applied on the fish for three successive days. The cured product is not sun dried, but left moist and soft. Pickling is done by thrusting salt and a small piece of tamarind (called "Gorukapuli" in Malayalam) into the abdomen and the pickled mackerel is mostly exported to Ceylon. Unsold mackerel are beach dried and then converted into manure for use in Cocoanut, Coffee and Tea plantations. Parts like viscera, guts and gills left over from the cleaning of the fish are at times used in the preparation of fishmeal which forms good protein food to cattle and poultry.

A tagging programme has been initiated on the west coast at various Substations and Units of the Central Marine Fisheries Research Institute in order to study the rate of growth, movements and migratory habits of the mackerel. It is hoped that as a result of the investigations that are being carried out, additional knowledge will be gained on the different aspects of the biology and fishery of mackerel which will ultimately lead to a rational exploitation of the fishery.

The Bombay-Duck

By S. V. Bapat
Central Marine Fisheries Research Institute

The Bombay-duck, popularly known as "Bombil" is of great economic importance to the fishermen of the west coast of India, north of Ratnagiri. It is supported by a single species *Harpodon nehereus* (Hamilton). It has a wide and discontinuous distribution along to the coasts of East Africa, Indian subcontinent, Malaya, Indonesia and China. In India it is taken in large quantities on the south and south east coasts of Saurashtra on the Gujarat coast and the Konkan coast of Maharashtra. It is also taken in appreciable quantities on the Andhra-Orissa coast and from the estuaries of Bengal. With the introduction of a programme of mechanisation of the fishing craft under the Five Year Plans, the fishing activity and the area of exploitation along the Maharashtra and Gujarat coasts have considerably increased, resulting in larger landings of Bombay-duck. The fishery today has attained the status of one of the major fisheries of India.

Table showing the Bombay–duck landings in relation to the total ladings of marine fish in India:

Year	Bombay-duck landings (Metric tons)	Percentage of Bombay-duck
1950	14,160	2.44
1951	7,261	1.36
1952	24,646	4.66
1953	45,259	7.73
1954	36,050	6.13
1955	104,113	17.48
1956	128,880	17.93
1957	119,500	13.65
1958	67,188	8.89
1959	57,210	9.79
1960	108,564	12.38
1961	93,844	13.72
1962	83,933	13.02
1963	91,870	14.01
1964	81 342	9.46
1965	73,894	9.06
Average	71,107	10.46

Fishing for Bombay-duck is as varied as its discontinuous distribution. On the west coast the fishing is mainly by fixed bag nets, locally known as "Dol". The mode of fixing and operating the nets slightly varies from region to region along the coast, the principle remaining the same. The nets are lowered and hauled depending on the turn of the tide. They are operated 6–12 miles from the coast at a depth of 20–30 metres. On the Andhra coast fishing is mainly done by boat seines whereas in Orissa fixed bag nets are operated. In the estuaries of Bengal they are caught in the "Behundijal", a fixed type of bag net.

The importance of the Bombay-duck fishery in our economy can be seen from the annual landings from 1950-1965. Till 1952 the percentage of the catch was comparatively low. But from 1953 onwards the catch has been steadily on the increase due to the impetus the fishing industry has been receiving under the developmental programmes. The statistics available so far indicate the maintenance of the fishery at a fairly steady level without indication of any depletion in catches.

The average for the last ten years shows that the Bombay-duck contributes to more than 12% of the total marine fish landings, 90% of this coming from the Maharashtra and Gujarat coasts. Therefore the well being of the fishing community in this area depends to a large extent, on the success or failure of this fishery. Thus the Bombay-duck stands very high in the order of priorities, just as the sardine and the mackerel are to the Kerala and Kanara fisherman. However, the information available on the biology of the species, prior to the initiation of investigations at the Central Marine Fisheries Research Institute was very meagre and was limited to its food habits in Bengal and the spawning periodicity along the Bombay Coast. Hence, with a view to gain full knowledge of the biology of Bombay-duck, the Central Marine Fisheries Research Institute initiated investigations as an essential preliminary in the proper management of this fishery.

The commercial catches of Bombay-duck at Bombay are constituted of fish in the size range of 60–270 mm in total length, specimens above 210 mm being about 18%. As the minimum size at maturity is 210 mm, it can be said that the fishery is mainly supported by immature specimens. The length frequency studies indicate that the fish grows to a length of 127 mm at the end of the first year and reaches a length of 217 mm at the end of the second year. Thus it is seen that the Bombay-duck attains maturity at the end of 2 years. Although continuous recruitment is indicated, the major recruitment to the stocks takes place after the monsoon months during September-December.

The discontinuous distribution of Bombay-duck on the coasts of India raises some doubts as to whether a single stock supports the fishery or more than one stock. Morphometric and meristic studies and their statistical analysis shows that the fishery is supported by three independent stocks. The fishery at Versova and Janjira-Murud on the Maharashtra Coast is supported by a single or closely related stock, whereas the fisheries off Jaffrabad in Gujarat and Masulipatam in Andhra are supported by independent stocks. It has been noticed that greater the distance between two places, the more outstanding are the differences among the characters.

Studies on the "Ponderal index" or the "Condition factor" were made for males and females separately. In the case of the female an inflexion at 210 mm was indicated which coincided with the minimum size at maturity. The values were generally lower in the female, particularly so during the period November–March which incidentally happens to be the peak spawning season. Fecundity studies showed a wide variation in the number of mature ova produced. Fishes 210 mm or so in length and maturing for the first time produce about 20,000 mature ova, whereas in larger specimens within a size range 240–280 mm the number was around, 1,00,000. The females predominate in the commercial fish landings, the sex ratio being 171 females: 100 males. The species breeds almost throughout the year with a peak breeding season extending over a period of four months from November to March. The individual of the species spawn only once in a year.

The fish is a voracious feeder, carnivorous and even cannibalistic in nature. The food mainly consists of fish and prawns, the latter forming the second biggest item. The following species of fish and prawns are common in the diet in order of abundance: *Bregmaceros macclellandi*, *Harpodon nehereus*, *Coilia dussumieri*, *Polynemus heptadactylus*, *Otolithus* spp., *Anchoviella* spp., *Acetes* sp., *Leander* sp., *Parapeneopsis* spp., *Metapenaeus* sp., and *Penaeus* sp. It appears that the Bombay-duck does not have any special preference to a particular type of food and takes any item that comes in its way. The periods of intense feeding and spawning activity appear to coincide to some extent.

The discontinuous distribution of Bombay-duck along the coasts of India has been attributed to various factors, the principal ones being the distribution and movement of various food components, variation of salinity along the coast, the 80°F summer isotherm of July, etc. It is felt that the presence of low surface temperature in the area of occurrence is primarily responsible for the peculiar discontinuous distribution of the species.

Valuable information in regard to various aspects of the biology of the Bombay-duck has been collected by the Central Marine Fisheries Research Institute during the last twenty years of its existence. Ultimately it should be possible to apply the knowledge gained as a result of the investigations carried out here to obtain a maximum sustained yield for the fishery.

Oceanic Fisheries

By E. G. Silas
Central Marine Fisheries Research Institute

Introduction

India is passing through a very critical period of food crisis and consequently the necessity of exploring various fields of natural resources to augment present production weighs heavily in the minds of our Planners. The situation calls for a more rapid transition from the present stage to a more dynamic practical stage in all facets of agricultural development and this applies equally to the utilisation of renewable protein resources of the ocean—in short, the marine fisheries. The oceanic fishery resources of our high seas and the Indian Ocean at large have been well recognised by other countries, notably Japan which is at present engaged in large scale fishing for tunas and related fishes, and billfishes (marlins, spearfishes, sailfish, and swordfish) throughout the length and breadth of the Indian Ocean. Even fishing boats from Taiwan are operating in the Eastern Indian Ocean and more than once have they been apprehended in our territorial waters in the Andaman Nicobar Islands. Russian vessels have started operating in the western section of the Indian Ocean from the Black Sea ports. Of the countries bordering the Indian Ocean, Australia and the Union of South Africa are rapidly developing their oceanic fisheries. India though favourably situated has yet to make a beginning in this field on a commercial scale as we have not ventured beyond our traditional fishing grounds lying mostly within fifteen kilometres off our coastline. With the advent of highly efficient technical aids in fish finding and better fishing craft and gear, each passing year is witnessing tremendous advance both in exploration and exploitation of oceanic fishery resources. Our present and future needs, and the experience gained from other countries successfully tapping this latent resource in the Indian Ocean and other Oceans should give us the impetus to rapidly enter into this new but necessary phase of our commercial fishery development.

Methods of Fishing

As in every other fishery, practical experience has helped considerably in the evolution of fishing craft and gear used in oceanic fisheries and a brief report of the different methods employed seems appropriate.

1. *Pole-and-line fishery with live bait*: This method is used in the traditional tuna fishery in the Laccadive and Maldive Islands as in few other areas in the Pacific. Fluctuations in the availability and abundance of suitable live bait affect the fishery as we have witnessed in the tuna fishery in Minicoy Island. The skipjack (*Katswonus pelamis*) and the yellowfin tuna (*Thunnus albacares*) are caught, but the fishery touches mainly the smaller size groups as young tuna tend to shoal at the surface more frequently and are easily chummed with live bait.

2. *Long line fishing*: The gear has been evolved by the Japanese with due consideration given to the habits of the fish, especially its swimming layer, as larger size groups which generally keep to depths are caught with this gear. However, the gear fishes in addition to tunas and billfishes, sharks which abound when long lining is done close to the continental shelf or in the vicinity of islands. Besides stray catches of baracuda, wahoo, etc., lancet fishes (*Alepisaurus*) regularly figure in the catches. The details of this gear are well documented and the Japanese generally use between 2000 and 2500 hooks per operation with a schedule of 20 hours or more of working per operation if the catch is good. As much as 50 nautical miles of lines will be set for such an operation and the hooks will be fishing at different depths from about 75 to 200 metres depending upon the length of the main line, floatline and dropper, the distance between buoys and the prevalent currents.

3. *Purse seining for tunas:* The importance purse seining for tunas has gained in the last few years can be seen from the fact that the California tuna 'clipper' fleet engaged earlier exclusively in pole-and-line fishery has taken to purse seine gear. The adoption of all nylon seine; the help of Puretic 'powerblock' to increase the handling speed of the net; the use of aircraft to scout for shoals; and an understanding of favourable oceanographic conditions influencing the availability of fish have all helped towards making purse seining for tunas a success and as McNeely (1961 *Pacific Fisherman*, 59 (7): 27–58) and others foresee, this gear will have a profound effect on oceanic fisheries throughout the world.

Surface trolling, gillnets, traps, handlines, and beach seines are also used for capturing tunas in small quantities.

Development of Japanese Tuna Fishery in the Indian Ocean

After World War II, Japanese long liners first restarted operating in the South Eastern Indian Ocean south of Java late in 1952 and by 1954 they had extended the area of operation to 75°E long. and by the end of 1955 were fishing throughout the Indian Ocean from 40°E to 130°E longitude Twelve years of tuna long lining in the Indian Ocean by the Japanese have shown that the high hooked rates obtained in the initial years when grounds were first exploited tended to gradually drop year by year, the bimodal size of the principal catch also becoming smaller year after year. The decrease of the large yellowfin tuna 130 cm and more in fork length is presumed to be within the bounds of possibility that is caused by the influence of fishing, while the fluctuations in the abundance of smaller size groups are considered to be due to natural causes. Unlike the bigeye tuna (*Thunnus obesus mebachi*), the yellowfin tuna especially the larger ones appear to be localised in distribution. Large scale fishing of the 'indomaguro' (*Thunnus maccoyii* of Australia) is carried out from two centres in the Eastern Indian Ocean by Japan and recently by Australia, the first 10°S to 17°S and 113°E to 120°E and the second 20°S to 30° S and 100°E to 110°E. Based on length/weight and gonad weight of the fish caught, it is suspected that although the fish in both the areas may belong to the same population, two spawning groups may exist.

The albacore (*Thunnus alalunga*), the most sought after species by the tuna long liners has a wide-spread distribution south of equator, though two fishing grounds for the albacore were detected by the Japanese, one along the equator (from April to September) and the other south of 8°S (from January to March).

None of the billfishes are so abundantly caught as tunas in the long line. However, the blue marlin (*Tetrapturus audax*), the striped marlin (*Makaira nigrescens*) and the black marlin (*Makaira indica*) are more frequently caught than the sailfish (*Istiophorus gladius*), the short-nosed spearfish (*Tetrapturus angustirostris*) and the swordfish (*Xiphias gladius*).

Tuna Longlining From The U. S. Research Vessel *ANTON BRUUN* In The Indian Ocean

One of the outstanding features of the International Indian Ocean Expedition was the two cruises undertaken by R. V. *ANTON BRUUN* for tuna longlining, in one of which (Vth Cruise) the writer also participated. Very useful information on problems relating to spatial and depth distribution of the various oceanic species of tunas and billfishes;

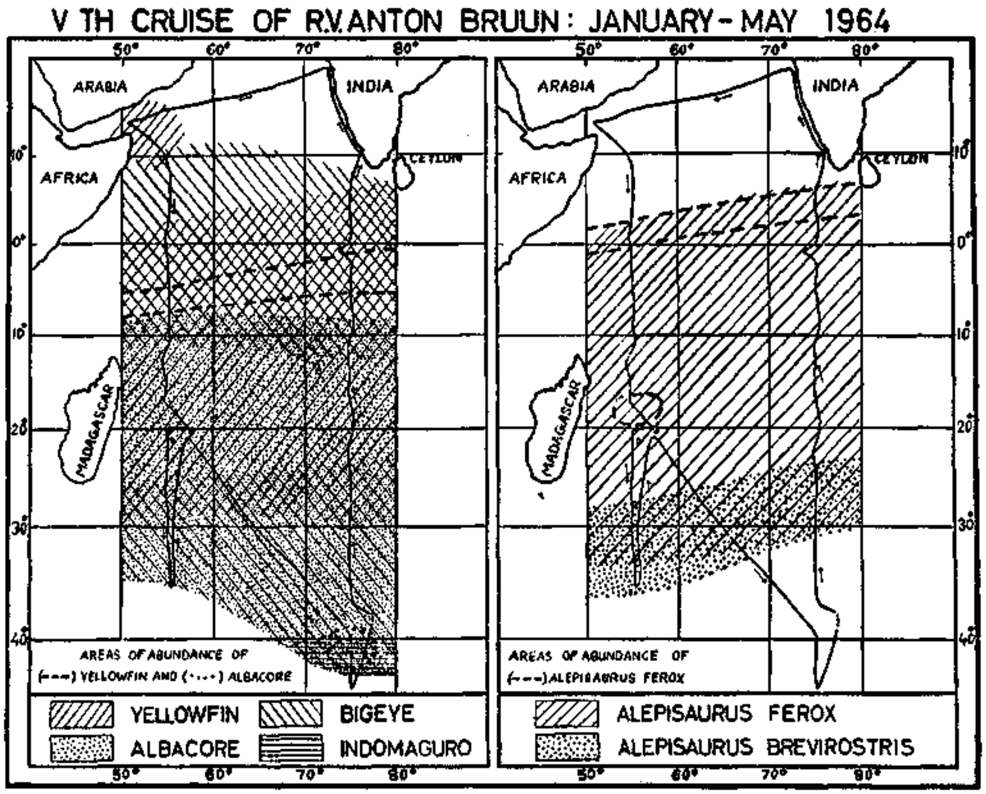

Fig. 1. Maps showing the distribution and areas of abundance of four major species of tunas and two species of lancet fishes based on longline catches obtained during the Vth Cruise of R. V. *ANTON BRUUN* in the Indian Ocean.

many aspects of the biology such as size, maturity, food, sex ratio, reproduction, spawning grounds, etc., behaviour of the fish, specially shoaling as seen from the distribution of the fish caught in the lines; and associated fishes in the eco-system were obtained. It will not be out of place to mention here that very good fishing grounds for the albacore and the bluefin (indomaguro) were discovered in the southern Indian Ocean in southern latitudes in the zone between the Polar Front and the Subtropical convergence around 42°S and 75°E. In the accompanying figure (Text-figure 1), I have shown the distribution of tunas and lancet fishes in part of the Indian Ocean investigated during the Vth Cruise of R. V. *ANTON BRUUN* between January and April end 1964. Inverse relationship in the abundance in the catch of tunas, especially yellowfin and the albacore on the one hand and lancet fishes on the other has been evident apparently as they compete for food. As we found, pelagic sharks, especially the whitetip shark, the silky shark, the great blue shark, the thresher shark, and the mako shark also play an important role in tuna longlining as they cause considerable damage to the hooked fish (plate I, fig. B). The lesser toothed whales such as the Killer whale also cause damage to tuna caught in long lines. Serological studies based on samples of tunas and other fishes collected during the cruise will give us useful information on subpopulations of pelagic fishes in the Indian Ocean.

TUNA ECOLOGY

The success of oceanic fisheries depends to a large measure on our understanding of the chain of events affecting the environment of the fish from meteorological conditions, the ocean currents, primary production, secondary production to the fishable stock of fish. The marine environment is so complex and diversified that an area which has proved very productive may not yield good catches during some years and only investigations over a period of time will help us understand such vagaries. Some of the problems connected with oceanic fisheries are of such magnitude that they call for international co-operation as well as co-operation between organizations dealing with different branches of marine sciences. The success of such ventures in the results obtained through the efforts of The Inter-American Tropical Tuna Commission, The Pacific Oceanic Fisheries Investigations, The California Co-operative Fisheries Investigations and the Nankai Regional Fisheries Research Laboratory programmes, are now well known. To tackle many problems of oceanic fisheries such as tuna ecology and to obtain quicker results which could be made use of by the fishing fleets in the Indian Ocean, international co-operation will be necessary. The role of the environment in oceanic fisheries is well understood by Japanese tuna fishermen who collect extensive data on temperature and salinity in all places where longlining is carried out. Much of what little we know about the ecology of tunas and other pelagic fishes in the Indian Ocean we owe to the Japanese and some of their more significant findings are pertinent in this connection.

The bluefin tuna (indomaguro) occurs in the Frontal zones with greatest concentrations in the cold water pockets in this zone and show seasonal north and south migration with the zones. The yellowfin tuna is more abundantly distributed in the offshore areas and in the vicinity and on boundaries of the equatorial current system and their vertical distribution is nearer to the surface as compared to the bigeye tuna, the spatial distribution of which corresponds with that of the yellowfin tuna. Like the bluefin tuna the albacore prefers temperate waters occurring chiefly in offshore waters and shows seasonal north-south migrations from the Polar Fronts. High surface temperature gradients where the optimum temperature zones are narrow are preferred places of concentration for the albacore as well as the bluefin tuna. They also tend to aggregate on boundaries of cold and warm eddies and cold and warm water intrusions. The thermocline ridges are also preferred places of aggregation due to the concentration of abundant food. The skipjack occurs just off coastal areas and on current boundaries.

Although temperature by itself may not vitally affect the behaviour of tunas, it is an easy indicator of good fishing grounds. The surface temperature in the tropics is fairly uniform throughout the year and localised differences may point to areas of slow upwelling, current boundaries, etc. The mixing zones of areas of convergence and divergence in the current system where forage will be abundant are also places where tunas will tend to congregate. The optimum current for good tuna fishing has been found to be 0.5 to 1.0 knots. Areas such as oceanic islands, sea mounts and continental slopes with higher bottom topography are also good tuna fishing grounds as they affect the surface currents and internal waves giving rise to eddies, rise in the thermocline level, etc.

The biotic part of the tuna food chain is least known. The data obtained by the various expeditions which investigated the Indian Ocean during the last five years should give us a better picture of areas of high productivity, relationships between abundance of phytoplankton, zooplankton and micronekton and possibly abundance of tuna forage.

Tagging of tunas and billfishes for understanding their growth and migrations; serological investigations to delimit subpopulations; and behaviour studies should also be given priorities in any oceanic fisheries research programme.

Oceanic Fisheries Investigations At The Central Marine Fisheries Research Institute

Investigations on tunas and billfishes were initiated chiefly through individual efforts towards the end of the last decade when two species of the genus *Auxis* were recorded from off the west coast of India. From this humble beginning, the subsequent growth of the work at the Institute relating to tunas and billfishes may be summarised as follows.

For the first time, a comprehensive review of the scombroid fishes of the Indian Ocean was made. The Indo-Norwegian Project fishing vessel *KALAVA* was the Institute's first 'Research Vessel' and investigations carried out with this vessel in the Laccadive Sea and off the west coast of India resulted in a detailed study of the tuna fishing industry in Minicoy Island and for the first time the larvae of tunas and billfishes were described from the plankton of this area. Later, regular observations on tuna fisheries in Minicoy Island were initiated which have resulted in the accumulation of very useful data on the food and feeding habits of the skipjack and the yellowfin tuna; fecundity of the skipjack in the Minicoy waters; livebait resources of the Laccadive Sea; seasonal fluctuations in the abundance of livebait fish in Minicoy; and the introduction of *Tilapia mossambica* as a tuna livebait in the Laccadives.

In our coastal waters, a survey of the troll fishery for tunas and billfishes in the Gulf of Mannar was carried out. The fishery and aspects of the biology of the oriental bonito (*Sarda orientalis*) and the little tunny (*Euthynnus a. affinis*) which form minor fishery along the south west coast of India were investigated.

For the first time a comprehensive review of the helminth and copepod parasites of scombroid fishes was carried out.

Exploratory fishing and planktological investigations carried out from the Indo-Norwegian Project Research Vessel *VARUNA* off the south west coast of India and the Laccadive Sea have confirmed that the skipjack, yellowfin tuna, little tunny, oriental bonito, and frigate mackerels spawn in this area, the peak period being February—March and May—June. Larvae and stray catches of early juveniles of billfishes have been obtained in the course of these investigations.

^{14}C experiments conducted in tuna fishing grounds in the Laccadive Sea point to high organic productivity.

Over 3500 'oceanographic stations' have been occupied during the cruises of R. V. *VARUNA*. Fluctuations in the thermocline levels; areas and seasons of upwelling; convergence and divergence zones of the south west coast of India and south east of Minicoy are but a few of the findings relevant to our oceanic fisheries. These investigations which are being continued should make the waters off the south west coast of India one of the best understood in the region of the Indian Ocean and be basic to any future studies in other parts of the Indian Seas and its resources.

Conclusion

The steady growth of oceanic fisheries of the world may be seen from the following gleaned from the FAO Year Book of Fishery Statistics for the year 1964. The landings are in thousand metric tons.

	1948	1957	1964
Tunas and related species	390	920	1,310
Billfishes (excluding swordfish)	7	41	77
Swordfish	4	18	34
Total	401	979	1,421

The same report also indicates that the Indian Ocean and adjacent areas accounted in 1964 for only 4% of the world's total fish landings of 51.6 million metric tons, the Atlantic and adjacent seas and the Pacific ocean and adjacent seas accounting for 35% and

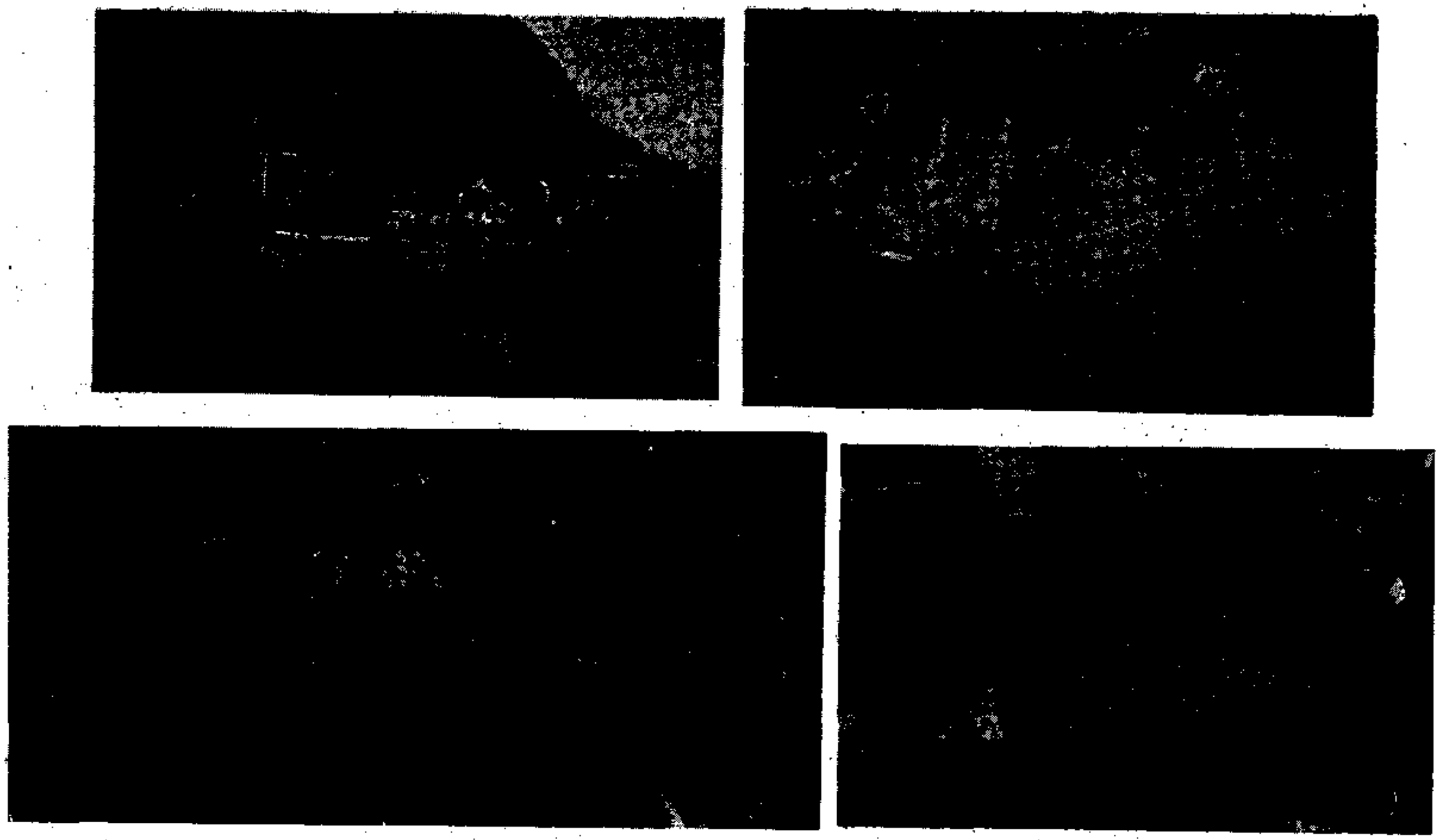

PLATE 1: A. Japanese tuna longliners and factory ships at Port Louis, Mauritius; B. Shark damaged bigeye tuna; C. Striped marlin (*Tetrapturus audax*); D. Part of longline catch of tuna (*bluefin*) on deck of R. V. *ANTON BRUUN*. (All photographs were taken by the author during the Vth Cruise of R. V. *ANTON BRUUN* in the Indian Ocean.

49% respectively and the rest being made up of landings from inland waters. These figures clearly indicate that the fishery resources of the Indian Ocean are under exploited and some even untouched. As for oceanic fisheries resources, this is glaringly evident when we look at the area of the three major oceans (Data after Sverdrup *et. al.* 1942. The Oceans, its Physics, Chemistry and General Biology) and the landings of tunas:

	Pacific Ocean	Atlantic Ocean	Indian Ocean
Area in Km^2	165,246,000	82,441,000	73,443,000
Landings of tuna for 1964 (Metric tons)	@ 840,000	@ 257,000	@ 150,000

Assuming that the environmental conditions in the Atlantic and the Pacific Oceans, being more or less similar as far as tunas are concerned, Shomura (1966: *Comm. Fish. Rev.*, 28 (5): 1-11) opines that the Atlantic being approximately 50% the size of Pacific Ocean, we may assume that the potential yield of the resource could be 50% of the yield of the Pacific. This criteria cannot be strictly applied to estimate the fishery resources of the Indian Ocean as its northern half is greatly restricted in area, though the Ocean itself is about 44% of the area of the Pacific Ocean. Except for the yellowfin tuna in the Eastern Tropical Pacific the landings of the other species of tunas in the Pacific as a whole have been less than the maximum sustainable yield of the Pacific stocks and as such the scope for still further expansion of the fisheries is indicated. In the Indian Ocean, the yellowfin tuna and the bigeye tuna constitute the bulk of the tuna catch, but it is unlikely that they are over exploited, though in some areas intensive fishing is being carried on. Considering these it may not be wrong to assume an eventual increase in tuna and billfish landings in the Indian Ocean to at least three times the present level to reach the maximum sustainable yield. The demand for tunas in the world market is so great that there will be considerable scope for exporting the catch either as frozen or canned products. Thus as tunas and billfishes constitute the most potentially important groups of oceanic fishes of the Indian Ocean and as the outlook for the future is bright, every effort should be made to catch up in this field of fisheries development where we have lagged thus far.

The Ribbon Fishes

By P. S. B. R. James
Central Marine Fisheries Research Institute

The ribbon-fishes, also called the hair-tails or cutlass fishes elsewhere, occupy an important place among the food fishes of India. They are abundant and cheap and as such are also preferred by poor people. Large fishes are consumed fresh and transported to the interior markets but the smaller ones in excess of the local requirements are usually sun dried on the beach. Their non-fatty nature and robbin-like bodies make them suitable for rapid preservation by sun drying. Thus, during times of glut, large quantities of the cured fish become available which ultimately find their way to interior markets at reasonably low price.

The ribbon-fishes belong to the family Trichiuridae and are represented in Indian waters by four species namely, *Trichiurus lepturus*, *Lepturacanthus savala*, *Eupleurogrammus intermedius* and *E. muticus*, the first named species being the most dominant. All of them are characterised by their ribbon-like body, prominent canine-like teeth, lack of tail fin and the silvery colouration. Ribbon-fishes are essentially marine, also found in the estuaries and occasionally straying above the tidal zone. While *T. lepturus* is found both in the Atlantic and the Indo-pacific, the other three species are essentially Indo-Pacific in distribution.

They are widely distributed along the Indian coast, one or more species contributing to the fishery at any particular place. They are especially abundant along the coasts of Andhra Pradesh, Madras and Kerala States where they are called *Savallu*, *Savalai* and *Vala* respectively in vernacular. The fishery is seasonal, from about July to March, the peak periods of occurrence varying from place to place, year to year and depending of-course, on the species concerned. Particulars of the ribbon-fish catches in India during the past six years (1960–1965) are given in Table I.

Table I

Particulars of ribbon-fish catches in India and their percentage in total catch from 1960 to 1965

Year	Total ribbon-fish catch (tonnes)	Percentage of ribbon-fish in total catch
1960	17,467	1.98
1961	19,515	2.85
1962	20,586	3.19
1963	16,452	2.50
1964	25,891	3.01
1965	41,298	5.06

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The maximum size attained by the ribbon-fishes varies according to the species. Reports indicate that *T. lepturus* grows to about 5 ft. in length. Although actual records of such length for this species are not available, fish measuring over a metre are not uncommon in India. Other species appear to attain only smaller lengths than this. *T. lepturus* is known to attain 18, 30, 46 and 54 cm at the end of first to fourth year respectively. The large individuals measuring 100 cm or more must evidently belong to a higher age-group and hence the life span must be more than four years. In contrast to this, *E. intermedius* grows to 21, 33 and 43 cm at the end of first, second and third year respectively. The availability of fish above 43 cm indicates that the life span of this species may be atleast four years. From the sizes recorded so far (*L. savala*, 80.0 cm; *E. muticus*, 58.4 cm) the other two species may also have a life span of atleast four years, if not more, as two of the species studied in detail show identical growth trends and since all the four species were found to have similar habits of life.

The breeding grounds of ribbon-fishes appear to be outside the usual fishing grounds. Ripe fishes, eggs, early embryonic stages and larval forms are not very common in inshore waters. While one of them (*T. lepturus*) is known to spawn only once a year in June, the other three species seem to spawn more than once as mature and spent fish and young ones appear more than once a year. These observations are also supported by the studies on the intra-ovarian eggs of these three species. The size at first maturity for *T. lepturus* is 47–48 cm (three years old) whereas *E. intermedius* begins to spawn for the first time at 30 cm when it is about two years old. As many as 18 thousand eggs are produced by an individual ribbon-fish, the actual number depending on the species and the number of times it spawns. According to available information, the eggs of ribbon-fishes are transparent, pelagic and range in size from 1.70–2.45 mm; newly hatched larval measure from 4.4–6.6 mm. While the sex ratio is not constant throughout the year, atleast in the case of two of the species studied in detail (*T. lepturus* and *E. intermedius*), females appear to be dominant in the commercial catches.

All the four species of ribbon-fishes are highly carnivorous and predominantly piscivorous. They are voracious feeders, feeding both during day and night. The most important items of food include a variety of small fishes (mostly of the anchovy type, e. g., (*Anchoviella*), prawns and shrimps (e. g., *Acetes*). Their predation on other economically important fishes and prawns is noteworthy. Although the ribbon-fishes exhibit some preference for the above items, in their absence they feed on a variety of others which are abundant in the environment. Instance of 'cannibalism' have also been recorded where their own kind are devoured. It is however, difficult to say whether it is intentional or accidental. Fish below 25 cm usually feed on smaller fishes and crustaceans but as they grow, they begin to add to their diet a greater variety of big fishes and prawns. The teeth and other oral structures of ribbon-fishes are suitable to hold the prey, bite and devour the same easily. Cestode and copepod parasites are sometimes found in the body cavity and mouth respectively of large ribbon-fishes.

Ribbon-fishes are essentially shoaling type of fishes, large schools entering the inshore fishing areas, often very close to the shore when enormous quantities of these are caught in various types of seine nets. Such large scale migrations are common with the predominant species, *T. lepturus* around the peninsula during August to October, the shoals normally composed of spent fish. Once the shoal and its directional movements are detected at one place, fishermen at all the other places keep alert and fish large quantities on the following days. The shoals have been noticed to disappear as quickly as they appear. It is possible that shoaling in this species is related to spawning. It is significant that although more than one species may contribute to the fishery at any one place, in such migrations the shoal consists purely of one species only. The size range of fish on such occasions is limited, from about 50 to 75 cm.

Generally, the ribbon-fish fishery along the Indian coast is mainly supported by *T. lepturus* except at places where it is not common. The commercial size range for this species varies from about 16 to 80 cm, the dominant size groups again differing from place to place and year to year. Therefore, the fishery is contributed to by all the age-groups of the fish. Hence the magnitude of the fishery in any year is dependent on the degree of dominance of one or more of the age-groups in that year. If the higher age-groups are dominant, the catches are expected to be better than in years when lower age groups are dominant. In the case of *E. intermedius* the commercial size range varies from 14 to 35 cm, the fishery contributed to mainly by the first and second year-class fish and partly by the third year-class. As in the above mentioned species, the magnitude of the fishery depends on the dominant age-group during the year. Generally, the other two species, *L. savala* anh *E. muticus* appear to contribute to the ribbon-fish fishery more substantially in the northern latitudes than in the southern latitudes. The commercial size ranges for these species also seem to be about 25 to 75 cm but more details are necessary as to their biology and actual extent of contribution to the fishery especially the age structure of commercial catches before any thing conclusive can be said about them. At several places where a regular seasonal ribbon-fish fishery exists, during the months of peak catches the ribbon-fish catch may amount to as much as 60 per cent of the total catch and average for the year may reach a maximum of 25 per cent.

The principal gear for these fishes are the seine nets operated from the shore (shore seine—*Karai valai* or *Peria valai* in Tamil) and the boat or catamaran (Pl. I, fig. 1) (boat seine or bag net—*Madi valai* or *Thuri valai* in Tamil). They are occasionally caught in otter trawl nets and in the gill nets. It is only rarely that they are caught on hook and line. The usual depth range varies from three to six metres but are often caught from depths up to 30 metres.

In addition to sun drying (Pl. I, Figs. 7, 8), during seasons of abundance, these fishes are salt cured. The simplest way is to keep the fish for a day in salt solution and then dry them in the sun on the beach. Sometimes salt is sprayed over layers of fish heaped on palmyra leaf mats (Pl. I. fig 2). The heaps are left in that condition for at least four or five hours. Then the heaps are turned, more salt is added and the fish muscle is slit laterally in several longitudinal lines for better penetration of salt and easy preservation. Next day the fishes are washed thoroughly in water kept in cement tanks and then dried in sun (Pl. I, figs. 3, 4). Another way is to keep the salted fish with intermediate layers of salt in rectangular

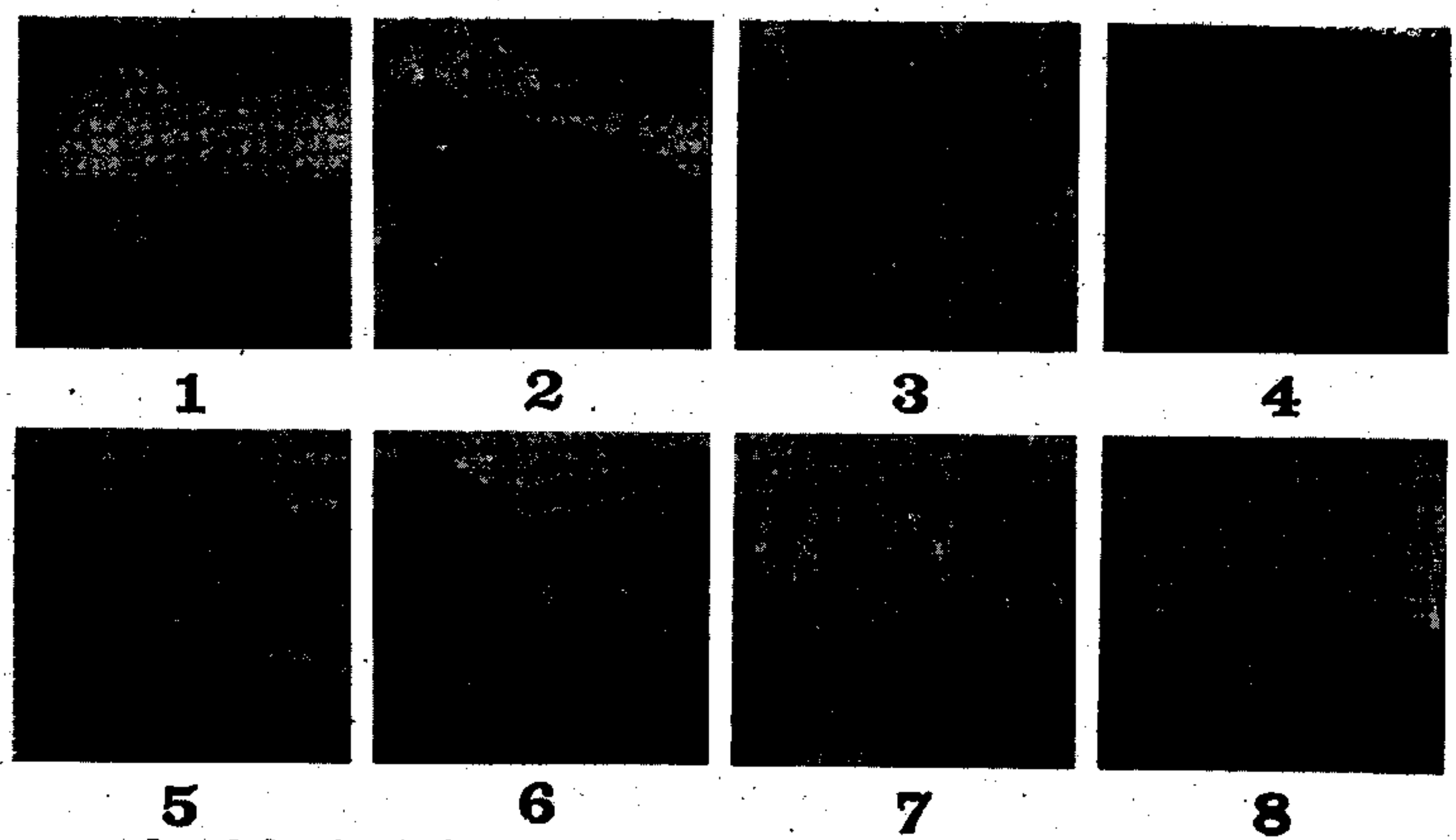

PLATE I. One of a pair of catamarans from which bag net is operated. 2. A heap of ribbon-fishes with intermediate layers of salt during the process of salt curing. 3. and 4. Washing and sun drying the salted ribbon-fishes. 5. and 6. Packing the cured ribbon-fishes. 7. and 8. Sorting of ribbon-fishes and their sun-drying on specially erected wooden frames along the Bombay coast.

cement tanks and press them down with feet. The third day the cured fishes are taken out, washed and packed with alternating layers of salt (Pl. I, figs. 5, 6). This method is employed only when there is a special market for this product.

At various places along the east and west coasts of India (in Andhra Pradesh, Madras and Maharashtra States) ribbon-fishes are also used as an effective bait for bigger fishes especially those caught on hook and line. Seer, tuna, jack, eels, cat fishes and jew fishes are some of the fishes commonly caught with this bait.

Apart from local consumption both in the fresh and cured states, considerable quantities of the cured products are exported to neighbouring countries like Ceylon and Malaysia where they are said to have a good market.

The Flatfishes

By K. V. Narayana Rao
Central Marine Fisheries Research Institute

Among the food fishes which contribute to the marine fish production in India, flatfishes constitute an important element in the ground fish resources which, until recent years, could not be exploited adequately due to the lack of suitable gear. The indigenous gear that are employed in the fishery for flatfishes are not quite efficient to capture them from the bottom; and are able to capture only when these fishes shoal in the surface and subsurface waters in the inshore area. Inspite of these drawbacks, the fishery produces an estimated average annual catch of 9,913 tonnes. There is a great possibility of increasing the production of flatfishes from the present level.

The flatfishes comprising halibuts, flounders and soles are bottom fishes and are characterised by assymetry, for in the adults the eyes lie either on the right or on the left side of the head. These fishes are closely related to perch-like fishes and have a remarkable capacity to change the colour of their body to match with the surroundings. Most flatfishes live in moderate depth. Some of them extend to deep water; while a few live close to inshore and even in estuaries. They are predaceous and carnivorous feeding on small fishes, worms, molluscs and crustaceans. They are prolific breeders. Most flatfishes are small; while a few attain large size. Some of the species are greatly esteemed for their delicate and flavoured flesh. They are cheap and are within the easy reach of the low income people.

Flatfishes are well represented in our waters. Most of these, however, are not commercially important. The only species of commercial importance, at present, is the Malabar Sole, *Cynoglossus semifasciatus*, comparatively a small sized species. It grows to a maximum size of 18 cm (about 7"). The dominant size in the fishery, however, varies from 10-13 cm (4-5") only. Other larger species viz., *Cynoglossus dubius*, *C. puncticeps*, *C. lida* and *C. bilineatus* are also caught in the fishery in small quantities. In recent years the Indian Halibut, *Psettodes erumei*, is being taken frequently from the trawling grounds off Bombay and Saurashtra area. Many of these species are represented on the East Coast also; but are not important commercially (Plate - I).

The Malabar Sole, *Cynoglossus semifasciatus*, supports a rich seasonal fishery on the West Coast of India. On this coast it is important next only to the oil sardine, mackerel and shrimp fisheries in the magnitude of catches. Due to its great economic importance this species has been studied in detail at the Institute.

The region between Moolki in South Kanara and Quilon in Kerala is important for the sole fishery. The heaviest landings, however, are confined to the region between

Edakad and Kadapuram on the Malabar Coast. Soles are popularly called *Manthal* on the Malabar Coast; while they go by the name *Nangu* in the South Kanara region.

The season for the sole fishery starts by late August or early September and extends upto November. One of the characteristic features of the sole fishery is that the bulk of the seasonal catch is obtained within a short period at the commencement of the season. The data given in the following table would illustrate this fact.

Quarterly landings of soles at Calicut during 1960—61 season

Quarter	Landings (tonnes)	Divergence from quarterly men
April—June	9.3	−120.7
July—September	484.5	+354.5
October—December	24.6	—105.4
January—March	1.6*	—128.4
Average	130.0	

*Approximate.

It is obvious from the above data that the peak landings are obtained in the second quarter. From the divergence of the catches during different quarters from the quarterly mean it is instructive that there is a sudden increase in catches during the second quarter and an equally sudden decrease thereafter. Out of the estimated total landings of 484.5 tonnes during the second quarter, the entire catch was obtained in September alone. This sudden increase and decrease in the sole landings is typical of the fishery all along the coast and is connected with the large scale shoaling of the species in the surface and subsurface waters of the inshore area in enormous numbers. This phenomenon is known to the fishermen as *Manthayilakom* and is taken advantage of by them in the large scale capture by employing boat seines (*Thattum Vala* and *Paithu Vala*), Cast-Nets (*Veechu Vala*) and Shore Seines (*Noona Vala*). The range of the fishing operations is limited to 7 fathom (12.8 metres) area. One can well imagine as to what would happen to this rich restricted seasonal fishery, apart from other causes, if the large scale shoaling of fish in the inshore area is not detected right in time or it occurs at a distance or depth which cannot be reached or fished effectively with the gear presently employed in the fishery.

Since the major portion of the sole catch is obtained within a short period at the commencement of the season; the disposal of the catch, sometimes, becomes unmanageable. Consequently some of the sole catch is diverted for use as manure. A small fraction of the seasonal catch is consumed in fresh condition as it finds favour only with the poorer section of the community. Most of the sole catch, however, is exclusively cured by salting and sundrying (Plate-II). The cured fish is exported to the interior places where it finds ready market.

The sole fishery is subjected to both annual and long-term fluctuations which is evident from the following data compiled by the Central Marine Fisheries Research Iustitute.

Sole landings in India during the decade from 1956 to 1965

Year	Landings (tonnes)	Divergence from annual average
1956	9,122	— 761
1957	3,687	— 6,226
1958	12,856	+ 2,943
1959	10,360	+ 447
1960	14,107	+ 4,194
1961	7,730	— 2,184
1962	17,644	+ 7,731
1963	8,781	— 1,132
1964	6,146	— 3,767
1965	8,693	— 1,220
Average...	9,913	

The magnitude of the sole landings, as could be judged from the above table, varies from year to year. During the decade the best catch was recorded in 1962 season, while the fishery in 1957 was least productive. The average annual catch of soles, for the ten year period, works out to 9,913 tonnes which is about 1.33% of the total marine fish production in India during the period. The divergence of the annual landings from the average annual catch during the decade shows that the sole landings during the years 1958, 1959, 1960 and 1962 are above average; while during the remaining years they are much below average.

The studies on the rate of growth and age of the Malabar Sole by means of its scales and length frequency distribution have shown that the species grows to a size of 10–12 cm during the first year and to about 14–16 cm by the end of second year of its life. The peak fishery is supported exclusively by the one-year olds; the older individuals being negligible in proportion. In other words the products of a spawing season grow to the adult size and directly enter the fishery in the following season. The strength of juveniles in one season, therefore, determines the number of adult fish available for capture during the next season. Thus it appears that the large scale fluctuations of the sole fishery, to a large extent, are related to the success of the spawning and the recruitment of the young fish into the fishery.

The peak fishery is based on potential spawners. By September when the large scale shoaling occurs in the inshore waters, soles in a large majority (75–80%) are already fully mature. The species spawns, for the first time, at the end of first year of its growth, attaining an average length of 11 cm. A single fish having a lengh of 15.5 cm produces, on an average, an estimated number of 55 thousand eggs. The breeding season is

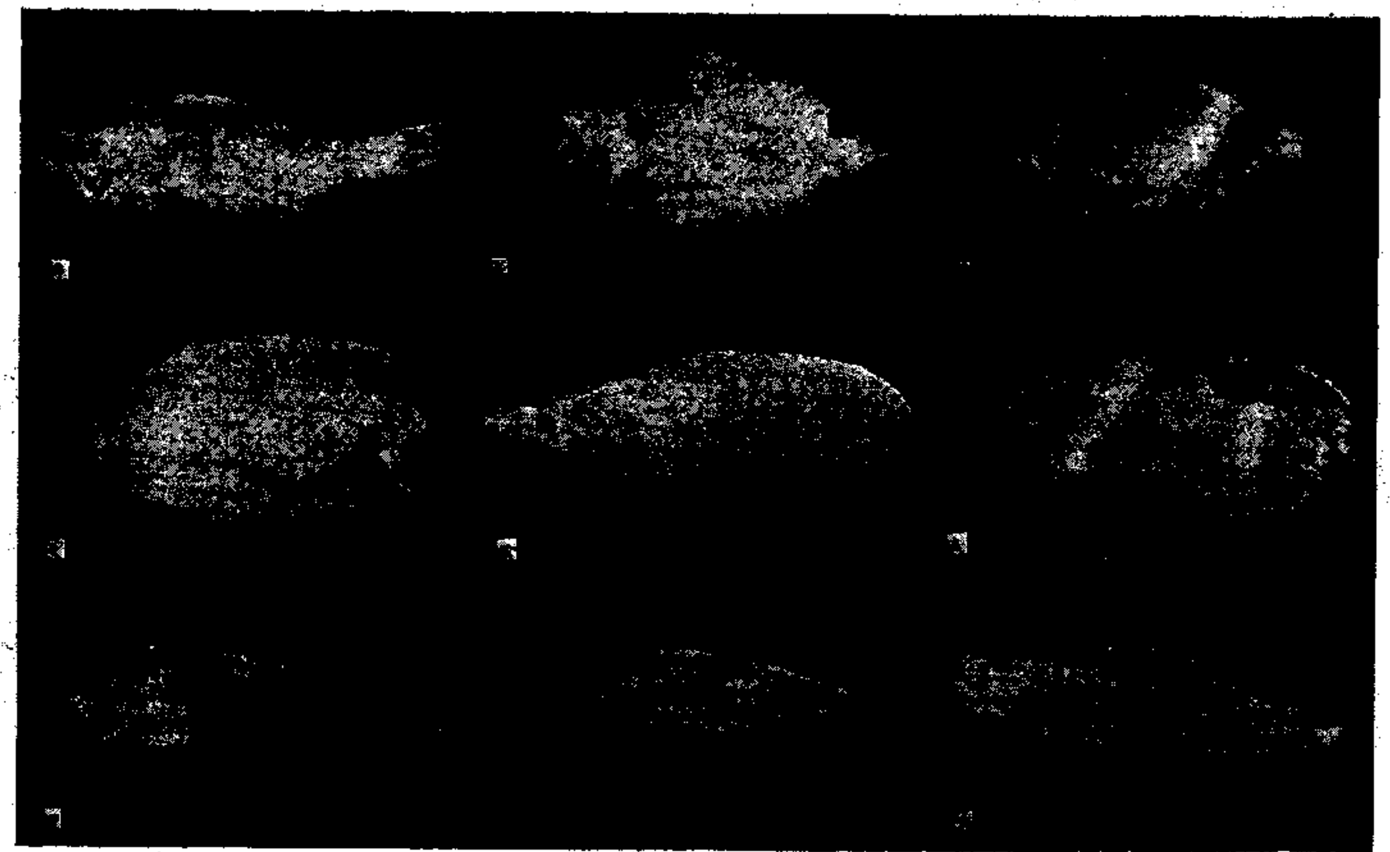

PLATE – I. Some representative species of the Indian Flatfishes: 1. Indian Halibut (*Psettodes erumei*) 16.7 cm; 2. Large-Toothed Flounder (*Pseudorhombus arsius*) 25.6 cm; 3. Javanese Flounder (*P. javanicus*) 12.1 cm; 4. Ovate Sole (*Solea ovata*) 10.0 cm; 5. Eyed Sole (*Heteromycteris oculus*) 9.7 cm; 6. Oriental Sole (*Brachirus orientalis*) 11.2 cm; 7. Malabar Sole (*Cynoglossus semifasciatus*) 14.7 cm; 8. Spotted Sole (*C. puncticeps*) 19.9cm and 9. Doublelined Sole (*C. bilineatus*) 18.2 cm.

PLATE – II. Extensive Dry Curing of the Malabar Sole in one of the Fish Curing Yards on the Malabar Coast.

protracted over several months with peak spawning occurring during the period October-January. The spawning is believed to take place in the deeper area. The eggs of the Malabar Sole are small, pelagic and each egg contains several oil globules. They start appearing in the plankton right from October onwards. The larvae which hatch out are symmetrical. They grow and metamorphose into young ones in about a month or so. The movement of the right eye of the larva to its left side during the metamorphosis is completed by the time the larva grows to a size of about 9-10 mm. Young soles (below 50mm) start appearing in the inshore catches right from November or December until May, with a peak abundance in March. It remains to be studied whether the large scale capture of both the potential spawners and the juveniles from the inshore area is likely to affect the sole stock in the area.

In the Malabar Sole sexes are recognizable when it has grown to a size of 6-7 cm. In smaller size and age groups males are more in number than females; but in the older fish females outnumber males. The females grow faster than males at comparable age and appear to survive for a longer period also.

The Malabar Sole being a bottom fish is a bottom feeder; feeding on the bottom fauna available in the area. It feeds actively on polychaetes (*Prionospio pinnata*), amphipods (*Cheiriphotis megachelis*) molluscs (*Pholas orientalis* and *Nucula* sp.). When the sole is in the surface waters it feeds on the planktonic stages of polychaetes (dominated by *P. pinnata*). molluscs and on diatoms etc. The occurrence of the food species in the gut content of the Malabar Sole has been found to be closely related to the occurrence of the fauna in the area.

A great deal has been said on the migrations of the Malabar Sole. The sudden appearance of the sole in enormous numbers in the inshore surface waters in September and their equally sudden disappearance from these waters soon after is considered to be connected with the migration of these fish from the offshore area to the inshore and *vice versa* for feeding and breeding purposes respectively. The actual contributory factors for this phenomenon are still obscure for want of adequate data on the behaviour of the Malabar Sole in the inshore area during the monsoon season.

It is pertinent, in this connection, to consider the profound role the South West Monsoon plays in the biologial cycle of the inshore area along the Malabar Coast. Every year with the onset of the monsoon the sea off Malabar Coast becomes turbulent due to the prevailing strong winds and tidal currents. As a result the bottom mud is greatly and frequently agitated, resulting in the formation and dissolution of extensive mud banks so characteristic of the inshore area. These mud banks are known to be rich sources of inorganic nutrients, especially phosphates. These nutrients are released into the surface waters during the monsoon and thus contributing to the production of rich plankton which in turn is responsible for the rich fisheries of the area.

Incidental to the turbulent conditions of the sea during the South West Monsoon and as a result of the violent and frequent agitation of the bottom mud, the bottom fauna of the inshore area is almost completely destroyed. It would, therefore, appear likely that the shoaling up of the Malabar Sole in the inshore surface waters in enormous numbers in September has something to do with these unfavourable physical and biological conditions of the inshore bottom habitat attendent with the monsoon. The disappearence of the sole from the inshore surface waters coincides significantly, with the return of favourable conditions attendant with the re-settlement of bottom fauna in the inshore bottom habitat. In other words the migration of the sole occurs, very likely, in vertical direction and appears to be limited in extent. This assumes added significance if it is remembered that the Malabar Sole is an inshore bottom species. If the fish is there in abundance all the time in the inshore area, why then, it may be asked, they are no longer caught in such large quantities as they were during the months of large scale shoaling of the species in the surface waters. This, obviously, has something to do with the suitability of the gear employed in the fishery at this time. The gear presently employed in the sole fishery can catch the the soles effectively only when they are shoaling in the surface and subsurface waters; but are inefficient to capture them when they are on the bottom. In this respect there is a certain extent of parallelism between the sole and shrimp fisheries of the west coast of India.

The "Choodai"

By K. V. Sekharan

Central Marine Fisheries Research Institute

The sardines, other than the oil sardine, though not so important as the latter nor as abundant, are of considerable local importance in that they are popular food fishes contributing to a seasonal fishery at some places along the east coast, especially the south eastern region. Due to their thin bodies and non-oily nature, they are conveniently and rapidly beach dried in large quantities and exported to interior places, in excess of local consumption in the fresh and cured states. *Sardinella albella* and *S. jussieu* are the two important species forming the fishery, others contributing only in a small measure to the fishery being *S. sirm* and *S. clupeoides*. In recent years (1960–1965) on an all India basis, these sardines which are together called "Choodai" in Tamil along the coast of Madras State, have contributed from 1.89 to 5.23 per cent of the total marine fish catch.

The "Choodai" fishery of the Mandapam area is the most important fishery in the region between Danushkodi and Panaikulam, an eight kilometre stretch of the Palk Bay coast. The fishery commences in late March or early April and extends upto October or November, by which time the Palk Bay becomes too rough for the fishing operations of non-powered craft.

However, what distinguishes the "Choodai" fishery from other fisheries is the very small size of the fishes caught which is only about ¾" to 4" (20–100 mm). That itself is apt to make any one wonder whether such a fishery can last long, a fear, however, not well founded.

Only a small portion of the catch is consumed in the fresh condition. Well over 95% is dried on the beach and exported to the interior places in the Madras State where there is good demand for the same. Some 3000 fishermen are engaged in the fishery. The magnitude of the catches within this limited area is about 1000 to 2000 tonnes on the average.

Production in a lean year may drop to as low as a third of that in a good year. Superimposed on these annual changes are changes within seasons - periods of high yield alternating with periods of low yield. Both these features are common to other fisheries also. However, both these types of fluctuations in the "Choodai" fishery have been investigated.

The fishery of Mandapam area is composed of two species of sardines, *Sardinella albella* and *Sardinella jussieu*, the former being more important of the two. These sardines appear to have a sort of mutually repellent relationship. When one is abundant in the catches the other is scarce. There is also a pronounced lunar influence on the catches, the fishery being highly productive during the periods of the dark phases of the moon, a fact explained by an interesting behaviour of the sardines. From April to June or July, the young sardines of the year are mostly under 60 mm in size and can be seen near the sea surface only at night in large shoals. They create brilliant flashes of luminous patches on the surface, very conspicuous on dark nights which the fishermen take advantage of for locating them. If a torch is lighted the sardines gather near the light, when they can easily be transferred to the boat with dip nets. This habit is exploited by the fishermen who use torches made of palmyrah leaves. But the most important method of catching the sardines is to surround the shoals with a shore-seine and simply drag them to the shore. With increase in size and age, that is, after June or July, they come up to the surface during day time also and are caught in gill nets. Even after July, the bulk of the catches is landed at night. The weight and number of fishes in a shoal can be truly amazing. A single 3-hour haul by a shore–seine may land as much as 12 tons eontaining 60,00,000 sardines each weighing from 1 to 6 grammes.

The breeding season of these sardines is February-June. They breed when about a year old, but the catches are composed mainly of fishes between 2 and 8 months old. There is reason to believe that the major cause of annual catch variations is the change in the number of fishes born and surviving to the catchable stage each year. In sardines and in fact in all fishes, the number of individuals in successive generations or year-classes may vary within wide limits. If the relative abundance of a year-class can be estimated sometime before it actually enters the fishery, it would go a long way towards removing the uncertainties about the prospects of fishing seasons. But most often we come to know of these variations in year-class strength rather late, the aim of the fishery biologist is to reduce this time-gap. What is required for this purpose is a thorough knowledge of the conditions in the sea at the time when the fishes are born. However, the situation in the "Choodai" fishery is a little more hopeful than in many other fisheries. As was stated earlier, the landings of a year are composed mainly of fishes born in that year itself. The production during the first 1 or 2 months of the season gives an indication of the relative strength of the concerned year-class, and this in turn helps in assessing the prospects in the remaining months of the season.

Greater success has attended the work on the variations in catches within a season. In the sea sometimes, blooms of *Noctiluca*, a minute planktonic organism numbering to millions under one square metre appear suddenly. When these organisms are abundant, there could be scarcity of sardines.

The sardines feed on both phytoplankton and zooplankton. When suitable plankton is abundant, an increase in the availability of sardines can be expected. The tendency therefore will be to gather in greater numbers in places where there is abundance of food than elsewhere. But with regard to the food of the sardines, viz., plankton, there can be wide changes in quality and quantity within short periods of time in the same area. A number of oceanographic and meteorological conditions contribute to these variations in plankton. In the Mandapam area, it has been found that when there is a steady wind from land to the sea for a few days, the sea is agitated and there is an increase in plankton production. This is followed by an increase in the availability of sardine shoals. A study of the fishery has also shown that there could be a peak in the availability of fish shoals in October-November, depending on certain oceanographic and meteorological conditions.

The prospects of increasing the catches are good by bringing more area under fishing. The shore-seines which at present bring in the bulk of the catches fish only up to about a mile from the shore; whereas gill nets can operate much farther. Therefore the increase in the number of gill nets taking part in the fishery is a welcome development in the direction of increased production. However, this has given rise to a controversy similar to the one that other nations like Japan and the United Kingdom had to face under similar circumstances. The shore-seine men complain that the gill net operators are catching fish, which otherwise should naturally come into their traditional fishing grounds. Investigations have shown that this fear is mostly groundless, because generally shore-seines and gill nets catch fishes of widely different sizes. If however, the gill net is operated inside or just outside the shore-seine grounds, it might conceivably break up or divert the shoals.

It has been stated that the sardines are caught between the ages of two and eight months. Why not then wait for them to grow older? There are a number of difficulties in the way. First, the fishermen stop fishing after October or November not because of the dearth of fishes but because of rough weather. Therefore a pause in fishing would only swell the number of fishes surviving into the off season. Moreover, the investigations have shown that as the sardines grow older and larger and especially after the first year of life, they tend to move away from the nearshore waters, where shore-seines which now account for over 90% of the production would not be able to catch them. There can therefore be no gain in increasing the number of uncatchable fish. If man does not catch them nature will work towards the attrition of the shoals. Predators like sea birds, sharks, and other big fishes feed on them extensively. They are also attacked by parasites, both internal and external, as different types of worms and copepods. Scientifically speaking, it is necessary to know the probability of survival of the young fishes saved from capture. However there is hope that gradual redeployment of part of the man-power engaged in inshore fishing to offshore fishing on sardines and other fishes could lead to desirable results.

The Grey Mullets

By G. Luther
Central Marine Fisheries Research Institute

The grey mullets comprising the family Mugilidae are a common sight in the coastal waters and estuaries of the tropical and subtropical zones of all seas. They are known to ascend frequently into the fresh water zone of rivers. The main food of the mullets restrict them to shallow waters for feeding and presumably explain their abundance in estuaries and lagoons where such food reach their greatest density. Mullets in general are hardy fish, capable of living in extreme conditions of environment. They tolerate wide variation in salinity ranging from that of fresh water to brine water (92%o), and temperature ranging from 3-4°C to 40°C. They are known to survive in oxygen levels as low as 0.5 p.p.m. On account of these properties the grey mullets are probably one of the most important of all salt water fishes for farming in fresh and saline waters. They are extensively cultivated in several countries of the Indo-Pacific region, in Israel and in Egypt to augment the food supplies. Due to their good flavour and high nutritive value, mullets form one of the best table fishes.

In view of their economic importance, the grey mullets of India have been investigated in some detail at the Central Marine Fisheries Research Institute in recent years. Twentyseven species of grey mullets were reported to be occurring in India, but only the following 13 species may be recognised: *Mugil cephalus* Linnaeus, *M. cunnesius* Valenciennes, *Liza macrolepis* (Smith), *L. tade* (Forsk°al), *L. parsia* (Hamilton), *L. carinatus* (Valenciennes) *Valamugil seheli* (Forska°l), *V. buchanani* (Bleeker), *Ellochelon vaigiensis* (Quoy & Gaimard) *Plicomugil labiosus* (Valenciennes), *Crenimugil crenilabis* (Forska°l), *Rhinomugil corsula* (Hamilton) and *Sicamugil cascasia* (Hamilton). Of these the occurrence of the last named species in India is restricted to the upper reaches of the larger river systems of north India, viz., the Ganga, Yamuna, Brahmaputra and Indus, its lower most point on the Ganga river being Patna. However, record for this species in Ceylon mentions that the species "enters rivers" and as such the identity of the same remains to be checked. *R. corsula* is the only species which has its natural distribution in the fresh and brackish waters of the Gangetic and Mahanadi river systems. This species has also been reported to occur in the sea off the Midnapore coast of Bengal where the salinity is low. The average annual catch of mullets from the marine zones of India during 1960-65 was 1409 tonnes which is about 0.2% of the total marine fish landing during the same period. It is possible that a similar amount if not more is caught annually from the estuaries and brackish water lakes in India.

The fishery of the grey mullets around Mandapam in the Palk Bay and the Gulf of Mannar, with particular reference to the biology of *Liza macrolepis* and *Mugil cephalus*, has been studied. These two species along with *L. parsia* are commonly caught in the shallow marine areas and in the adjacent lagoons. Other species occurring in the area are *L. tade*, *V. seheli*. *V. buchanani*, *M. cunnesius* and *E. vaigiensis*. An average size of 13 cm, 22 cm and 29 cm are attained by *L. macrolepis* at the end of the first, second and third year of its life respectively. Males and females attain sexual maturity at 16 cm and 17 cm respectively. Individual fish spawns once in a season, which extends from June to February with a peak during July and August. Sexes are equally distributed. The fecundity varies between 1,51,920 to 6,76,200 ova. The modal size group of *M. cephalus* progressively increase from about 9—11 cm in January of one year to 25—26 cm in January of the next year thus showing an average increment of about 15 cm during a period of 12 months. An interesting case of shedding the gill raker processes was observed in grey mullets during the present investigations. Mullet shed these tiny processes present in double row in the inner face of the gill rakers into their habitat. These are also taken in by the fish while feeding at the bottom. Such an unusual habit has not hitherto been reported in fishes.

The consensus of opinion on the spawning of salt water mullets, as evidenced by isolated observations, from tagging experiments and from other circumstantial evidences is that normally, they migrate to sea for spawning. However, *M. capito*, a salt water mullet, has been reported to have bred successfully in brackish water in the Lake Qarum (Egypt) while *M. cephalus* has failed to spawn, inspite of gonadal development to maturity in the landlocked Salton Sea of the southern California which has an annual variation in salinity and temperature at 31.4—33.0‰ and 10—36°C respectively. *R. corsula* was reported to be breeding both in the salt water as well as in fresh water habitats. The two well authenticated instances of spawning of *M. cephalus* were at sea in surface but over deep water, 50 and 750 fathoms, in the Black Sea and in the gulf of Mexico respectively. Very small larva of this species were reported from the surface in water more than 100 fathoms and 28 fathoms deep off Kabashima (Japan) and along the south Atlantic coast of the United States of America respectively. *M. cephalus* has been reported to undertake regular breeding migrations from the Chilka Lake to the sea during the months of September to January. Relatively large mature fish migrate away from the lagoon early in the season and progressively smaller ones migrate later as the breeding season advances.

A study of the reported breeding periods of Indian mullets indicate that most species have a protracted breeding period extending from 4 to 10 months. Only *M. cuunesius* and *R. corsula* seem to have a brief breeding period extending from 4 to 5 months. The breeding season of each species, the actual months and the duration involved, appear to vary from region to region, one overlapping with the other in many cases. The composite picture for the breeding season of each species is: *M. cephalus* September to May, *L. macrolepis* June to February, *L. parsia* August to March, *L. tade* May to March, *M. cunnesius* May to August, *V. seheli* May to February, *E. vaigiensis* May to February and *R. corsula* May to September.

Juvenile and adult *L. macrolepis* and *M. cephalus*, as also of other mullets, are essentially bottom feeders subsisting on decayed organic matter supplemented by fresh and decaying plant (algae) and animal matter, which is constituted by the 'biological complex', from what is known as the iliotrophic layer on the substratum of their habitat. Other items met with in the mullet stomach are sand particles and sponge spicules. While the latter could have been ingested along with the food items, particularly foraminifera, since species of foraminifera are known to build 'houses' with sponge spicules, inclusion of sand seems to be deliberate and is believed to assist in grinding the food in the muscular gizzard-like stomach. The 'biological complex' referred to above is the green scum that develops at the bottom of the shallow water areas and is known to consist essentially of a rich growth of *Phormidium* and *Oscillatoria* and other forms such as *Microcoleus*, *Lyngbya* and *Spirulina* and also harbour a variety of littoral diatoms, desmids, ciliates, rotifers, nematodes, planarians, small annelids, amphipods and a few insect larvae, besides considerable quantities of organic detritus and associated bacterial flora.

The early juvenile of *L. macrolepis*, *L parsia*, *L. tade* and *M. cephalus* and possibly of other species feed on phyto and zooplankton, the particular type of organism ingested being dependent on their availability in the area. In the food of mature and spent *L. macrolepis* a greater proportion of diatoms and copepods have been observed.

The foregoing observations would therefore explain the views put forward by different authors for considering mullets as plankton feeders, omnivores, foul feeders, bottom feeders etc., and indicate the necessity of studying the food habits of fishes in relation to size and maturity stages.

While the early juveniles are mostly found close to surface, juveniles and adults in the trophic phase are seen to move at the bottom at an angle of about 45° to it, and mature and spent adults again are found close to surface. Where two or more species of mullet occur in the same natural environment there appear to be some sort of species-wise segregation. Adult mullet in the trophic phase tend to be scattered or in small schools of a few individuals. Younger fish tend to be aggregated in schools of moderate size, which tend to congregate into larger schools as maturity and the spawing migration approach. Mullet in the spawning run move close to surface. Their movements could be recognised by the dark patch and the characteristic ripples they cause on the surface. Employment of suitable fishing gear for mullets keeping in view these differential distribution patterns of fish in the different phases of life would certainly yield a better catch.

In India nets specially meant for catching mullets are devised with regard to their peculiar habits. They are known to ascend in schools to the shallow littoral areas and connected creeks and channels with the high tide for feeding purposes. Such schools when scared, leap and rush in their effort to escape. Mullets are caught mainly in the gill nets, *Mangan jal* and *Khanderi jal* in the gulf of Kutch and gulf of Cambay, *Kendai valai* in the Coromandel coast *Khainga jalo* or *Noli jalo* and *Menjia jalo* in the Chilka Lake; in the cast nets, *Pag* in Konkan area, *Shendi* in North Kanara; *Veechu valai* in the Coromandel coast and *Kapla jal* in Bengal; in the dip nets, in Kanara and Kerala, *Hela jal*, *Kharra jal* and *Khorsula jal* in Bengal; in the stake nets or barrier nets, *Jadi jal* in the gulf of Cambay *Valu valai* and *Waghur* in Kanara and Kerala, *Kalomkattivalai* in the Palk Bay and the Gulf of Mannar *Kala valai* and *Kattu valai* in the Coromandel coast, *Jano* in the Chilka

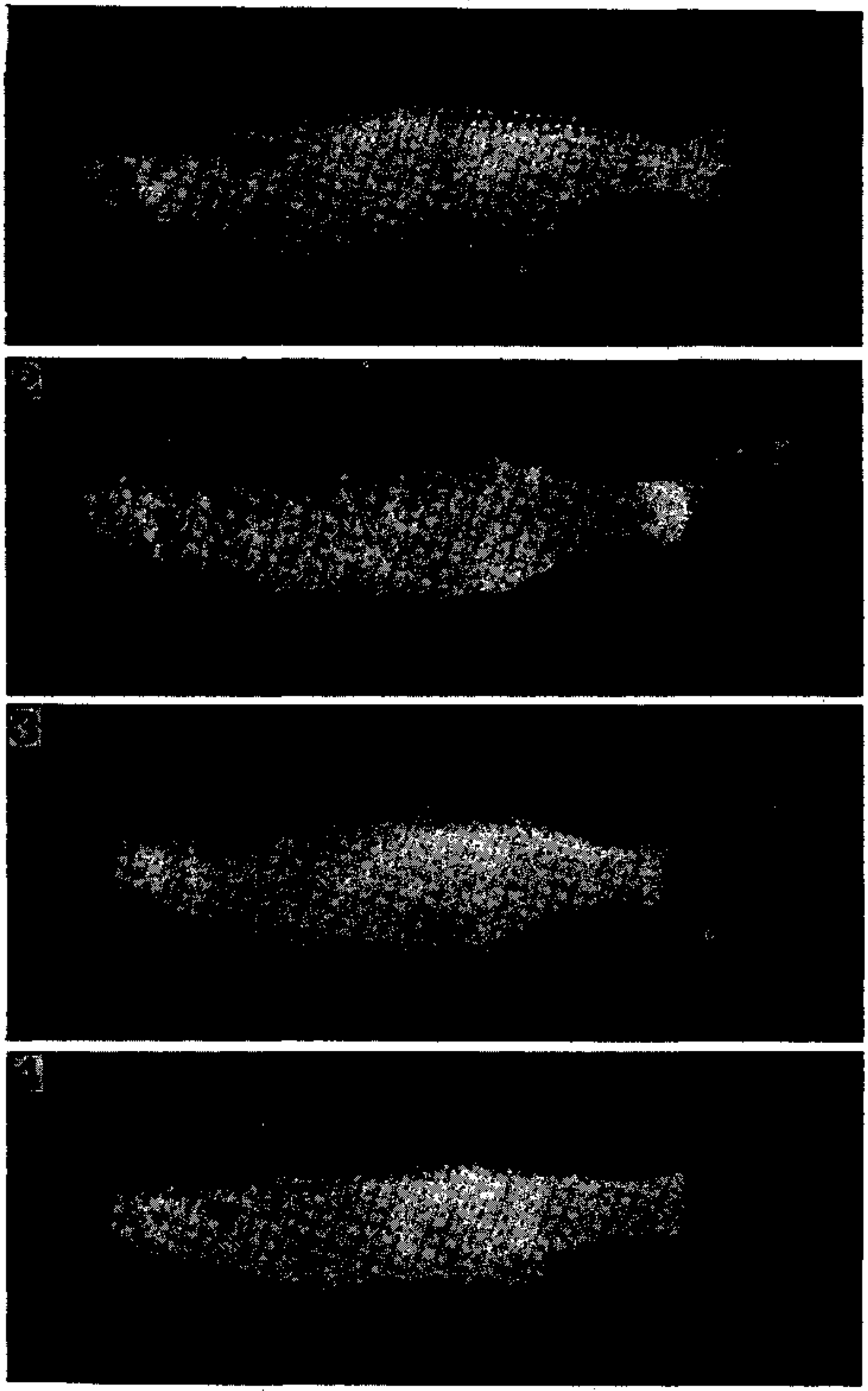

PLATE I.
1. *Mugil cephalus* Linnaeus
2. *Mugil cunnesius* Valenciennes
3. *Liza parsia* (Hamilton)
4. *Liza tade* (Forskal)

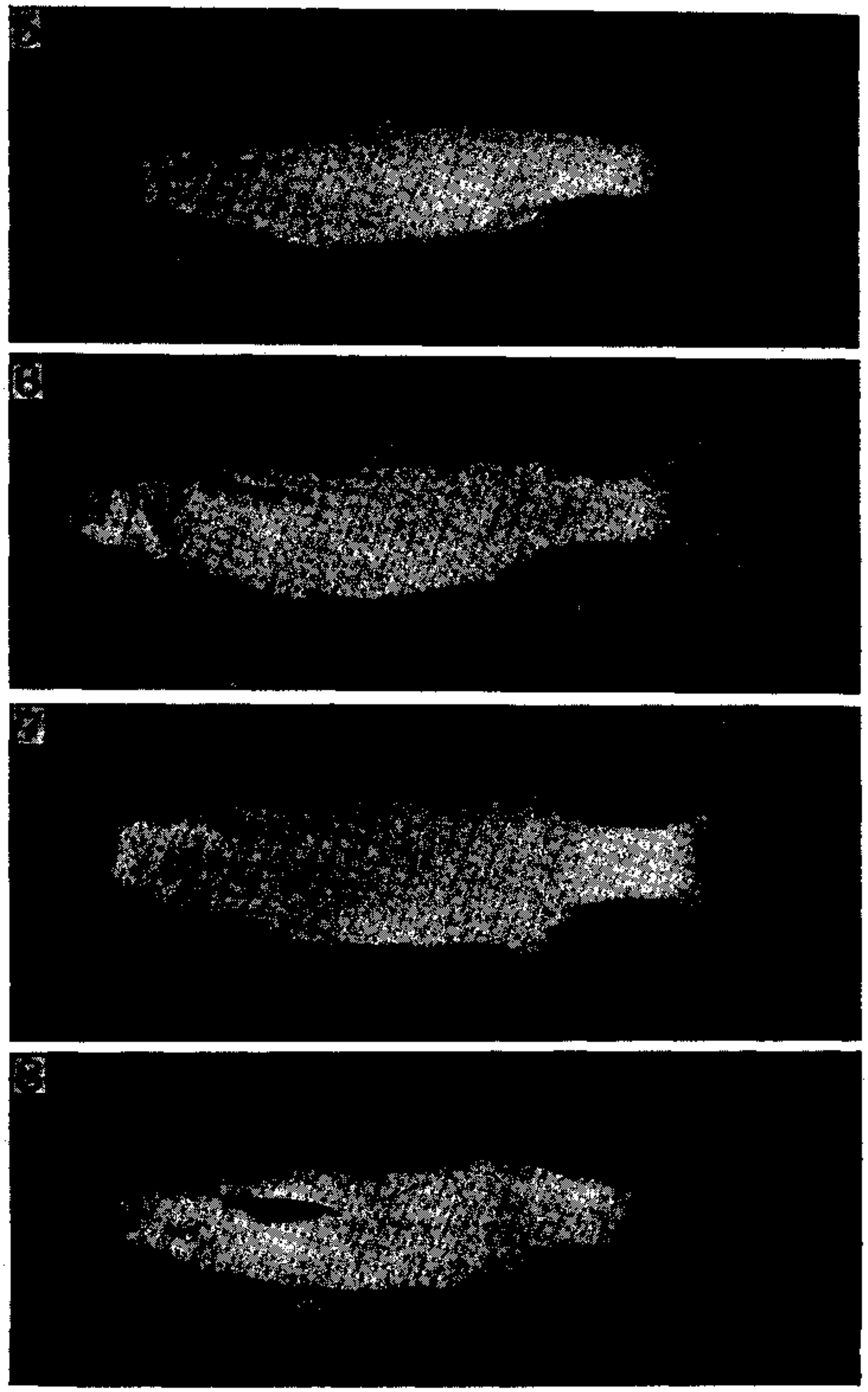

PLATE II. 5. *Liza macrolepis* (Smith)
6. *Valamugil seheli* (Forskal)
7. *Valamugil buchanani* (Bleeker)
8. *Ellochelon vaigiensis* (Quoy & Gaimard)

Lake, and *Char-gherra jal Bher jal, Charhatta jal* and *Komar jal* in Bengal; and in the pouch nets, *Ghalwa* in the Gulf of Cambay and *Vidu valai* in Palk Bay and the Gulf of Mannar, and *Iriga valai* iu the Coromandel coast. The last mentioned net is specially adapted to catch mullet in the spawning run.

. Fishing for mullets takes place in the estuaries and coastal inlets at all times of the year. A study of the size composition of the mullet catches reveals that in India their fishery is based mainly on immature fish. However, the formation of migratory schools before spawning is taken advantage of in several areas to obtain increased catches. Mullets are of considerable commercial importance in the fisheries of the Mediterranean, Black sea, Florida, Gulf of Mexico, Gulf of California, Southeast coast of Japan, Philippines, the northern shores of China, South Africa and southern Australia. In India the principal regions supporting mullet fishery are the estuaries of the rivers Ganga, Mahanadi, Godavari Krishna and Cauvery, and the brackish water lakes of Chilka and Pulicat on the east coast, the estuaries of the Narbada and Tapti, the Gulf of Kutch and the backwaters of Kerala on the West coast, and the innumerable shallow bays and creeks in the Andaman group of Islands.

Although different species of mullets have been reported to be occurring in the fisheries of the different areas in India, *M. cephalus, L. macrolepis, L. parsia* and *L. tade* may be considered as the important species from the fishery point of view. East coast of India produces larger quantity of mullets compared to the west coast. The Chilka Lake, the largest brackish water lake in India, being about 400 sq. miles in extent, produces an annual mullet catch of about 600 tonnes, which is nearly 17% of the total fish production (about 3535 tonnes) of the Lake. Fishing for mullets is done almost throughout the year, best catches being available during October-March. A flourishing trade for small cured mullet roe was reported to have existed in the area prior to World War II. The Mahanadi estuary produces annually a mullet catch of about 230 tonnes, constituting nearly 38% of its total fish production. Fishing for mullets is done throughout the year, best catches being available during November-January. Mullets contribute to about 1% of the total annual catch of about 5750 tonnes in the Hooghly and Matlah estuaries. In the Godavari estuary mullets form about 4% of the total annual catch of about 300 tonnes. In the Pulicat Lake mullets constitute about 30% of the total annual fish catch of about 850 tonnes.

Mullets lend themselves well for culture purposes. The fry of salt water mullets can be collected from almost all estuaries; particularly the shallow marginal areas of rivers, tidal streams, creeks, swamps and inundated fields are ideal spots for their collecticn. They are more abundant in these areas 4–6 days after the full and new moon. The peak abundance of the different species in the different zones depends on the peak breeding season of the species concerned. Mullet fry collected from sea and the creeks when directly stocked in fresh water ponds do not show appreciable mortality. However, the general opinion is that acclimation and conditioning are desirable before transporting and stocking them in ponds. Mortality during acclimation can be minimised by feeding the fish during the process.

Profitable fish culture aims at the production of maximum quantity of edible fish flesh by employing rapidly growing fish capable of shortening the food chain and converting decaying organic matter or the next link in the food chain, namely, algae effectively into edible fish flesh. These conditions are fulfilled to some extent by the herbivorous and detritus feeders like the grey mullets, etc. Among the salt water mullets, *M. cephalus*, *L. parsia*, *L. tade*, *M. cunnesius*, *L. macrolepis*, *V. seheli*, *V. buchanani* and *E. vaigiensis* are species highly suited for cultivation (Plates I&II). The first three species have been reported to be extensively in use in the Indo-Western Pacific region for culturing in brackish and fresh water ponds along with the milk fish, *Chanos chanos* and other species. In brackish water ponds, *M. cephalus* has been reported to attain a size increment of 29 cm during a period of six months while its average growth rate in natural environment is about 14 and 24 cm only at the end of the first and second year respectively; *L. parsia* attains a size of 15 to 19 cm at the end of first year while it is known to grow to about 10 cm only in natural environment; *L. tade* attains a size of 24 to 25 cm at the end of first year and 34 to 36 cm at the end of second year while it is known to grow in natural environment to about 17 and 25 cm at the end of the first and second year respectively. It is therefore obvious that grey mullets cultivated in ponds grow faster than those in natural environment; this coupled with their hardy nature and food preference, rank them high as a primary group in mixed fish culture.

Prawn Fisheries

By K. H. MOHAMED

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The most outstanding development that has taken place during the past decade in India's fishing industry is the phenomenal increase of prawn export brought about chiefly by the introduction of modern processing methods. The insatiable demand for prawns from the United States and other foreign countries has been the incentive for most of the entrepreneurs to establish up-to-date processing plants for packing prawns. As a direct consequence of the high demand for raw material and due to the timely help and advice rendered by the various research and other organisations of the Government of India, a number of mechanised fishing vessels were introduced into the capture fisheries for prawns. While these developments had their effect in the fishing industry all over the country it is to be admitted that maximum development has taken place in the south-west coast of India from where more than 80% of the exportable varieties of prawn are now being landed.

TREND OF PRODUCTION

According to the latest estimates average annual marine prawn landings of the country amount to 77,461 tonnes and it accounts for over 10% of the total catches. In addition to these quite a substantial quantity of prawns are landed from the backwaters, lakes and estuaries on the east and west coast of India.

Table I. Prawn landings and their percentages among crustaceans and overall marine fish landings of the country.

Year	Prawn landings in tonnes	Percentage in total crustacean landings	Percentage in total marine landings
1958	85,191	98.26	11.27
1959	65,436	96.90	11.19
1960	68,029	96.36	7.73
1961	62,768	96.85	9.18
1962	83,235	98.78	12.92
1963	81,593	97.54	12.45
1964	94,895	95.41	11.04
1965	78,544	97.08	9.64
Average	77,461	97.14	10.68

Although there are no reliable statistics, the landings from these sources are generally considered to be as high as half the quantity of marine landings. The trend of marine prawn production indicates (Table I) that the catches remained more or less steady over a number of years and its proportion in the catches fluctuated between 12.92 to 7.73% during the period of 8 years. Although prawns are landed from all the maritime states of India more than 89% of the total resources comes from the west coast; the states of Maharashtra and Kerala contributing to the bulk of the landings (Table-II).

Table II—Statewise Prawn landings and their percentages
(Average of 8 years)

State	Average prawn landings in tonnes	Percentage
West Bengal and Orissa	1.843	2.39
Andhra	3,426	4.45
Madras	2,625	3.41
Kerala	20,445	26.55
Mysore	950	1.23
Goa	123	0.16
Maharashtra	40,605	52.73
Gujarat	6,983	9.07
Andamans	1	—

THE FISHERY

The fishing methods employed in the capture of prawns from all over India have been described by various workers. The only new method that has come into practice in recent times is the trawling by mechanised fishing vessels. Most of these vessels are 7 to 11m long and are powered by 10 to 45 h. p. engines. They carry out daily fishing operations using ordinary cotton 2-4 seam shrimp trawls of 15 m head rope having a mesh size of 2 to 3 cm. A few large and well equipped trawlers capable of staying out in the sea are also operating from Cochin. The chief source of prawn landings is still the indigenous gear operated from dug-outs and canoes; the catches from the stake nets of Gujarat and Maharashtra and the boat seines of Mysore and Kerala even now forming the bulk.

The operations of the mechanised vessels have, however, extended the area of fishing into slightly deeper waters and have helped to keep up a steady supply of exportable varieties of Prawns. The present commercially exploited prawn fishing grounds lie within 40 m depth on the west coast. From the overall pattern of distribution of prawns it is seen that they are generally more predominant off the bar mouths of lakes and estuaries possibly because the discharge by the rivers would help to create the loose muddy sea bottom on which these animals abound. In spite of the indications that larger prawns are likely to be more in the deeper waters attempts are not so far made to fish such areas partly because these areas are not adequately surveyed and also due to the uncertainty of the economic aspects of such trial ventures by the industry.

Catch composition

India's marine prawn catch can be divided into two broad categories—the penaeid and non penaeid—each of them contributing to nearly half the total landings. The penaeid prawns are relatively large sized and are represented in the commercial catches by about a dozen species, chief among them being *Penaeus indicus, Metapenaeus dobsoni, M. affinis, M. monoceros, M. brevicornis, Para-penaeopsis stylifera, P. sculptilis* and *Solenocera indicus* while the latter category consists of a few species of small sized prawns viz., *Palaemon tenuipes, P. styliferus, Hippolysmata ensirostris, Acetes* spp. From the point of view of the export industry the former category is of utmost importance as virtually all the prawns exported from the country belong to this category. The catches from Gujarat and Maharashtra areas mostly consist of the non-penaeid prawns while those from Mysore, Kerala and Madras are the large sized penaeid prawns. (~~vide Tables I & II. The figures include a small portion of other crustaceans also~~) Details regarding their size, seasonal occurrence, gear employed in capture and approximate proportion in the commercial fisheries are given in Table III.

Fishing season

The prawn fishery is seasonal, but the seasons vary from place to place. Generally speaking, the fishing season for prawns extends from Novermber to May in the west coast and from December to August in the east coast; in both cases interruption of the season being brought out by monsoon, the success or failure of which is believed to have influence over the fishery. In the Gulf of Kutch there is a monsoon fishery for prawns and so also in Kerala where the formation of mud banks in close inshore waters in June-July support a flourishing prawn fishery in some of the areas. The turbulent conditions of the sea and the stormy weather that are prevalent during monsoon render it difficult for the fishing vessels to succeessfully operate during this season. A few trawlers that are working from Cochin at present brave the rigours of monsoon and carry out fishing operations during this period. Their operations have shown that succesful prawn fishing could be carried out even during monsoon.

Processing and Export

Some portions of the prawn catches are marketed in fresh condition. The long prevalent methods of processing such as simple sun-drying, extracting pulp by boiling and drying semi-drying, etc., are still in vogue. At present the modern processing methods like freezing, canning, pickling, etc., claim better part of the large sized prawns landed in the country. Simultaneous with the increase in export of the sophisticated products like frozen and canned prawns that of the dried prawns have come down considerably. In 1966 a total quantity of 11,470.014 tonnes of prawns and prawn products valued at Rs. 112,719,139 were exported from India. This included a variety of products like frozen prawns, canned prawns, dried prawns, prawn powder, prawn meal, prawn pickle, prawn curry, etc., and were exported to over 50 countries of the world. Most of these products now pass through a strict quality control by the Government and are well accepted in the world markets.

Name of Species	Vernacular names	Area of occurrence as Commercial fishery	Season of fishery
Penaeid Prawns			
Penaeus indicus	'Naran Chemmeen'	West coast & East Coast	December to February
Penaeus monodon	'Kara Chemmeen' 'Bagda Chingiri'	West Coast & East Coast	Throughout the fishing season.
Metapenaeus dobsoni	'Poovalan' 'Thelly Chemmeen' 'Chingiri'	South–West Coast & East Coast	October to June
Metapenaeus affinis	'Kazhandan Chemmeen' 'Jinga'	West Coast & East Coast	Nov. – Dec. & May – June
Metapenaeus monoceros	'Choodan Chemmeen' 'Jinga' 'Koraney Chingiri'	West Coast & East Coast	Nov. Dec.
Metapenaeus brevicornis	'Dhanbone' 'Chingiri' 'Jinga'	W. Bengal Andhra Maharashtra Gujarat	Feb. – March
Parapenaeopsis stylifera	'Karikadi Chemmeen'	West Coast	Sept.–Oct. & May – June
Parapenaeopsis sculptilis	'Jinga'	Gujarat Maharashtra Andhra	Dec. – March
Parapenaeopsis hardwickii	'Jinga'	Gujarat Maharashtra Andhra	Nov.–Feb.
Solenocera indicus	'Jinga'	Maharashtra Andhra	Jan. – May
Non-Penaeid Prawns			
Palaemon tenuipes	'Kolbi'	Gujarat Maharashtra Orissa West Bengal	Dec. - Feb.
Palaemon styliferus	'Kolbi'	Maharashtra West Bengal	All round the year
Hippolysmata ensirostris	'Kolbi'	Gujarat Maharashtra Andhra	Sept.–Nov.
Acetes spp.	'Kardi'	West Coast & East Coast	Dec.–March
Macrobrachium rosenbergii	'Konchu' 'Golda Chingiri'	Fresh water rivers of India	May - Nov. in Kerala

the commercial prawns of India.

Principal Fishing gear employed in capture	Approximate representation in the annual catch	Maximum size: total length mm	Majority size in the catches mm.	Remarks
Shrimp trawl Boat seine Cast nets	10.0%	220	136–145	Juveniles fished from lakes, backwaters and estuaries as commercial fishery
,,	0.9%	250	170–180	Largest of the marine prawns.
,,	35.0%	130	86–95	Juveniles fished from lakes, backwaters and estuaries as commercial fishery
,,	12.0%	180	121–130	Juveniles poorly represented in the backwater catches
,,	10.0%	190	126–135	Juveniles fished from backwaters in significant quantities.
Stake nets Seines	4.0%	135	101–110	Ascends the tidal rivers in Bengal.
Stake nets Trawl nets Boat seines	18.0%	142	81-90	Purely marine species
Stake nets Trawl nets Boat seines	0.8%	152	76–85	
Stake nets Trawl nets Boat seines	0.6%	130	81–90	
Stake nets Boat seines	0.9%	125	76–85	
Stake nets Boat seines	3.0%	74	45–50	
Stake nets Seines	0.6%	100	51–60	
Stake nets Boat seines	0.9%	90	66–75	
Stake nets Boat seines	3.0%	25	16–20	
Traps, Cast net hooks & lines.	—	310	200–250	

Different methods of freezing and packing are in practice. The prawns are first beheaded and deveined before they are graded according to size. The larger grades are frozen with shell on in suitable cartons while the smaller grades are peeled and the meat is either frozen direct or cooked and frozen. After freezing the packed cartons are stored in cold storages until they are shipped. Generally smaller grades of prawns are used for canning. The raw material is shelled and deveined at the production centres and when it comes to the factory it is already in the meat form well iced. The meat is then cleaned, graded and filled in cans containing brine. It is then cooked, seamed and subjected to the necessary canning procedures.

BIOLOGY OF PRAWN

Almost all the penaeid prawns breed in the sea and their young ones enter the estuaries and backwaters when they are in post-larval stages. The only known exception to this is *P. stylifera* which, however, completes its life cycle in the sea itself without entering the estuarine environment during any stage of its life cycle. The question why these juvenile prawns enter the estuaries is not fully understood yet. The physical and chemical factors such as temperature, currents, tides, salinity, nutrients, etc., of the environment or the characteristics of the life cycle themselves may be responsible for these movements. The juvenile prawns that enter the estuaries feed and grow there upto a particular stage and return to the sea where they attain sexual maturity. In the trawling grounds these prawns show seaward and shoreward movements in different seasons and these movements are either sex oriented or size oriented. Investigations carried out by the Central Marine Fisheries Research Institute show that *M. dobsoni* and *P. stylifera* breed in 20-22 m depth regions and *M. monoceros* in 50-60 m regions. Although conclusive evidence is not available in respect of *P. indicus* and *M. affinis* indications are that these two species breed in still deeper waters. It is estimated that these prawns breed five times during their life time and that the interval between two successive breedings is about two months. The prawns fished from the backwaters are generally 4 to 10 months old while those fished from the sea mostly belong to late O-year and 1-year groups.

It is interesting to report here that during some of the research cruises in 1965 it was found that a few species of deep water prawns (*Aristaeus semidentatus*, *Heterocarpus woodmasoni*, *H. gibbosus*, *Parapandalus spinipes*, *Penaeopsis rectacuta*, *Metapenaeopis andamanensis* and *Plesionika martia*) were present in considerable quantities in deeper waters of 300 to 340 m off the south-west coast of India Some of these species appear to have Commercial possibilities and it is likely that we may be able to exploit this resource in due course.

FUTURE WORK

The life history of the prawns and their movements are only partly understood at present. Reliable data onthe various biological aspects of the individual constituents of the fishery are essential for planned development and rational exploitation of the resources.

While the introduction of mechanised boats has resulted in maintaining a steady supply of raw material for the export industry no appreciable increase in overall landings has been evident. This situation has to be very carefully studied and management policies framed, if found necessary, at appropriate time. The fast rate of development that is taking place in the industry calls for finding out additional resources to increase the catch. The potentialities of the east coast grounds are not fully known and remain to be studied. A detailed survey of the grounds lying off the river mouths in the east coast may prove fruitful. Possibilities of exploiting the recently observed resources of deep water prawns on the continental slope of the south-west coast have to be fully explored. Culturing of prawns in estuarine waters, as is practised in some of the south-east Asian countries, is another aspect to be examined. The present attempts at culturing the fresh water prawn *M. rosenbergii*, if successful, will open up vast scope for widespread stocking of this species in the reservoirs. Transplanting of this species to other river systems where it is not known to occur is likely to yield good results.

The Indian Spiny Lobster

By M. J. George

Central Marine Fisheries Research Institute

The Indian spiny lobster, *Panulirus homarus* (Fig. 1) and allied species, has come to the lime-light during the past decade due to the great demand in foreign countries as a favourite of epicurean gourmets. Exploitation of the spiny lobster resources of the country, mainly from the south-west coast of India, which remained as a subsistence fishery for the local fishermen till recently has now developed into a more profitable venture encouraged by the marine products export industry. The edible part of the spiny lobster is known to the industry and consumer by the term "lobster tail". Today the frozen lobster tails from India are available in most of the world markets and as such it has become an important commodity earning valuable foreign exchange for the country. The demand for the same is ever on the increase and the industry is on the look out for additional resources.

Fig. 1. The Spiny Lobster PANULIRUS HOMARUS

What is a spiny lobster?

The spiny lobster is one of the crustaceans, a group of cold blooded animals with hard but jointed and flexible "crust" or shell and a number of jointed legs which include over 25,000 species of varied size and description. Among the crustaceans the Decapoda, so called because of their possession of a distinct tail region and ten walking legs, comprises most of the familiar larger shelled forms like shrimps, prawns, crayfishes, lobsters and crabs. The spiny lobsters have a large and spiny head shield called carapace covering the forward part of the body, a pair of long whip like thorny feelers or antennae extending from the head region, 5 pairs of walking legs and the fleshy abdomen or tail ending in a leathery tail fan. The abdominal region is the popular lobster tail. The spiny lobsters are readily distinguished from the true lobsters and crayfishes by the absence of the large crushing claw.

INDIAN SPECIES AND THEIR IDENTIFICATION

Spiny lobsters are known from the warmer seas throughout the world and support valuable commercial fisheries in many areas. In India there are nearly half a dozen species of these lobsters belonging to the family Palinuridae occurring in the rocky patches of the coastline and contributing to the fishery. For their easy identification the following key based on characters of the tail will be of use.

1. Abdominal or tail segments grooved..2

   Abdominal or tail segments without grooves...3

2. Abdominal grooves not interrupted medially.................... *Panulirus penicillatus*

   Abdominal grooves interrupted medially............................ *Panulirus homarus*

3. Transverse yellow stripes present...4

   Transverse yellow stripes not present. Colour greenish with patches of blue and yellow................................ *Panulirus ornatus*

4. Transverse yellow stripes bounded by blue on either sides................................ *Panulirus versicolor*

   Transverse yellow stripes not bounded by blue.................. *Panulirus polyphagus*

Among these *Panulirus homarus* is the most important species contributing to the fishery of the south west coast of India. In Bombay waters as well as on the east coast *P. polyphagus* and *P. ornatus* are also fished. Different aspects of the biology and fishery of *P. homarus* of the south west coast of India have been under investigation by the Central Marine Fisheries Research Institute for the past several years.

SEXUAL DIMORPHISM

Sexes are separate and usually males are larger than females. In the male the fifth or last walking leg ends in a single simple claw, but in the female the tips of these legs are provided with three points formed by spurs used in caring for the eggs attached to the under side of the tail. The male also differs by the presence of swollen sexual openings at the base of the last pair of walking legs. The female openings at the base of the third pair of legs are much smaller. When the tail alone is available also separation of sexes is not very difficult. In the males swimming legs on the under surface of the tail end in a single leaf-like joint. But in the females these legs end in 2 branches, both of those on the first pair being leaf-like while the inner branch on the following legs is a rod-like joint to which the eggs when laid are attached in the form of large mass of orange-red berries.

HABITAT AND FOOD

The spiny lobsters generally occupy areas with rocky bottom. Movement is usually carried out by walking sideways, forwards or backwards on the legs. By quickly bending and stretching the tail the animal moves backward rapidly to avoid danger. They are most active at night when they move in search of food. They are omnivorous feeders, frequently a scavenging type. Their normal food includes marine worms, molluscs, smaller crustaceans, etc. Food is usually detected at some distance by means of a special sense in the feelers or whips. Traps and other devices used for fishing these lobsters on the south west coast are baited with mussel flesh obtained from the locality.

LIFE HISTORY

Although the animal has a prolonged breeding period the peak season for egg laying is November-December months. After mating the females lay their eggs which remain attached to the swimming legs on the underside of the tail. The number of eggs varies from 2 to 4 hundred thousand depending on the size of the lobster. The eggs hatch into transparent, flat and leafy larvae quite different from the adult. This larva passes through a series of successive moults before it attains the adult form. The most peculiar and characteristic of these stages — the phyllosoma larva - has the form of an extremely thin, flat, roughly circular, transparent disc about 2 cm in diameter with eyes and long legs protruding from the margins. They are planktonic in existence and dispersed far and wide by

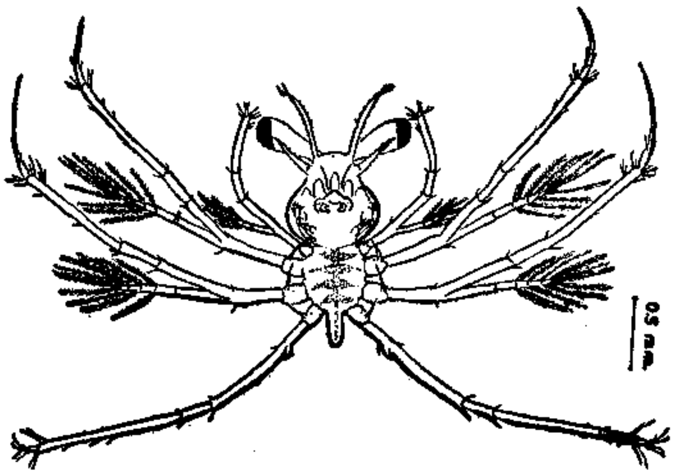


Fig. 2. PHYLLOSOMA LARVA OF PANULIRUS HOMARUS (after Prasad & Tampi 1959)

currents. Their dispersal is further aided by the lengthy larval life which is estimated to be about 7 months during which period they undergo about a dozen moults. The phyllosoma larva finally metamorphoses into a form similar to the adult, known as the puerulus stage, differing from the adult principally in lacking lime in the shell and also much smaller in size. At about this stage they settle down to the bottom of the sea. The survival of these young lobsters at the time of settlement largely depends on the nature of the substratum particularly in respect of protection it can afford from predators.

Growth and movement

The lobsters grow by periodic moulting, i.e. shedding the shell and growing a slightly larger one. This process of moulting is more frequent when they are small. The tagging experiments conducted by the Institute on the lobster *P. homarus* at Muttom-Colachel area of Kanyakumari district has shown very interesting results about the growth of the animal. In these experiments coloured plastic tags bearing serial numbers are attached behind the head by inserting on the muscle connecting the head and the tail and released in the sea. By the recovery of these tagged animals, a phase in which the complete co-operation of the fishermen is essential, their growth and movement are studied. In experiments conducted so far nearly 30 % recoveries have been obtained and these have shown that after settling on the bottom the animal reaches about 200 to 220 mm in total length during a period of 2 years. Thereafter growth is very slow, being about 20 to 30 mm per year. These experiments also showed that once the animals settle on the grounds of this area there is very little movement taking place, the maximum movements noticed in recovered lobsters being less than 5 miles even after one year.

Fishery

In the Kanyakumari District the lobster fishing season commences in November and ends by April. There is a short season in August—September at Tikkoti and nearby rocky areas of the coast north of Calicut.

The methods of fishing may be divided into those requiring bait and those which are effective without bait The former comprise of the traps, anchor hooks and scoop nets operated in the southern region. The gill nets and cast nets, the latter mostly employed in Tikkoti region, are operated without baits. The traps are constructed out of palm leaf stalk stripped to thin fibres. The fishermen engaged in trap fishing are good divers They dive and leave the trap with baits and heavy stone sinkers inside between crevices and cracks of the rocky substratum overnight. The next morning the catches are emptied and the traps set again. The bait used is the mussel (*Mytilus* sp.) called "sippi" in Tamil.

In the anchor hook fishery anchor shaped hook with 6 sharp arms made of cast iron are let down to the bottom by means of baited lines. When the fisherman feels the lobster biting the bait (mussel meat) the line is pulled suddenly thereby hooking the lobster on its abdomen This fishing is also done during night and from a type of boat catamarans. In the scoop net fishery, baited lines are slowly pulled up when the lobster bites the bait and while nearing the surface scooped up by a round scoop net. Stretches of wall nets set at the bottom during night are operated as bottom set gill nets in the southern region. Cast nets of different sizes are employed in catching the lobsters to a considerable extent in Tikkoti.

PROCESSING AND EXPORT

The agents of freezing companies collect from the fishermen all the lobsters as soon as they are landed at the rate of Rs. 0.75 to Rs. 1.50 per lobster depending on the size. These are then beheaded and the tails packed in ice for transport to the processing plants where they are thoroughly cleaned and processed. The tails are graded according to weight and individually packed in alkathene bags and frozen in suitable cartons. It is in this form they reach the consumer.

In recent years the export of lobster tails have increased considerably as is seen from the table below:-

Year	Quantity of frozen lobster tails exported in kg.	Value in Rs.
1962	39,763	2,26,364
1963	55,304	3,12,721
1964	41,304	3,71,021
1965	1,11,600	12,74,517
1966	80,802	14,74,471

FUTURE PROSPECTS

With the increasing demand from all quarters of the world and location of more and more resources as a result of exploration and exploitation of different areas along the coastline of India, it is expected that this fishery will play an increasing part in the frozen fish trade of the country. In this connection the recent findings of the occurrence of good concentrations of the spiny lobster *Puerulus sewelli* in the deeper waters off Kerala in depths of 200 to 300 metres along the continental slope, during the exploratory cruises of the research vessels of the department, are of significance. In the search for new resources for the ever increasing demand of the industry this finding might prove to be of immense value.

Pearl and Chank Fisheries - A New Outlook in Survey and Fishing

BY K. NAGAPPAN NAYAR AND S. MAHADEVAN
Central Marine Fisheries Research Institute

The Gulf of Mannar and the Palk Bay Zones of the east coast of the Madras state, particularly the area from Rameshwaram to Manapad, are of very great fishing importance as far as the pearl and chank fisheries are concerned. The submarine plateau of the inshore areas of the sea here affords excellent habitat for the growth of the shell fish, *Xancus pyrum* (Linn.) (the sacred chank) and *Pinctada fucata* (Gould) (the pearl oyster). Chank fishing and pearl fishing in this zone had been conducted from time immemorial under the control of the State. All along the stretch of the sea-bottom, extensive, flat rocky patches occur at a distance of 8-12 miles from the shore within 7-12 fathoms, separated from one another and surrounded by equally extensive patches of fine sandy areas at the same or slightly deeper zones. Whereas the chanks prefer fine and soft sandy areas called locally 'Poochi-manal' or 'pirals' as their abode, the oysters are sedentary and are attached to hard rocky substrata called 'Paar'. Occasionally the one is found in the natural habitat of the other. There are more than 65 well known 'Paars' (rocky sea-bottom) and lesser in number of good chank grounds in the Gulf of Mannar known to fisherman by their depth and location fixed by land bearings. The sea bottom on Palk Bay side is not rocky, at the same time less shallow also. The chanks growing in this zone are classified as 'Patti' variety which is priced less than the 'Jadhi' variety fished from Rameshwaram to Tiruchendur. The differentiation between these two lie in the latter being elongate, elegantly formed, comparatively narrower and with well balanced spire whereas the former is with a short spire. The Tirunelveli and Ramanathapuram chanks now constitute the bulk to meet the demand from Bengal for chank bangle industry. The price of chank offered was Rs. 160/- per thousand about sixty years ago but now it amounts to more than Rs. 1500/- per thousand. The annual catch delivered at Tuticorin alone ranges from 6 - 10 lakhs while chanks delivered at Kilakarai, Rameshwaram, Tondi, etc., may all be equally high if not more. In addition to the chank fishery which is an annual feature, pearl fishery off Tuticorin was also conducted in recent years, after a gap of 27 years. There have been successive pearl fishing since 1955 to 1961 and annually it brought a revenue of a few lakhs of rupees to Madras Government and to the world market several lakhs of rupees worth of oriental pearls. The pearl and chank fisheries are unique in the southern zone of the east coast of India and, therefore, deserve our special attention in the rational exploitation of the stocks so as to regulate the yield and reap these hidden treasures of the sea.

The chanks and oysters are fished by the age old skin diving. Excellent passages on skin diving practised in India are seen in the writings of a few fishery scientists but special mention should be made of the classic writings of late Mr. James Hornell. The craft and accessories used for fishing both chanks and pearl oysters are identicial.

The fishing season depends on the locality. Fishing by skin diving is possible only in clear waters for obvious reasons. During the period extending from November to middle of May the Palk Bay water is turbid while Gulf of Mannar is calm and its water clear. The conditions from June to October are congenial for Palk Bay fishing since gulf of Mannar becomes rough and turbid at this time. Skin diving is done by expert divers drawn from the districts of Ramanathapuram, Tirunelveli and Kanyakumari.

Viewed in the perspective of modernization or mechanization of shell fishing techniques to improve the lot of the diving professional, the introduction of modern diving apparatus in the commercial exploitation of the fishery becomes essential. The present skin-diving method can be effectively replaced. An expert skin-diver is capable of remaining underwater for just over a minute at a depth of 11 fathoms. Beyond this no regular skin diving is practised at present. This is one of the limitations of the diving. Any account of skin diving will be incomplete without relating the dangers to which the diver is exposed once he professes to dive. Apart from his own folly, the inherent dangers of the sea poses the problems of life and death to him. Shark bites, sting of the scorpion fishes and ray fish spines, stings of jelly fishes etc. are some of the agonies experienced by him. The introduction of modern diving equipments like the 'Self contained underwater breathing apparatus' (SCUBA) or Aqua-lung has come in handy and are being extensively used in foreign countries by divers in the place of skin diving practice. The use of this equipment together with fins for swimming and face mask for vision, not only increases the efficiency of the divers but also lessens many of the dangers enumerated above. The diver can clearly see the animals at the bottom and avoid dangerous animals. Naturally, the need of the present day is to train the divers in this modern method of diving. The Aqua-lung is very safe in diving up to 25 fathoms and normally a good diver can remain underwater for nearly 45 minutes at a time. Some of the unexplored regions beyond 11 fathoms can be commercially exploited by remaining longer under water facilitated by compressed air used in the aqua-lung. The diver, once he is trained in the usage of these, will find it easy to avoid cumbersome and elaborate procedures and routines. The skin divers at present reach the fishing grounds only by means of sail boat and so far no mechanized boat has been used by them for this purpose. This is a big handicap for them since on calm days they have to depend on towage by Government or private launches for reaching the grounds. Even on reaching the place, movement from place to place in search of chanks or oysters as the case may be is rendered a physically tiresome job. Physical exhaustion to divers hampers their efficiency in diving. In this context mechanization of their craft also becomes imperative. During the off season they can usefully carry out normal fishing with the mechanized vessels thus serving a double purpose.

Already steps have been taken by the Union Government to popularize the mechanized fishing boats among the fishermen and to train scientists and professional divers in the use of Aqua-lung. There are expert, young Indian biologists at Tuticorin well versed in this technique having been trained with the help of F. A. O. Rome A batch of professional divers has been also trained. It is hoped that other biologists and divers will take the opportunity to learn the modern diving techniques and put them to practice. The Government for their part will help in importing sufficient equipments with the help of F. A. O. and popularize them once the divers show a positive response. There is little doubt that the day is not far off when the divers engaged in pearl oyster and chank fishing will have their own mechanized boats and Aqua-lung sets and equipment.

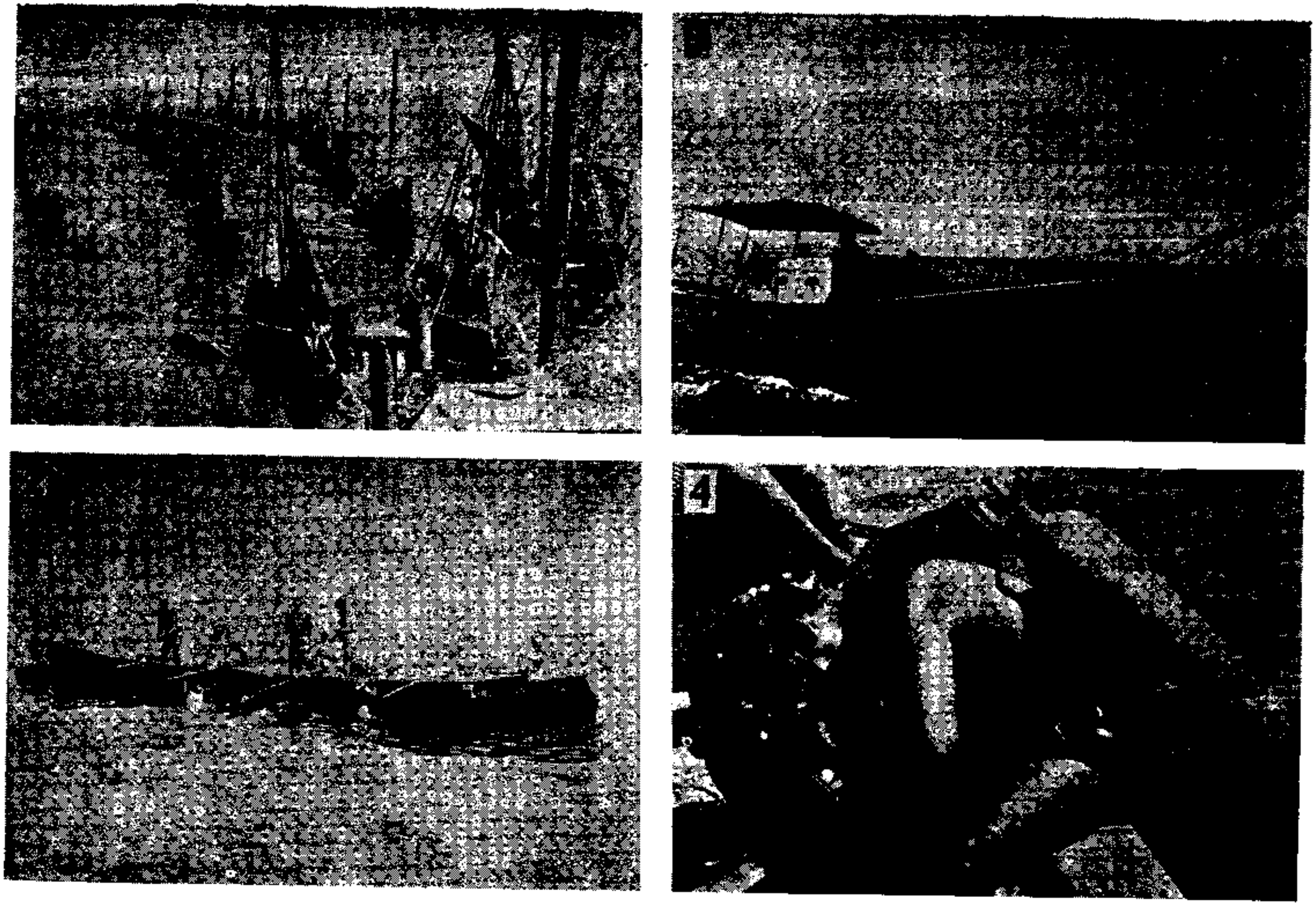


PLATE I. 1. Canoes engaged in chank fishing being towed to the fishing ground by motor launch. 2. Skin diving for chanks by local divers. 3. Mechanised boat recommended for diving with aqua lung. 4. Aqua-lung diving by a scientist.

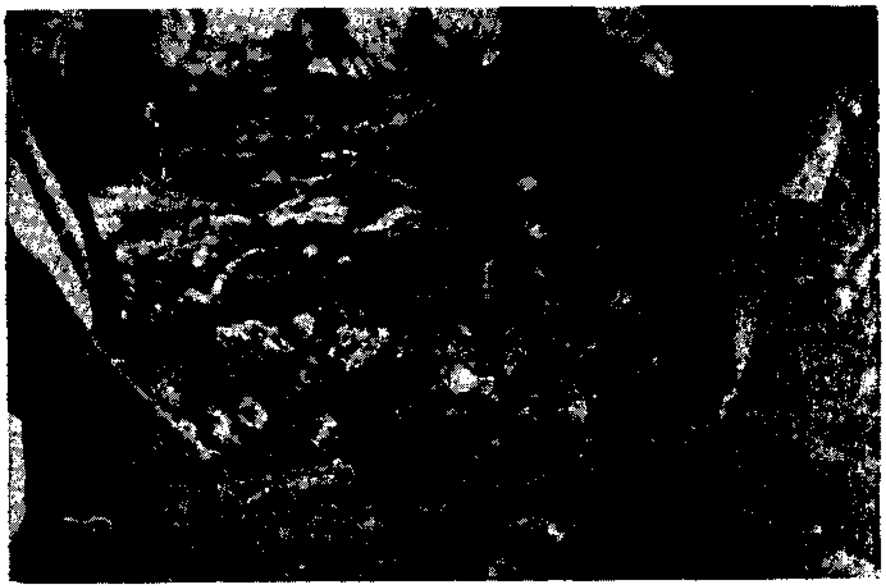


PLATE II. 1. Sacred chank (dextral type)
2. Pearl oysters

Phytoplankton

By R. Subrahmanyan

Central Marine Fisheries Research Institute

It is well known that all life depends primarily on the conversion of carbon and nitrogen into protoplasm. This can be accomplished only by the living plants which absorb the nutrient elements from the surroundings and with the aid of pigments in them, particularly chlorophyll, and with the energy from sunlight build up starch, proteins, fats, etc. In the terrestrial environment this is quite obvious–accomplished by plants such as grass, the crops, fruit trees and so on; in the aquatic environment, small simple plants with not much differentiation of parts, known as algae play this role.

Just as on land, animal life including that of man is not possible without the plants-plants feed the herbivores, the herbivores nourish the carnivores and man is an omnivore–so also no life can exist in the waters including that of fish without the algae. The algae contribute to the food of all organisms in the waters including that of the fishes, directly in some instances and indirectly in others through the smaller animals; and, man catches the fishes for his sustenance.

Algae are of several kinds; the greens (Chlorophyceae), browns (Phaeophyceae), reds (Rhodophyceae), yellowish-brown (Bacillariophyceae or Diatomaceae, Dinophyceae, Chrysophycese) and the blue greens (Cyanophyceae or Myxophyceae), so named because of the colouring matter in them which characterises each class; however, all of them contain the vital chlorophyll. In addition there are many minute flagellates of uncertain affinity with various hue.

The browns and reds and a good percentage of the greens are attached forms; compared with the quantity of the members of other classes mentioned above, consisting almost wholly of unicellular or simple colonial forms constituting the free floating flora, *the phytoplankton*, the bulk of the attached forms are almost insignificant from the practical and economic points of view.

In the inland waters–lakes, ponds, reservoirs and so on it is common to notice members of the Chlorophyceae, Cyanophyceae and Bacillariophyceae, chiefly in the order mentioned; in the sea, the Bacillariophyceae, commonly known as diatoms, account for the bulk of the floating vegetation.

The diatoms remained for years objects of attraction for microscopists, prized and wondered over because of the astonishing beauty of their ornamentation and sculpturing on their walls (Plate-I). Fossil deposits of these, known as kieselgur, or diatomaceous earth, were used as abrasives and bacteriological filters, and this also proved an excellent medium to hold nitroglycerine to form dynamite!

But their role, together with the other floating forms, in human economy came to be known and appreciated only recently, in the last 60 years or so, because of their value directly as food of our edible fishes. They are the most important of the prime synthesisers of all food in the vast masses of water all over. They are the *grass* of the sea. They are found in all the waters whatever be their nature and in all climes. Though individually insignificant, they surpass in their productiveness and bulk all other aquatic plants several hundred fold. Not only in the shallow waters along the coast are they available as food for fishes but they are the only prolific form of the plant life in the open sea, save the *Sargassum* (brown alga) of the Sargasso Sea off Mexico.

The study of these forms is beset with difficulties as special devices have to be employed to collect them. Usually a conical net made of the finest bolting silk (meshes of which roughly measure 50-60 microns, (one micron = 1/1000 of a millimetre) is towed through the water and the plankton collected in a small bucket attached below, or water is collected and centrifuged in a Centrifuge at high speed to concentrate the organisms in it. A high powered microscope is required to examine them. Collections have to be made at frequent intervals at different places, for which a well equipped research vessel is required It may be of interest to mention here that the Central Marine Fisheries Research Institute is engaged in this work since 20 years and recently much work is being done in the offshore waters with the help of the R. V. *VARUNA*.

Let us now examine the magnitude of the production of phytoplankton. As already mentioned, the phytoplankton constitutes the food for the smallest of animal organisms, including the young ones of fish. They are only removed one stage in the food chain of the largest mammal, the Antarctic whale, *Balaenoptera*; this whale is a feeder of the small shrimp like animal commonly known as *krill* (*Euphausia superba*); the krill is wholly dependant on the bloom of phytoplankton during the southern spring for its survival and growth. And when one considers the rate of growth of the whale, to weigh almost a 100 tons in three years, one can easily understand the importance of phytoplankton. Whales are much sought after for their meat and fats and whale fishery engages the men and hundreds of ships of several nations. The largest of the fishes, the basking shark, is also a plankton feeder, the copepod *Calanus* constituting mainly its food, the copepod itself thriving on the phytoplankton. The success of the herring fishery of the North Sea entirely depends on *Calanus*; the vicissitudes of this fishery in the past has affected the fate of several European nations. The fortunes of our oil sardine, mackerel and prawn fisheries are entirely dependant on the bloom of phytoplankton on the west coast of India. There are several other fishes; mammals of the sea and birds whose life is linked close to the phytoplankton; only the number of links in the food chain vary in each instance.

Phytoplankton is highly nutritious. They contain carbohydrates, proteins, fats, oils, etc. As an example, it may be mentioned that the value of cod liver and other liver oils of fish, their vitamin contents and so on, have been traced through the cod's diet ultimately to synthesis of these by the phytoplankton.

There are hundreds of species of phytoplankton in the waters, some characteristic of certain waters or regions. Thus we have freshwater and marine forms, forms of the arctics, temperate and tropical regions. Around our own shores, the writer has recorded over 500 species representing over 150 genera.

Though many species occur in the waters, only a few numbers are seen at a time and further only a few of them are found to occur in some bulk.

As each species has its period of growth and growth intensity depends on many external factors such as temperature of the water, salinity (saltiness of the water), nutrients in the water (phosphates, nitrates, silicates, trace elements and so on in solution – same as for land plants) and the physiological state of the species itself, *bulk* constituting species vary; and, external factors cited are related to water movements — horizontal (*Currents*) and vertical (*upwelling* – bottom water coming to the surface) and these in their turn are influenced by seasons and climatic factors. Thus there comes to occur a periodicity in the production of phytoplankton The peak period of production in the temperate and arctic regions occurs during the spring and summer; at other times, the temperature being very low limits growth, or, sometimes, the depletion of nutrients from the surface layers of water puts a check on growth as during late summer. In the autumn, due to rough weather, the bottom water, with nutrients is brought to the surface, upwells, when again there is a spurt of production; however, as temperature falls thereafter rapidly, production comes to an end.

Until very recently, very little was known about the conditions in our waters as most of the investigations were of a casual nature. Since the establishment of the Central Marine Fisheries Research Institute, work has been going on in our waters which has thrown considerable light about plankton life in our waters and its importance. Let us now briefly examine what obtains in the tropical waters such as ours.

In the west coast waters, maximum production of phytoplankton takes place during the south west monsoon months of May to September, after which there is a decline in the crop; later, during the north east monsoon also, another peak of production takes place– may be any time between December and February – though of a much lesser magnitude, compared with the first. The first bloom is comparable to the spring bloom and the second to the autumnal bloom occurring in the temperate regions The magnitude of the south west monsoon bloom here on the west coast waters is of a very high order surpassing those known from some of the most fertile waters of the world.

On the east coast also, though not investigated at such length, generally the maximum production occurs during the south west monsoon months followed by one or more peaks of production of a lesser magnitude during the north east monsoon months.

The diatoms form the bulk of the phytoplankton (PLATE-I); they determine the trend of fluctuation of the total phytoplankton crop; the peaks of production are mainly due to their multiplication. The Dinophyceae also show peaks of abundance, one during the south west monsoon as a result of the bloom of forms without hard cell walls (*unarmoured*) *e. g. Noctiluca*, (Plate II middle); and other blooms of armoured forms *e. g. Ceratium* (PLATE II top) during the north east monsoon months. The Cyanophyceae composed chiefly of a thread-like form, *Trichodesmium*, occurs in abundance during the warmer months of the NE monsoon.

Investigations on the factors responsible for the production of phytoplankton have shown that it is during the monsoon (active) months that conditions in the waters attain the optimum; abundance of nutrients (such as phosphates, nitrates, silicates and so on), due to upwelling and river discharges; a fall in the temperature of the water, from 31-32°C to 23-25°C; and a fall in the salinity of the water from 35‰ or more to 30-31‰, to mention the most important ones. At no time is there a complete depletion of the nutrients as in the temperate waters to act as a limiting factor. However, it is seen that the limiting factor here is the physiological state of the plankton elements themselves.

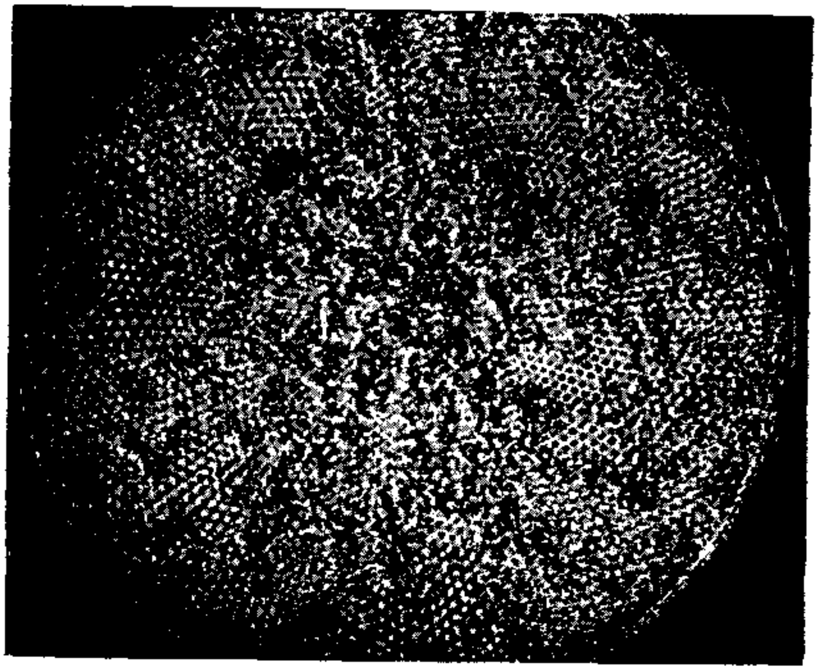
We have thus an oscillation in the production of organic matter and, as on land where crops are influenced by the monsoons, in our seas also the monsoons play an important role in the prospects of the phytoplankton crop, the basis of all food.

This enormous production of phytoplankton goes to cater to the requirements of hundreds of species of animals in all stages of development and size, the zooplankters, the fishes and so on. In fact, there is generally an increase in the population of these predators (*e. g* Plate-II, bottom, a Copepod) side by side with the increase of phytoplankton; and, often the plants are eaten up and one comes across only an animal population in the water some time. The latter aspect occurs during the north east monsoon season, when phytoplankton production is not as intense as during the earlier monsoon.

The links in the chain would have become evident from the above – the more plankton is produced, more food for the animal life, which in their turn constitute the food of many predators including young ones of valuable fish; more food for the latter means better survival rate and better harvest of fish for us at a later date.

Before concluding this review, it may be worthwhile to examine the magnitude of production of phytoplankton and its relationship to commercial fish landings. This would throw some light on the intensity of exploitation going on at present and also show whether there is scope for increased exploitation or whether we are already depleting the stock.

The phytoplankton production calculated for the west coast for an area of 155,400 sq. kilometres of 100 metres depth, a potential fishing area, works out to 1,813 million metric tonnes. The quantity of commercial fish landed on the west coast, on an average (upto 1965) is about 519,00 tonnes – represents about 76% of the total marine fish landed in India. The ratio of phytoplankton production to fish landed works out to only 0.029 %; this is only *about half* of the corresponding figure of 0.06% for the North Sea, an intensively fished area, probably the maximum return one can expect. The rate of turnover being



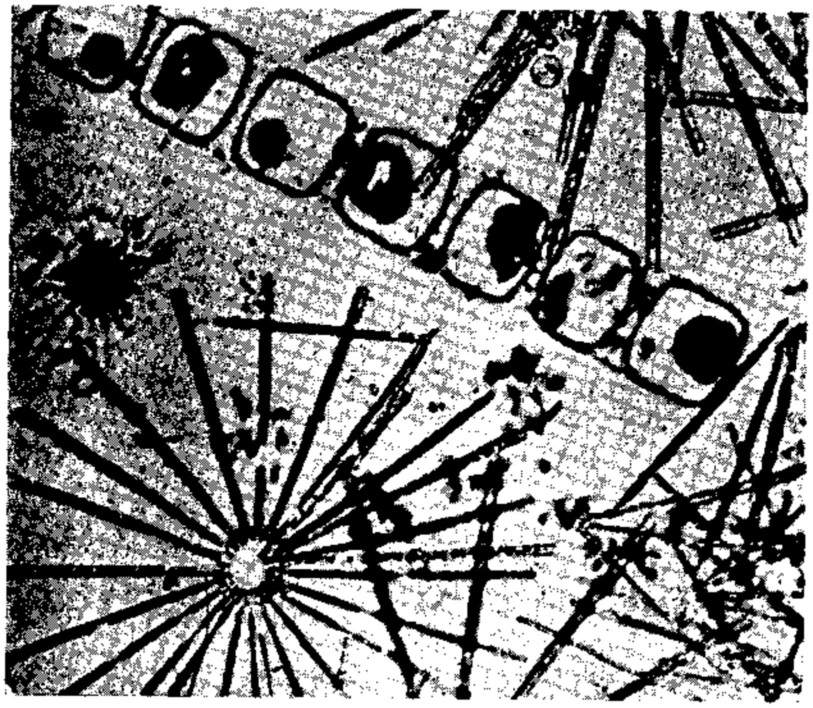


PLATE I. Upper: Photomicrograph of a diatom cell (portion) showing sculpturing on its wall.

Lower: Photomicrograph of some species of phytoplankton (diatoms).

— Photos by courtesy of Mr. P. R. S. Tampi.

PLATE II. Upper: Photomicrograph of a Dinophyceae.
Middle: Photomicrograph of another Dinophyceae which at times discolours the water.
Lower: Photomicrograph of some copepods, small animals which feed on the phytoplankton.

—Photos by courtesy of Mr. P. R. S. Tampi.

more in our tropical environment one could expect the same return if not more; therefore, our fish landings could be increased atleast two times or more with increased effort. Similar estimates for the south east coast of India indicates prospects of a five fold increase. These hypotheses have been substantiated by the increased landings since 1955 on the west coast with more fishing vessels operating and on the SE coast by the exploratory fishing of the Indo-Norwegian Project vessels. On the west coast, in 1955, the exploitation was 0.025%; which is about $\frac{1}{3}$ of the North Sea figure; in 1965, the ratio has increased to $\frac{1}{2}$ of the North Sea figure showing therby that there is still scope for exploitation.

Another interesting observation was that while a few species in great bulk constitute the landing on the west coast, on the east coast, the landings comprise of several species. A similar feature is noted in the constitution of the phytoplankton also; a few species account for bulk on the west coast while no one of the species can be said to occur in *bulk* on the east cost. Further, the magnitude of production on the west coast is many times that of the east coast waters; this is reflected in the fish landings also, 76% of the marine landings being on the west coast. Again, it was found that the plankton of the west coast contained more fat in them when compared with those of the east coast. This is of significance, for, this might explain the high fat content of the oil sardine and the mackerel caught on the west coast and their nutritive value as also the oil deposits off the west coast; for, it is due to the activity of these microorganisms at an earlier geological epoch that such deposits are caused.

The question may occur that as plankton is produced in such abundance and is very nutritive, why not catch plankton itself for food. Unfortunately, the quantity of water that has to be filtered to obtain, say 1 kg of plankton, will be so enormous that the attempt will have to be given up as it will be economically not feasible. Fishes are still the best and economical mode of utilizing this vast production of matter.

It may be mentioned in passing that an intense bloom of certain species which at times discolours the water red, yellow, green, brown and so on according to the pigments present in them, acts as a set back to the fisheries or even brings about mortality of marine organisms including fish. However, this is not of such frequent occurrence in our waters to cause any anxiety.

The phytoplankton, the pastures of the sea, thus play an important role of significance to our food resnurces from the sea and thereby in our economic life.

Fishery Oceanography

By C. P. Ramamirtham

Central Marine Fisheries Research Institute

The ocean in itself is not a homogeneous medium although it is a single phase environment. The temperature, the amount of dissolved organic and inorganic matter, the amount of dissolved gases and the physical nature of the ocean are subject to various changes seasonally and regionally. The climatic conditions of the atmosphere also affect the ocean and the exchange of energy between the sea and the atmosphere is also important in this respect. The *in situ* changes in the ocean affect the production of planktonic organisms which form the food material for the fish. The spatial differences in the mass distribution of the oceans which can be estimated from temperature and salinity, give rise to ocean currents, which help the transport of fish eggs and larvae and which affect the movements of adult fish also. Thus the fluctuations in the environmental conditions have a profound influence on the aperiodic and seasonal migrations and occurrence of fish. Furthermore, the conditions in the aquatic environment and their changes influence the recruitment, survival and growth of fish. The environment also interferes with such biological activities as spawning and growth. Thus, for instance, the survival and abundance of all the food specimens of fish are affected by the environmental factors most decisively. Oceanography, which deals with the study of the physics, chemistry, as well as the biology of the oceans, is thus indispensable for the study of fishery conditions in a particular region.

The pursuit of all oceanographic studies have had as its objective the exploitation of the resources of the seas for the benefit of mankind. It would be interesting to recall, curiously enough, that the studies started in the wake of charting sea routes for the fabulous riches of the east, when incidentally the ships sounded the depths of the sea. The first remarkable cruise solely devoted for oceanographic studies was that of the *CHALLENGER* in 1872 under the leadership of Sir Wyville Thompson. Since the beginning of this century there have been several more expeditions with more sophisticated equipments on board. Amongst these are those of the *VALDIVIA* sponsored by Germany; the *DISCOVERY I & II* and the *WILLIAM SCORESBY* into the Antarctic and in the near past *GALATHEA* visited our seas. By the close of the last century various nations had recognized the importance of oceanographic investigations and extensive researches were started in many of them. In this connection it is worth mentioning here the formation in 1901, of the International Council for the Exploration of the Seas with its headquarters in Charlottenlund near Copenhagen, to promote cooperation between the countries of Europe in the researches of the sea.

The first person to give a general feature of the surface conditions and pattern of circulation in the Indian Seas was the late Col. R. B. Seymour-Sewell. Hydrological studies were started in the Central Marine Fisheries Research Institute as early as in 1947, but the observations were restricted to localised shallow stations off Calicut, Bombay, Cochin, Madras and Mandapam Camp. A hydrographic survey of the shelf waters was carried out along the east coast of India by Prof. E. C La Fond, during the years 1952–53 and 1956-57. But, detailed systematic studies along the west coast where nearly 80% of the marine fish catch is landed was initiated by the Central Marine Fisheries Rasearch Institute in September 1957, with the co-operation of the Indo-Norwegian Project, Ernakulam. The first vessel to be utilised for oceanographic research work was *M. O. KRISTENSEN*, but due to the unsatisfactory condition of the vessel it was condemned and replaced by *R. V. KALAVA*. The latter vessel was used till December 1961. During this period, observations were made in the area Cape Comorin – Mangalore, and the Laccadive region. The fully equipped research vessel *VARUNA* arrived in December 1961. This enabled an extension of the area of investigation and the duration of the research cruises. 674 oceanographic stations were worked out along the west coast in the Arabian sea by *M. O. KRISTENSEN* and *R.V. KALAVA* in 63 cruises, and nearly 2950 stations have been worked out by *R. V. VARUNA* in 104 cruises till now.

Of all the environmental factors temperature plays an important role to influence the behaviour of fish. The sense of temperature in fish seems to be well developed. There are tolerable limits of lowest and highest temperature, beyond which fish may no longer survive. Another thermal feature which affect the vertical migration of fish is the thermocline. The latter is defined as a layer within the sea where rapid decrease in temperature occur in the vertical, downwards. Above this thin layer, the waters are usually warm and also rich in dissolved oxygen content, which conditions are favourable for the pelagic fishes.

The major commercial fisheries like those of the sardine, mackerel and prawns along the west coast of India exist within the continental shelf. During post monsoon season and subsequent months the waters over the continental shelf are warm (temp. range 27–29°C roughly) and sardines generally appear along the west coast by the end of monsoon or the beginning of post monsoon. From a preliminary study it is observed that the fishery starts from the south, gradually proceeding northwards. The warm waters after the monsoon period seem to be favourable for these pelagic fishes and never is found a thermocline within the shelf during this period viz., November–May. These more or less isothermal waters are rich in oxygen content also. Such conditions are in general found to be favourable for these fisheries. The peak sardine fishery seems to be in November and December in the south generally, while December and January are the months in which peak fishery in the north occurs During late November and December it could be said that winter conditions exist along the west coast when the waters are cooler than the following summer. Sinking of the offshore waters over the continental shelf also occur, and this phenomenon defined as convergence cause dynamically a concentration of zooplankton and an accompanied concentration of fish. Figuratively, one may say that there is an accumulation of everything on the convergence zones, from plankton to fishermen. Drastic changes in temperature affect the fishes in an adverse manner and thus during the year 1962 a predominent failure in the sardine and mackerel fishery occurred. Considerable investigations have been done on this problem. However, the failure in the mackerel fishery may perhaps be due to an increase of the surface temperature which occurred during that year.

The demersal fisheries along the west coast after the monsoon are also good. R. V. *VARUNA* is regularly conducting bottom trawling along the west coast during the various seasons.

Now coming to the conditions existing during the monsoon and post monsoon periods the following points can be noted. From the year 1962 onwards, regular research cruises are conducted during the monsoon season also, along the west coast. During the above season a considerable amount of upwelling takes place along the entire west coast. This process can be primarily defined as the incursion of offshore subsurface waters into the continental shelf. Thus the temperature of the waters within the shelf is considerably reduced and the whole of the shelf (the major fishing zone) is filled with very cold oxygen-poor waters. Sometimes the intensity of the process is so high that a decrease of nearly 7°C occur at the upper layers, (5, 10, 20 m etc.) than the preceding summer. During the period of upwelling the demersal fishes will try to escape the oxygen poor cold waters, and either migrate to upper layers or to the shoreside waters inside 4–5 fathoms depth, where saturation takes place due to vertical mixing by wind and wave action. Similarly the pelagic fishes like sardine and mackerel are also found to escape the normal fishing zones.

The drastic decrease in the temperature of the environment can be attributed as a probable cause for the above phenomenon, combined with the depletion in oxygen content. The intense rough nature of the sea may also be a probable cause. The upwelling has been defined as vertical migration of the deeper waters, and this may produce vertical accelerations and this turbulence helps in the replenishment of the upper layers by nutrients from below. Preliminarily this may cause the formation of mud-banks along the coast, at localised areas. The fishery near the mud-banks during the monsoon also is good, and may be attributed to the calm conditions prevailing near the mud-banks and due to the oxygen enrichment due to the shallow depths.

Within the sea the temperature decreases depthwise and the nutrient contents (such as phosphate, nitrate, silicate etc.) generally increase. The nutrient contents are important for the primary production in the sea. As mentioned earlier, the upwelled nutrient rich water is thus fertilizing the coastal waters and form a feeding area for plankton organisms, which again form the food stock for the commercially important fishes. The monsoon period of the year 1962, gave pronounced upwelling between Beypore and Mangalore along the west coast. Thus one may expect the area mentioned to be the most productive regarding food stock and therefore, it should also be expected to give the best fishing possibilities in the post monsoon period by which time the aeration of the waters is complete. The intensity of upwelling and its duration will change from year to year and region to region. Thus, mechanized fishing operations in the area off Cannanore has proved to be better during the post monsoon period of the year 1962 than in the South Malabar coast during the same period.

The theory of the influence of upwelling has to be verified with observations during subsequent years and such regular studies are being conducted by the Central Marine Fisheries Research Institute. With a close follow up of the theories however, a valuable prediction of the fishing possibilities of the commercial fishing fleet may be obtainable. In general it may be said that in the premonsoon period of the year 1962, shoals were mostly registered within a distance of approximately 10 nautical miles from the coast. During the monsoon period, considerable shoals of fish were observed at surface layers all along the coast, with the best registration in the area southwest of Alleppey and between Cochin and Calicut.

From the investigations carried out by R. V *VARUNA* a large convergence zone has been found during the early winter (late November) along the 8°N latitude, around the 74°E meridian. As mentioned earlier, these convergence zones form suitable spawning grounds for the fishes and an area where zooplankton production may be high. The hypothesis based on catch data that sardines first appear in the south, may thus be primarily correlated with the above mentioned convergence zone, but more data is necessary to confirm the above.

The sunlight penetrating from the surface through various layers of the sea is important from the viewpoint of the fundamental production. It is by utilising the light energy, that the phytoplankton of the sea produce for themselves the carbohydrates by photosynthesis. The limitation of penetration of sunlight in the sea puts a natural limit to the primary production. The latter in oceanic waters is directly correlated with the optical nature of the water masses, optically clear water being less productive and the turbid water being highly productive. Light measurement studies of the Arabian Sea are being done on board R. V. *VARUNA* by the Central Marine Fisheries Research Institute, likewise primary production studies also using the radioactive isotope of carbon viz., ^{14}C.

It appears from observations that every species of fish has a particular optimum light intensity where the activity of the fish is at maximum. Fishing with different gear also is affected by conditions of light. It is due to the scattering of light from an object that the fish can perceive it. There must be sufficient day light for the bait of longline to be visible, to attract the fish in turbid waters. Fish like Tuna can avoid gill nets if they are visible.

The response of fish to currents depends upon the factors like the manoeuvara bility of the fish to resist movement, their swimming capacity and the stress of the current. Some observations on herrings in the high latitude waters suggest that they were stemming the current at the swimming speed of a few knots, although they were being carried along with the current. In light, fish swim against the current and in darkness they drift with it Large eddies keep the larvae and fish eggs concentrated at a particular locality. From the investigations done by the research vessels *KALAVA* and *VARUNA* around the Laccadives, it has been observed that around the islands there exist circulatory movements upto a notable depth (100-200 m from the surface and these help to maintain the highly productive waters in the vicinity of the islands, thus contributing to the rich fisheries that are found in the Laccadive area. Several fish species concentrate in the centres of eddies and this. refers to spawning in some cases. It is observed that feeding pelagic fish usually move with the water masses. Along the west coast it is found that the currents are mainly southwards during the monsoon and postmonsoon seasons, and mainly northwards from December to February. This probably influences the movement pattern as well as regional intensity of fishing of sardine as referred earlier. As a preliminary step, it may happen that the fish migrate along with the northward current and this may be the reason for the time lag in the sardine fisheries along the west coast. Now that the Central Marine Fisheries Research Institute has initiated tagging programme to study the migration of the pelagic fishes, this may throw more light on the fluctuation and the regionwise variation in the pelagic fishery.

The salinity variations mainly depend upon rainfall, run off from rivers and evaporation at the sea surface. These variations affect the buoyancy of the pelagic eggs and the osmotic regulations of the fish. The salinity maximum found along the west coast during the winter and summer seasons, may act as a buoyant barrier for the vertical migration of the eggs and fish. It is also observed that this salinity maximum layer usually coincides with the thermocline. The position of these two layers viz., the thermocline and the associated salinity maximum zone are important from the view point of the vertical distribution of the buoyantly floating eggs and larvae of the pelagic fish, which are affected by the vertical turbulence occurring in the mixed layer above the thermocline. This zone, so to say, is a barrier making it for some fish to pass through because of the temperature contrast of the water bodies within the thermocline, as well as the consequent density contrast which affect the buoyancy.

The pH observations from an important part in fishery oceanographic studies The pH generally encountered in the sea ranges from 7 5 to 8.4, that is the sea water is generally alkaline. pH below 7 indicates that the water is acidic, and pH 7 indicates neutral water. High pH values are associated with the photosynthetic removal of carbon dioxide. From observations made on board R. V. *VARUNA*, it has been observed that the mixed layer above the thermocline has always high pH ranging from 8 to 8. 3, during the period of summer. This range thus seems to be suitable for the pelagic fishes is general. The dis continuity in pH in the vertical, always coincides with the discontinuity in temperature- Fishes in general are able to detect slight changes in pH values and the actively migratory, fish such as sardine and mackerel are more efficient in this respect. Scientists in other countries have actually proposed an optimum pH range for particular species.

Thus the fishes and fisheries are very much influenced by the oceanographic conditions in the sea. During recent years the importance of oceanography in fisheries had come to be fully recognized. Several countries in the west and Japan in the east have by many decades of intensive research, come to a state when they could forecast the prospects of a fishery much ahead. In this respect we are still at the infant stage and much work has to be done in our waters to help solve the problems connected with two of our main fisheries viz., the oil sardine and the mackerel. More and more oceanographic as well as fishery data are being collected and intensive correlation studies are being made. The observations from the International Indian Ocean Expedition during the period 1961-1965 may also throw light on the fishery aspects of the Indian Ocean. The studies are in vogue in the Central Marine Fisheries Research Institute, on the west coast of India on all aspects of oceanography. Thus, fishery oceanography investigations are quite essential in any large scale fishery investigations and these studies have to be of a continuing nature, the sea being a dynamic aquatic environment.

The Mud Banks of the West Coast of India

By D. Sadananda Rao

Central Marine Fisheries Research Institute

The periodic formation of mud banks along the southern section of the West Coast of India between Cannanore in the north, and Neendakara near Quilon in the south is a most interesting phenomenon the like of which has not been reported from anywhere else. This takes place with cyclic regularity in the inshore areas during the South West Monsoon reducing considerably the wave action in the sea on an otherwise surf-ridden coast. The areas where such mud banks are formed provide safe anchorage for ships and facilitate fishing operations also and are therefore welcomed by the coastal people who depend on the sea for their livelihood. As the richest prawn fishing grounds in the country are located within the same region, the mud banks are of great interest from the economic as well as scientific points of view. Not much work appears to have been done on them since the extensive observations made in the thirties of this century by late R. C. Bristow, the architect of Cochin harbour whose reports are still the most important contributions on the subject.

The most important and well known mud banks are at Narakkal just north of Cochin, off Alleppy and two smaller banks at or near Calicut. The bank at Narakkal is usually situated at the mouth of the Periyar river and extends about 3 miles along the shore from south to north and 4½ miles out to the sea. The mud banks at or near Calicut as well as that at Alleppey are mobile in nature. In addition to the above four, the mud bank formation occurs at Quilandy, at Beypore, at Veliyangod, at Munambam, off Cochin south of the harbour entrance, near Chellanam and near Alleppey. These mud banks are often of an ephemeral nature appearing during some years and absent at other times.

With the commencement of the monsoon, when upwelling takes place, the bottom mud gets stirred up. During this process, there is the same surf as in other parts of the sea shore and the water becomes discoloured and dark with the churned up mud. The water has an oily look at this time and at times brings air bubbles, stems and branches of apparently submerged trees and along with them dead fish also. The Alleppey mud bank is peculiar in that at times its smooth surface is disturbed by "mud vulcanoes" or huge "cones" of mud and water bobbing up. But after this stage, the mud settles down and water becomes clear. The full characteristics of these mud banks in providing a perfectly quiet anchorage during the monsoon are not fully developed till the monsoon has sufficiently advanced to render water in the backwater on the landside quite fresh and during this period the water out to the sea is also fresh. The effects are that monsoon swell gradually subsides over the outer limits of the bank. At this stage the mud banks have the special property of giving complete quiescence to the waters in its environs even in the roughest monsoon weather. No surf breaks along the margins of the banks and the waves merely die away.

The sea bottom from about a mile from the shore out to 30 fathoms along this part of the coast is composed of soft grey mud with small dead shells. It is believed that the mud deposits are terrigeneous in character and largely derived from the laterite and alluvial belt of the coast which originated from the disintegration of gneissic rocks of the interior. The mud of both sea bed and mudbanks are thought to be brought down by the present and past rivers.

The mud banks are probably formed by the interaction of forces of a varied nature such as currents, river discharges, tides, wave action, ground swell etc. as also cyclones of exceptional storms and seismic disturbances. The investigations carried out at this Institute show the presence of upwelling and divergence near the bottom between 20 and 30 metres along the coastline north of Quilon during the South West Monsoon period. These produce vertical accelerations with the resultant lifting of the bottom waters. As the bottom is composed of fine silt, the mud is also consequently lifted up which comes almost to the surface. This mud being kept in position in the regions of convergence along the coast, we get the formation of mud banks. Thus the convergence takes place against a barrier, mud bank and thereby more mud deposited. This along with the forces mentioned above play an important role in the formation, maintenance, dissipation and movement of the mud banks.

Mud banks are known to shift from place to place. The Narakkal bank which is situated at the mouth of Periyar river sometimes moves south, not continuously, and these southward movements occasionally cease and shifting to north takes place. The mud bank at Alleppey also moves south, but something very remarkable happens here, either the bank is rapidly driven to north again and inshore, or another bank bursts up from sea bottom at or north of the Alleppey pier. Its movement to the south is generally more rapid and constant probably because the currents are from north to south during this season aiding their movement to the south.

The analysis of the offshore mud as well as the inshore mud shows that both have a common nature and origin. The mud is of a fine grained type, about three-fourth of which is composed of particles having effective diameter of 0.002 mm, or less and the remaining which is called the silt fraction composed of particles between 0.02 and 0.002 mm. in diameter. The mud itself which is peculiar and is not found elsewhere along the coast is dark green in colour, fine in texture and oily to touch. The X-ray and minerological examination of the mud particles show that the coarser particles are composed predominantly of quarts and a mineral of the kaolinitic type. From a chemical point of view, the mud has been found to contain in addition to the volatile matter, silica, aluminia, ferric oxide, ferrous oxide, lime, magnesia, sulphates and phosphates. The examination for the oil content indicates that it is about 40 parts per million of the original mud.

The investigations carried out on the bottom muds have indicated that values for interstitial phosphate were higher than the corresponding values for the inorganic phosphate in the overlying water during the pre-monsoon months and that the mud here retains relatively large quantities of phosphate and probably other nutrients. The water expressed from the mud of the mud banks gives high figures for phosphate and silicate and these nutrients show a rise in the concentrations with falling tide possibly due to turbulence set up by the ebb tide bringing the nutrients out of the sand and mud banks. The bottom muds also contain organic matter and the extraction with organic solvent like ether gives a deposit which is composed of colourless, crystalline needles probably of a carbohydrate nature. It is shown that the mud also contains besides inorganic nutrients, important organic substances and growth promoters which are essential for the growth of phytoplankton and the absence of which could act as a limiting factor. The muds of these banks have been found to contain the diatoms belonging to several families also.

The mud banks appear to play an important part in the biology and chemistry of the sea water in these parts. During the South West Monsoon, owing to the abundant rain fall, there is a fall in the salinity of water which is considerable at times in the surface layers. At this period of lower salinity, the conditions are favourable for the growth of phytoplankton. Cells of those species of diatoms which have attained their minimum characteristic size form auxospores. Auxospores of several species as also large cells of many others indicating the occurrence of such a process, have been met with in the plankton collections at this period made by this Institute which confirms the view that the conditions are favourable for this process of rejuventation of the protoplast of the diatom cells. The mud of the mud banks which is a rich store house of various nutrients like phosphates, nitrates and silicates makes the water replenished with these nutrients during the process of the formation of mud banks when churning up of the mud with water takes place. These nutrients in the sea water act as an ideal culture medium from which phytoplankton draws its requirements and rapidly multiplies leading to its main bloom during the South West Monsoon season. Sometimes a bloom of phytoplankton appears even when the salinity is as high as 34 or 35‰. This does not, however, appear to be a result of sexual reproduction and auxospore formation of the diatom elements. Here it is due to vegetative multiplication chiefly of the diatoms. Such blooms occur during or after a period of strong winds which appear to mix up the water layers and make available certain growth promoting substances from the lower layers of the bottom sediment, for there is always a good quantity of nutrients present in the water, such a change leads to the multiplication resembling renewal of media in the cultures. Thus the process of formation of mud banks seems to play an important role in the production of phytoplankton blooms in these parts. As these microscopic organisms fluctuate in response to climatic changes, water movements, nutrient content of water and so on they form an important and convenient link in the assessment of the stock of fish.

One characteristic feature of the mud banks is that the water in their environs remains extremely calm even when the roughest weather prevails and sea is very rough in the surrounding areas. In the region of the mud banks the water surface has been found to be oily and this was believed to effect the calm conditions. However, this effect is supposed to be due to the suspension of fine matter increasing the viscosity of the water which helps to break up the force of the waves.

During the monsoon period when upwelling takes place the oxygen poor waters of the bottom layers are brought up and the fishes migrate to the near shore regions where they can get more oxygen. Due to the extreme calmness prevailing in the region of the mud banks the fishes can find an easy shelter here.

It may be pointed out that with the onset of the South West Monsoon, owing to the stormy weather, regular fishing operations are at a stand still and calmer conditions prevail in the sea about August. So the apparent paucity of fish landings during this early part of the period may not be entirely due to the fishes being not available in the waters, but fishing operations being not possible due to the weather. It may be seen that good landings can be expected even during the peak period of the monsoon as may be seen from the landings made in June 1953, when the fish mainly caught was the oil sardine, a phytoplankton feeder. Fishing operations are possible during this season at places where mud banks occur. The sea is calm in its environs and fishermen are able to take their canoes out; otherwise, the strong surf near the shore during rough weather prevents them from launching their boats. The topography and the presence or absence of the mud banks seem to influence the fishing operations here during these early South West Monsoon months.

From the fish catch data collected by the Central Marine Fisheries Research Institute, for the years 1965 and 1966, during June-August, the catch composition in the Alleppey mud bank area is found to be as given below.

	Quantity in Tonnes	
	1965	1966
Penaeid prawns	929.10	1280.88
Oil Sardine	51.05	1469.92
Other Sardines	21.54	312.81
Sciaenids	57.59	317.57
Mackerel	107.89	51.16
Soles	10.64	402.67

Average fish catch (in Kg.) per landing centre per day in the mud bank and other area in Alleppey zone during June-August is as given below.

	1965	1966
Mud bank area	2,011	10,907
Other area	356	309

This shows that the formation and occurrence of mud banks play an important role in the fishery, possibly because of the calmness prevailing in their regions.

The mud bauks, which are found to occur along this west coast of South India, have great influence on the fish catch which is high compared to that of the other parts of the country. Investigations are in progress now at the Central Marine Fisheries Research Institute on the various hydrographical, chemical and biological aspects of the mud banks.

Ocean Currents

By A. V. Suryanarayana Murty
Central Marine Fisheries Research Institute

Looking at the sea one sees the ripples on the surface and the rolling waves, but a more keen observant sees that more portions on the shore are submerged at times and exposed at other times owing to the rise and fall of sea surface, the tidal influence brought about by the gravitational pull of the sun and moon on the oceans. What one fails to notice is that the body of water is in constant flowing motion; this becomes obvious when one watches some debris floating on the surface. This movement of water is known as current. Some of these currents are so enormous in extent that the Amazon could be found a rivulet. The speed of movement varies from a few meters per hour to several knots.

The three-dimensional motions lead to and ensure a thorough mixing and circulation of the ocean waters which is of significance; they ensure a constancy of temperature, despite the heating and cooling processes at the surface; ensure transport of oxygen to the depths of the oceans and maintain the constancy of the salinity of the waters and ensure the distribution of nutrient salts. These lead to the sustenance of the tremendous organic production and supply of food to the millions of organisms in the water including fish on which we are dependent. The currents are not only at the surface but in deep waters also. These can be studied by measuring the temperature and salinity at all depths at several geographical positions and studying their distribution across the length and breadth of the oceans. The density gradients and wind force and so on cause this horizontal movement of water. The vertical and horizontal distribution of dissolved oxygen and nutrients, the similarity of plant and animal populations are also used to trace the origin and movements of water masses. We have several well-established currents in the oceans, the Gulf Stream, Kuroshio, California, Benguela and Peru currents to mention a few. The Gulf Stream of the North Atlantic carries larvae of the eel from the Sargasso Sea to the coasts of Europe. The Kuroshio Current of the North Pacific supports vast pelagic fisheries of Japan. The California Current flownig along the west coast of the United States is important for the California sardine fishery. The Benguela Current of the west coast of South Africa has a tremendous impact on the pilchard industry of the Southwest Africa. The Peru Current off the coast of South America is one of the highly productive waters and accounts for the vast shoals of anchovies and the guano deposits which are the faecal deposits of birds which feed on these fishes. Guano deposits are a rich source of fertilizers.

We owe our knowledge of the currents in the Indian Ocean and adjacent seas to the data gathered by the British Admiralty and the pioneering work of the late Col. R. B. S. Sewell (the '*INVESTIGATOR*' cruises) and the *JOHN MURRAY EXPEDITION* and quite-recently of the work carried out in the Central Marine Fisheries Research Institute and the International Indian Ocean Expedition.

In the North Indian Ocean the main water mass is the Equatorial Water (Tropical Water) which covers the central part of the Indian Ocean and extends into the Arabian Sea and the Bay of Bengal. This water mass is present at depths 100-200 m. The Bay of Bengal Water is subdivided into the North Dilute Water and the Southern Bay of Bengal Water. The Southern Bay of Bengal Water which is relatively productive is the most predominent surface water mass in the Bay. The North Dilute Water of the Bay is formed during the fall due to the influx of water from the rivers emptying into the northern region of the Bay. The highly saline surface water in the Arabian Sea area sinks and forms the so called North Indian Deep Water (Arabian Sea Water). This water mass penetrates to the south and could be traced up to Java in the East. Its exact limit to the south is yet to be established. It is characterized by high salinity and very low oxygen content. The warm and highly saline Red Sea Water flows along the bottom of the Strait of Bab-el-Mandeb into the Indian Ocean where it mixes with other water masses and spreads. The transform ed Red Sea Water was observed up to 68°E longitude only. Recent investigations of R. V. *VITYAZ* revealed that the role of the Red Sea Water in the formation of the Arabian Sea Water is not as considerable as it was believed earlier. Apart from the Indian Ocean Tropical water which extends from the Equator to the Tropical Convergence (24°S), the Subtropical Surface Water and the Subantarctic Surface Water are the main surface water masses in the South Indian Ocean. The Subtropical Surface Water extens from the Tropical Convergence to the Subtropical Convergence (42°S). The subantarctic Surface Water extends from the Antarctic Convergence (50°S) to the Subtropical Convergence. The mixed Subtropical and Subantarctic Water masses in the Subtropical Convergence region give rise to the formaiion of the Central water Mass which sinks and spreads northward from the Subtropics at depths 200-600 m This water mass bridges the poorly saline Antarctic Intermediate Water and highly saline Surface and Subsurface waters. It is known for its moderate temperature and salinity, and high oxygen content. The Antarctic Intermediate Water forms in mid-depths by mixing up of Antarctic and Subantarctic Water just north of the Antarctic Convergence. This water sinks and spreads northwards at about 1000 m, depth. This water mass may spread even into the Northwest Indian Ocean. The Deep Water which is of Atlantic origin is also present in the South Indian Ocean, apart from the North Indian Deep Water. This water usually lies between 1600 and 3000 m. The Antarctic Bottom Water exists below 3000 m. It is a very stable layer. Very little change occurs within this layer. Temperature of this watermass in the Indian Ocean is usually less than 2°C and the salinity about 34 7 parts per thousand.

A very wide belt of of the equatorial region (from about 20°S) of the South Indian Ocean is occupied by westerly drifts at the surface. The current is called the South Equatorial Current. It starts from the north-west corner of Australia, branches into two off the east coast of Madagascar. The southern branch of the current partly joins the south flowing Agulhas current and partly mixes with the east flowing Antarctic West-Wind drift. The northern branch of it feeds the Somali current during the Northern Hemisphere summer and the Equatorial Counter-Current during the Northern Hemisphere winter. The Equatorial Counter Current is an eastward flow. The width of this current which is very narrow depends upon the season. But it however, lies south of the equator unlike its sister currents in the other oceans. North of this counter current, there is again a west-bound flow spreading upto about 5°N which is known as the North Equatorial Current. There is a relative seasonal spread of the respective bands of these currents which may be associated with the shift of the doldrums. The South Equatorial Current and the Equatorial Counter Current are steady throughout the year whereas the North Equatorial Current reverses its direction during the Northern Hemisphere summer during which season the southwest monsoon is active. Apart from the east-bound strong drift currents, the monsoon circulation develops drift currents in the North Indian Ocean which vary from region to region. The drift currents developed in the Bay of Bengal, which flow northeastward, lead to an extremely high piling up of water along the eastern side of the Bay. As a result of these drift currents, the coastal currents in the southern part of the east coast of India will have northeasterly components flowing away from the coast and the coastal currents in the northern part of the east coast will be parallel to the coast.

The drifts in the Arabian Sea during this season (Northern Hemisphere summer) are relatively strong. They take a clockwise deviation (anticyclonic shear) as a result of the continental effect. In view of this, the drift currents in the Arabian Sea assume more southerly components on the western side of the Indian peninsula. Therefore, the currents off the west coast of India, during this season, flow southwards parallel to the coast. Beyond the Indian peninsula, the drifts regain their eastward components and are finally reinforced with the eastbound Equatorial Counter Current. As a result of this reinforcement, the easterly currents south of Ceylon get strengthened.

During the Northern Hemisphere winter the drifts in the Arabian Sea are south to southwesterly. The drifts in the Bay of Bengal, during this season, present with an interesting feature. The entire Bay region is occupied by a single cell constituted by clockwise drift currents. As a result of this, the waters of the central part of the Bay are almost at a standstill and the waters of its southern region experience a reversal of the currents of the previous season.

As the current from the southern rim of the clockwise cell joins with the Equatorial Current, there would be a concentrated westward flow south of Ceylon. Due to the boundary effects, it is possible that this strong current may take a northerly deviation from its general westward flow. It flows close to the Indian sub-continent or even northward to some extent on the western side of the sub-continent. Such deviations of the flow during this season (Northern Hemisphere winter) may be important from the view-point of the commercially important pelagic fisheries like the sardines and the mackerels which are supposed to enter the Indian fishery from the latitudes south of India and which show marked differential regional changes in their fisheries along the Southwest Indian Coast In fact, the northward movements from the surface to at least down to 200 m. depth, in the southeastern Arabian Sea area (off the southwest coast of India), were revealed from the hydrographic observations of R. V. *VARUNA* during the same season.

From the fishery view-point, the important upwelling regions, namely the Somali Coast, the Java Coast and the North West Australian Coast, are all associated, directly or indirectly, with these wind drifts. The fishing grounds of the tunas in the Indian Ocean are located within the broad belt of the Equatorial Currents. The tuna fishing is more intense in the South Equatorial Current region rather than the region of the other two counterparts of this current.

Apart from the wind drifts which occupy a wide suface area of the Indian Ocean, there are some major currents in the ocean. It may be interesting to deal with them in detail.

In the Southwestern Indian Ocean (south of Madagascar) there is a rapidly flowing southward current along the east coastline of South Africa. This is known as the Agulhas Current. It is strongly developed during the Northern Hemisphere winter. It varies from 50 to 100 miles in width with surface velocities of about 2 to 4 knots. It extends to much greater depths (about 3500 m) unlike the other currents in the Indian Ocean, The current is bounded offshore by a weak couter current at the surface. There is also a counter but weak flow at great depths under the current. In the view-point of extending to great depths, the Agulhas Current is comparable with the Gulf Stream.

There is a strong northward flow parallel to the Coast of Somalia. This is known as the Somali Current. This current was studied in great detail by R. R. S. '*DISCOVERY* III' during the International Indian Ocean Expedition in the recent years. Surface currents of the order of 6 knots are present in the core of the current. The current takes a deviation from the coast in the northern part of its course (8°N). The current is bordered, on its oceanic side, by a weak counter current at the surface. A weak opposite flow is also present underneath.

As it is driven by the stress of the monsoon airflow, the Somali Current is present only during the Northern Hemisphere summer. This is the reason why it runs across the equator, unlike the other "western-boundary" currents such as the Gulf Stream and the Kuroshio. During the other season, a reversal of this current takes place, but it is feeble when compared with the north-bound Somali Current.

In the Northern region of the Somali Current upwelled cold waters have been recorded. In this region plankton growth is poor, though the upwelled waters are found rich in nutrients. Further, fish mortality is observed in the colder waters. The very low temperatures recorded possibly explain the paucity of life in this area. Further north of the current (10°N) warm water from the Gulf of Aden is found spreading at the surface. The biological activity in this northern area is found to be good with abundant plankton and large number of larval fish.

The Equatorial Undercurrent was recently discovered by R. V. *ARGO* in the Indian Ocean. The current is about 4° wide flowing from west to east. The high velocity core of it is situated in the region of thermocline (at a depth of about 100 m from the surface) along the Equator. The Equatorial Undercurrent in the Indian Ocean, unlike its sister currents in the other oceans, is not steady with time. It is more unsteady and less pronounced during the southwest monsoon period. Its flow is faster in the eastern part of the Indian Ocean than in the western part.

Spreading of the thermocline is an interesting feature which is associated with the Equatorial Undercurrent. As this feature is an indication of upwelling, the equatorial regions, where the influence of this undercurrent is more, would be important from the biological point of view.

It may be mentioned finally that we have hardly touched the fringe of the problem and a great deal remains to be known before the picture of circulation during the seasons becomes clear. Intensive work on these aspects is being pursued at the Central Marine Fisheries Research Institute.

Fisheries and Weather

BY G. S. SHARMA

Central Marine Fisheries Research Institute

The importance of weather in our daily life is well known. It is a common experience to us that the early setting in of the monsoon or a late monsoon or its failure affect our agricultural production, some times with disastrous consequences. Similarly life in the sea also is dependent on the various elements of weather like temperature, wind, duration of sun shine etc., either directly or indirectly. Indeed there is practically no business in our daily life which does not depend to a greater or a smaller extent on weather, but there is scarcely any other profession which is dependent to such a high degree on weather as that of fishermen.

The currents and the distribution of various hydrographic features in the oceans represent a dynamic equalibrium between the sea and the atmospheric conditions. Part of the energy which drives the ocean currents and generates waves at the sea surface is derived from the winds; another part of the energy is transmitted to the ocean by radiational processes which are modified by atmospheric conditions. But the winds and the atmospheric conditions themselves depend on the distribution of physical properties in the ocean. Therefore the oceanic circulation and the atmospheric circulation are closely linked. The supply of energy from the ocean to the atmosphere is localised in some parts of the world by the nature of the currents; in these parts the sea exerts a profound influence on the climate and weather. The warm Gulf Stream in the west and the Kuroshio Current in the east may be cited as examples; but for these the life would have been in a different way in the British Isles and in the Japanese Islands because of the intense cold that would envelop these regions.

The marine meteorological features around India are more fascinating by virtue of the uniqueness of the ideal monsoon non-existent elsewhere in the world. The rythmic nature of climatic changes in this area reflect on the fish catch in a similar manner to their variation.

EFFECT OF WEATHER ON PRODUCTION

Solar radiation, the source of energy for ecological cycle in the sea, varies daily, seasonally and geographically. The total energy impinging upon the sea surface and available for photosynthesis is a function of the intensity and the length of daylight as modified by the average cloudiness of the particular area being considered. The insolation and the replenishment of nutrients are principal determinants of the biomas which may be produced in any oceanic environment. The species composition of population is certainly dependent upon energy and nutrient supply, but may also be modified by the characteristics of environment. The supply of nutrients in turn again depends on the atmospheric circulation.

When steady winds blow parallel to the coast with the coast line on the left hand side of the wind flow in the northern hemisphere the surface waters are transported away from the coast and the subsurface waters that are rich in nutrients are moved up. This phenomenon known as upwelling is an important process for refertilizing the impoverished surface layers. Such a process is occurring on both the coasts of India seasonally due to steady monsoon winds. A detailed study of the upwelling has been undertaken at the Central Marine Fisheries Research Institute and this has shown that upwelling starts at subsurface depths by the end of February and the upwelled water reaches the surface by May. The cessation of upwelling varies from south to north and it takes place by July in the south and by August in the north. The process of upwelling occurs in the open oceans also when two water masses diverge as in the equatorial regions.

In contrast to these dynamical situations which are comparatively rare in the oceans as a whole, there is also static system in which the surface waters are enriched by winter mixing known as thermal mixing. During winter, in the temperate and northern regions, surface waters cool sufficiently to destroy the summer thermocline which acts as a barrier for vertical mixing and the water becomes mixed even below the euphotic zone. Not only are the nutrients from below the euphotic zone brought up and mixed with the surface layers, but the plankton algae are transported downward and spend some of their time in darkness. As a result, though nutrients are plentiful, production is severely curtailed due to limitation of light. With return of spring, the surface waters begin to warm up, a seasonal thermocline develops and the euphotic zone becomes stabilized against vertical mixing. At the same time radiation increases. Those phytoplankton which find themselves in the euphotic zone are held there and suddenly have access to both light and nutrients. The stage is set for spring bloom, a feature characteristic of the temperate oceans.

Influence of weather on fish availability and migration

As meteorological factors are main causes for changes in hydrographical conditions in the sea an indirect correlation between the behaviour of the fish and meteorological factors can often be found although mostly direct causative factors are to be sought in hydrographical parameters.

The surface temperature in the sea is dependent on the amount of insolation and its daily and seasonal variations and on the cloudiness. It is also affected by evaporation which is a function of wind speed and humidity of air. A part of heat exchange between sea and atmosphere is caused by convective transfer of heat which in turn is a function of sea air temperature and wind speed.

A low water temperature can considerably delay spawning or displace spawning area, so that the development of eggs and larvae is changed in time and space. This may result in low survival because the larvae grow up in areas where the environmental conditions, including the availability of food for them are likely to be unfavourable.

Storms have great influence on the occurrence and migration of fish and they are some of the limiting factors in shore-ward movement of many fish. Some species of fish not normally found in shallow exposed waters, may become established in such habitats during the period of calm weather. Hence maximum catches are expected one to two days before and after the passage of cyclones possibly as a result of turbulence.

The passage of storms or persistence of onshore winds results in turbulent conditions and the fish are killed apparently due to erosion of gill filaments by accumulation of sediments. The persistence of the particular type of condition may at times give rise to mass mortality of the fish and this may be one of the reasons for such mortalities in the Arabian Sea. The mass mortality can also take place when there is a sudden fall of surface temperature due to strong upwelling. For example a sudden fall of surface temperature by 15°C due to intense upwelling seems to be responsible for the mass mortality recently reported by R. R. S. *DISCOVERY* on Somali coast. Further the mass mortality may also be the result of shifting of the level of oxygen minimum layer due to meteorological factors.

PRESENT AND FUTURE PLANS OF STUDY FOR FORECASTING FISH CATCH

Long period trends in climate and hydrography affect the distribution and abundance of all species, whether they are fished or not; and they affect different species in different ways. There is a continuous change in numerical interrelations among many species inhabiting an environment, perhaps, with some pattern of oscillations. Thus the weather not only helps to determine the size of the fish stock but also their seasonal, daily and hourly behaviour, availability and vulnerability of fishing and hence the relatively great variation in catch. And so the weather conditions during a particular fishing season for a given species can be compared with the average climatic conditions during that seasonal period for many years and on this basis the weather can be classified as favourable or unfavourable from fisheries point of view.

It is some times more apt to analyse the direct influence of a single environmental factor on fish behaviour and availability and relate these by physical cause and effect to meteorological factor. One of the most easily measured and observed environmental factor is sea temperature which influences the migration of economically important stocks. The investigations on temperature anomaly that are being carried out at the Central Marine Fisheries Research Institute are expected to give a fair picture for forecasting the fluctuations in fish catch.

For the area around India, the controlling weather factor is mainly the South West Monsoon and so a study of the variation in sardine fish catch with the intensity of the South West Monsoon has been taken up by the staff of this Institute. The average pressure gradients along the west and east coasts of India are considered as the indices of the monsoon intensity on both the coasts and the changes in the annual pressure gradients are correlated with the sardine fish catch. The results indicate a decrease of fish catch with the increase of intensity of monsoon upto a certain optimum pressure gradient and beyond this the increase of fish catch is accompanied with the intensity of monsoon. Apparently the decrease of fish catch is due to the decrease in upwelling in the area when the onshore monsoon winds oppose the process of upwelling. But this effect is masked beyond the optimum value as wind mixing, perhaps, plays a major role.

The monthly or seasonal anomaly of barometric pressure is sometimes a suitable parameter for the interpretation of the causes of fluctuations in fish catch. The pressure anomalies that are the deviations from the normal distributions of air pressure for that particular period, indicating the anomaly winds, acts upon surface currents and their boundaries and thereby influence the direction of cold or warm water in an anomalous way.

Conclusion

The operations of even the large fishing vessels are so much determined by the weather conditions, that the catches and landings depend greatly on the frequency of cyclones during the main fishing season. Almost all kinds of fishing gear are adversely affected by waves and currents in the sea. Hence apart from the knowledge of the weather conditions helping in gaining an understanding of the behaviour and distribution of fisheries resources, weather forecasts should help Indian fishermen who are forced to keep in port during the major part of the South-West Monsoon because of heavy seas. However, even at the height of the monsoon, lulls occur lasting a week or more during which a temporary resumption of large scale fishing would be feasible. Since fish are more plentiful in summer than in winter at least over the Arabian Sea, the advantage to the fishermen from the improved short range forecasts is obvious.

The experience of some of the European countries, America and Japan speaks of the importance of the establishment of a good and a reliable weather service for economical fishing and it is needless to emphasise the necessity for such a service in the Indian waters. Observation platforms such as anchored buoys in a close net work might most appropriately and profitably be located in the Indian Seas thus making it possible to obtain truly synoptic data on oceanographic and meteorological conditions in the mid-oceans. Although such a study would involve heavy expenditure, the effort would be worthwhile in view of the fruitful results that it would lead to in the fields of fisheries, meteorology and naval operations.

Salt Water Fish Culture in India

By P. R. Sadasivan Tampi

Central Marine Fisheries Research Institute

Despite a tradition that dates back to the very ancient times, salt water fish culture as a profitable industry is only a recent development in India, largely prompted by the urgent need to increase our much-needed protein food. But within the past half a century even after the realisation of our potential, it must be said at the outset that we have not made adequate progress in harnessing our resources, especially when compared to the great strides this industry has taken in the east-Asian countries or along the Adriatic coast of the Mediterranean region. Generally speaking, fresh water fish culture has shown much greater promise and improvement and this practice is fast developing in our country, perhaps on account of easier management and quicker results that are obtained. The following discussion, however, will be confined to some of the special aspects involved in fish farming in environments that are more akin to marine conditions, and the scope for improvement in the existing methods of salt water fish culture.

Ever since the practical possibilities for coastal fish farming were suggested by some of our pioneering fishery workers, there had been sporadic attempts to rear fish in saline ponds and lagoons. Most of these efforts were only on experimental levels and in very few instances have these been developed into any full-fledged industry. The salt marshes of the Sunderbans in West Bengal (deltaic regions of the Ganges) are well known for their natural fishery potential and a lucrative, but unorganised, fishery amounting to primitive fish culture methods exists in these regions.

While such simple fish cultural practices exist in many of the coastal regions, one of the earliest attempts to start a salt water fish farm, where selected species of fish could be reared, was made by the Fisheries Department of the Madras State. They had their farms started near Tuticorin and later another one in Krusadi Islands (both in the Gulf of Mannar on the south-east coast). However, the Tuticorin farm was swept away by coastal floods while the Krusadi farm had gone to disuse for want of proper maintenance and up-keep. The Krusadi farm particularly had indicated definite possibilities of how salt marshes and tidal creeks which are common in those surroundings could be utilised for fish culture purposes. Encouraged by these results some private enterprise had sprung up locally utilizing restricted areas for fish culture, besides organising nurseries and fish fry trade. Currently, work on an estuarine fish farm is in progress within the city of Madras where a system of ponds is being developed near the mouth of the Adyar river.

The Fisheries Department of the State of Cochin (now a part of the Kerala State) on the south-west coast of peninsular India ventured on a more extensive brackishwater fish farm. The gradual expansion of these farms from about 13 acres (5.5 hectares) to nearly ten times in extent is itself indicative of the success of the project. Mullets constitute the main-stay of these farms while the milkfish, and to a small extent the 'bekti' are also grown in these ponds. In the matter of natural production the farms in these regions are unrivalled because of the excellent soil conditions and the constant supply of nutrients from the back-waters. The annual variations in salinity is of the order of 2–32 parts per thousand while the temperature goes up to nearly 31°C in the summer months. Almost a similar but smaller fish farm is in operation further south in Ayiramthengu, which also enjoys somewhat similar environmental conditions and consequently a high rate of production. Experimental prawn culture in the backwater ponds of Cochin has given a phenomenal production rate of approximately 1000 lbs per acre per year, consisting mainly of prawns.

In contrast to these fish culture attempts were the experiments undertaken by the present author from the Central Marine Fisheries Research Institute at Mandapam. Low-lying salt lagoons which remain cut off from the sea for the greater part of the year occupy several square miles in this part of the south-east coast. A remarkably low degree of biological productivity has resulted because of several basic factors such as the poor quality of the soil, the meagre organic content with very low nutrient level combined with hypersaline conditions for most part of the year. Thus the conditions that prevail in the area are far from conducive to promoting biological production, much less to fish life. Judging from the seasonal fishery an average annual catch of 57 kg per hectare of fishable area limited to a short period of the year was estimated from these waters. Nevertheless, a pilot-scale experiment was launched to find out how these places could be made to yield higher rates with minimum effort and investment so that wastage of precious land could be reduced. The fact that even such apparently unproductive waters could be successfully converted to give at least about 450 kg of fish per hectare has been proved by our experiments. The most significant achievement in these experiments is that but for the initial expenses in acquiring the land and for the construction of the ponds, the recurring expenditure in management had been very low while the annual returns at the rate indicated had been justifiably high. This is a very important factor for Indian conditions.

Some of the figures on the basic productivity of these lagoons reveal the low productive potential of our coastal lagoons. Fluctuation in salinity is a major factor. While fluctuation from hypersaline conditions in summer to comparatively low salinity during the short monsoon period restricts the species of micro-organisms which constitute an important link in the food chain. Similarly the concentration of phosphates and nitrate-nitrogen is very low all through the year. The replenishment of nutrients from the surroundings through the run-off water is negligible and the only source is through inundation from the sea with which the lagoons get connected during the short monsoon period.

It is said that in the High Venice Lagoons, the hydrographic conditions, particularly the concentration of the nutrient salts, undergo constant changes as they depend on incoming and outgoing tidal currents. The organic phosphorus in these lagoons is very low but tends to be high in the inner canals due to the human metabolites, rich in ammonia and nitrogen, which are constantly being discharged into the canals. Our coastal lagoons are thus in no way comparable to the lagoons in the Adriatic region which are reputed for their high degree of natural fertility.

Supplementing with chemical fertilisers, such as superphosphates or organic manures like green manure and compost fertilisers, showed that the basic productivity of our lagoons could be temporarily enhanced to some extent. Normally the total production of a fixed area of these lagoons per day is considerably lower than the values obtained from the adjoining open seas or when compared with the values reported as the average production for all the oceans.

The foregoing general resume only shows the little progress that we have made so far in salt water fish farming, especially when great potentialities do exist and resources are in no way lacking. Apart from the experimental and pilot-scale projects initiated through governmental channels which have no doubt given us some scientific background to this important field of study, the private investments that could be drawn towards this industry has been only negligible. Perhaps, this is not entirely surprising in this country where marine fishing itself as a commercial proposition has begun to appeal to the private agencies only within the last decade or so. Besides the very fertile backwaters of the south-west coast there are other extensive but less productive salt water lagoons spread over the east coast which altogether are estimated to cover about 3000 hectares. It is to develop these areas and to take advantage of their potential that our attention will have to be immediately devoted.

These coastal saline lagoons may be broadly divided into two categories, namely, (i) those that are more or less perennial bodies of water which periodically get inundated from the sea and where some kind of unorganised seasonal fishery exists, and (ii) those that are only transcient and where the water that comes in during the tides dries up, giving the appearance of barren lands. The latter type of environment may have to be given up as almost unsuitable for our immediate requirements of fish culture as conversion of such areas are bound to involve extra heavy expenditure and prove uneconomical for our present conditions. Besides these two categories there are other salt water areas adjoining river mouths and surrounding the salt water lakes where some amount of fish culture could be carried out with advantage.

It may be seen that in some of our experimental work, the soil conditions, the effect of tidal influence and such other basic factors had not been given due importance. There had been serious and unexpected problems on management and maintenance or, as it had happened in more than one instance, the farms had been swept away by severe tidal floods. Many of these saline lagoons are isolated from any access to fresh water and this becomes a serious handicap especially when in summer the connection with the sea is cut off and the salinity goes up beyond limits that could be tolerated by many fish. Thus, fish culture in such environments has been fraught with several special problems. Although we have achieved some interesting results of a fundamental nature our experiments had been aimed more to seek scientific information connected with the problem.

Our present conditions, however, call for an increase in actual production of fish in available areas. A large part of our time and expenditure has also been invested in the construction of model farms. Fish farming, to function on sound economical basis, should be planned on a much larger scale than had been attempted hitherto. Judicious investment and utilisation of all the local resources are necessary in order to maintain satisfactory economy. With these objects in view and in the background of our experience, the following suggestions are made in order that the industry may be developed in its proper perspective.

Our experience so far seems to indicate that governmental undertakings of this type are likely to be less economical whereas private enterprise is bound to make better progress because of vested interest. Therefore, practical fish farming may be left in the hands of private or co-operative agencies who should be given suitable encouragement and scientific advice and governmental agencies should function only in a supervisory or advisory capacity to render technical assistance.

One positive way in which the government can help authorised co-operative bodies is by giving them on nominal lease the extensive lagoons so that within a specific period these corporate bodies should be able to reap the benefit of their labour and investments. In many such instances the government should extend to them suitable subsidy. Most of the fisherfolk in the coastal areas who cannot go out into the sea during unfavourable weather would find it a useful occupation to attend to the management of the fish farms during the off-season. Thus the expenditure on labour will be at a minimum which will be a very helpful factor in the management.

Many of the salt lagoons are so diffused and shallow that conversion of these places into regular fish ponds will necessarily involve considerable initial expenditure, and this will be beyond the capacity of any private investment. On the other hand, if the excavations and bunding up can be restricted to a minimum, the cost can be kept low. In the Valli culture of the Adriatic or the Tambak system of the Far Eastern countries, it may be seen that the existing physiognomy of the land is disturbed to a minimum and the farms are laid out so as to make effective use of the tidal flow. For peninsular Indian coast this may pose a serious problem because of the low tidal amplitude during any part of the year. Even so, if the low-lying areas are managed in such a way as to provide permanent connection with the sea so that effective tidal flow could be maintained throughout the year, this itself will improve the habitat and make it favourable for the growth of organisms. The environment will thus be able to support a richer growth of fish and the problem of periodical enrichment of the waters will also be solved to a great extent. Access to fresh water sources will be an added advantage.

Many of the shallow bays and tidal creeks at present serve as excellent collection grounds for the fry and fingerlings of important culturable species of salt water fish, such as the milkfish and mullets besides shrimps. On the southern coast alone there are about sixty fry collection centres and from where several lakhs of fish fry may be collected without much effort. However, these fry resources are not fully utilised. With a possible increase in fish farm development there will, no doubt, be an increasing demand for these fish fry which can be met from many of these places and for this a proper organisation of the fish fry trade will be essential. Even in those places where fertile fish farms cannot be constructed, smaller nurseries for temporary holding of fry and fingerlings should be organised so that a continual supply of healthy fry and fingerlings can be assured. Thus side by side with the development of coastal fish farming, due attention will have to be paid for improvement in fish fry industry and nursery management.

The idea of improving our culturable waters with the use of fertilisers has not yet been fully appreciated in this country and is often looked upon as an uneconomic practice. The success of artificial manuring of enclosed bodies of salt water and bays have long been demonstrated experimentally in the European regions. Making up deficiencies in the environment by the use of chemical fertilisers or supplementing with cheap and easily available compost manures made up of materials like sea weeds, cow dung and the like, can play a significant role in the improvement of the farms.

Only a kind of salt marsh vegetation exists in and around many of these coastal lagoons. Nevertheless, there are important crops such as the coconuts that may be raised in these areas, particularly along the farm bunds. This will form an important aspect while working out the economics of the industry.

With the gradual development of coastal fish farming in our country and after the conversion of the existing extensive low-lying areas, even on a conservative estimate these areas can provide not less than 1200 tonnes of fish annually. Thus, the urgent need for harnessing our resources needs no further emphasis.

Physiological Studies in Relation to Fisheries

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Studies on the physiological mechanisms and responses of fishes, which are closely linked with their ecology, have a significant role to play in fisheries development inasmuch as optimum survival of fishes is desirable and planned both in the capture and culture fisheries. While knowledge of the influence of various environmental factors on fishes are of direct value in formulating improved methods of fish culture, information on those responses of fishes which lead to their concentrations in fishable waters are of immense use in evolving more efficient methods of capture. Even though fish and prawn culture in India have existed for centuries the emphirical knowledge gained so far can be perfected, as pointed out elsewhere, only by acquiring a fuller understanding of the physiology of the animals concerned.

Among the ecological factors governing the life of aquatic animals the physical and chemical characteristics of the water in which they live are the most important. Physiological experiments designed to study the influence of these factors on fishes can provide information on the physiological mechanisms and also on the tolerance range of each of these identities. With knowledge accumulated as a result of such studies it is possible to know the suitability of a body of water for holding and culturing fish. However, it must be stated that there is wide variation in the physiological requirements of the different species and therefore it is difficult to draw general 'norms of water conditions' suitable for fishes. A solution in such a situation is possible only by studying the responses of the individual species separately with reference to each factor and also the interaction of the various factors on the species concerned.

The adaptive abilities of animals to new environments are marked The process by which an animal becomes attuned to the new environment is called acclimation. This phenomenon is so important in studying the influence of the environmental factors on the animal that a proper definition of the past history of the animal with reference to the ecological identities concerned are of paramount importance. This has been classically proved to be so in the case of lethal temperature relations of fishes. In the case of goldfish (*Carassius auratus*) it was shown that the upper lethal temperature can be shifted by as much as about 10°C by changing the temperature of acclimation. Recently it was shown that change in the acclimation level of ambient oxygen causes a reduction in the energy expended in terms of oxygen consumption by goldfish to do the same work (swimming at a given speed). Information of this nature is of much value in planting and culturing fish.

Among the primary conditions of water which regulate the life of fishes can be listed temperature, dissolved oxygen, salinity, pH, dissolved carbon dioxide and toxic substances such as ammonia, inorganic sulphides and salts of certain metals such as zinc, copper, lead etc Studies on the influences of the various factors listed above on fishes are relatively fewer with reference to marine environment.

The interspecific differences in the tolerance of temperature are large. It is seen that the upper lethal limits of the cold water fishes such as the trouts are near 25°C, whereas those of the warm water or tropical fishes such as Tilapia (*Tilapia mossambica*) and goldfish are above 40°C. Among warm water fishes themselves the tolerance range of temperature is quite wide. Experiments at the low lethal temperatures on Tilapia and on mullet (*Liza macrolepis*) (both acclimated to 30°C), which often occur together in the brackish waters around Mandapam, showed that at 18°C the mullets died within 42 hours while *Tilapia* lived for days together at this temperature. Another marked difference lies in the temperature resistance or in the effective time, which is the time required for the death of 50% of the test group of animals. At 14.5° and 16°C mullets took respectively 420 and 1200 minutes to die, whereas *Tilapia* took almost double the time (930 and 2280 minutes) to die at the same temperatures. The interspecific differences in the value of lethal temperatures and resistance times have been found to be so sharp that the lethal temperature has been found as an efficient 'tool in taxonomy'. It may be pertinent to mention here that though a functional concept of the species has been incorporated in the earliest definition of species, only a proper delineation of categories of ecological factors as per their influence on the animal, and physiological experiments as those mentioned above have made it possible to describe the 'species' from a physiological standpoint.

OXYGEN dissolved in water acts as a limiting factor on fish metabolism and activity. The lethal level of dissolved oxygen varies much with species In fishes such as the trouts which normally live in swift-flowing and colder waters the lethal level is near 2 p. p m., whereas at this level fishes such as the carps and *Tilapia* which live normally in stagnant warmer waters, can survive for months As shown recently these fishes derive considerable energy anaerobically when forced to live at low oxygen concentrations. It has been shown that the crucian carp (*Carassius carassius*) can live for months in water practically devoid of oxygen at 4°C deriving energy almost entirely through anaerobic means. Possibly anaerobiosis is more common than is actually known among those fishes which are known to tolerate hypoxic conditions. Investigations in these lines will be of value in piscicultural practices.

The SALINITY of water tolerated by the aquatic animals depend on the osmotic regulation they are capable of. Fresh water fishes are known to tolerate upto 14‰ salinity. Fishes such as *Liza macrolepis*, *L. parsia*, *Tilapia mossambica* and *Gerres abbreviatus* were recorded at salinities as high as 87–92‰ in the land locked tide pools around Mandapam. Important contributions have been made from this Institute on the osmotic regulation in the milk fish, *Chanos chanos* and in the penaeid prawn, *Metapenaeus monoceros*. Both these are known to stand wide changes in salinity as also observed in the case of many other fishes and prawns occurring in the brackish waters of the Indian coast. In *Metapenaeus monoceros* it was shown that the animal maintains osmotic equilibrium by active regulation of chloride in blood at salinities ranging from that of fresh water to hypersaline conditions. More recent studies at this Institute on another penaeid prawn, *Penaeus indicus* have shown that the osmotic regulation is achieved by the young ones of this prawn with comparative ease at salinities ranging between 7 and 21‰, there being little difference between their oxygen consumption at these salinities between 19° and 29°C. Most of the Indian penaeid prawns are known to tolerate a wide range of salinity as could be judged from their migratory patterns from the sea to the brackish water and from there to the sea for spawning. A study of the olfactory responses of these migratory animals, as shown in the case of the salmon (*Onchorhncus kisutch*) migrating up the rivers of North America, may aid in the understanding of their migratory behaviour. What factors are responsible for these movements of these prawns? Is it possible to make them stay at low salinities and breed too? Answers to these questions can be obtained by proper design and execution of physiological experiments. A solution to these problems when found will usher in new vistas for prawn farming in India and elsewhere.

pH varies with the amount of carbon dioxide in various forms such as free CO_2, bicarbonate and carbonate in water. Acidic and alkaline pollutants discharged into natural waters change their pH considerably. Fish are known to tolerate pH within the range of 5–9. Determination of the levels of pH which permit growth and reproduction will need extended study.

Tolerance of dissolved carbon dioxide differs markedly in fishes. Some fishes like the goldfish can tolerate free CO_2 concentrations as high as 200 p. p. m. When coupled with a low oxygen environment the critical level of carbon dioxide will be much lower. Observations of the latter type are significant in that, as pointed out earlier, consideration of interaction of factors is essential to fix the safe levels of the various ecological factors influencing an animal.

Certain instances of mass mortality of aquatic animals and their total disappearance have been attributed to the occurrence of toxic substances in their environs. This is especially true of toxic substances emanating from industrial wastes disposed off into waters which support fisheries. Toxic substances can also be of bacterial origin such as those liberated by the bacterial decomposition of organic matter.

Mass mortalities of fishes reported from the sea are often attributed to sudden unfavourable changes in the environmental conditions brought about by natural causes as evidenced by data obtained at the time of 'red tide'. While occurrence of toxic substances or oxygen depletion might be a good reason for some instances of mass mortality of fishes, temperature as one of the potential factors should not be overlooked especially if there is evidence for upwelling of colder waters. Since the normal temperature to which tropical fishes are exposed to is quite high, as shown earlier, relatively the low lethal temperature of these fishes must be also quite high. In this context information on the lethal levels of oxygen and temperature of various fishes will be of much value.

Studies on the behaviour of fishes in relation to water currents also need attention from a fishery-point of view. It is known that most fishes do orient and swim against water currents. Fishes such as the mackerel and other scombroids cannot obtain sufficient oxygen for their sustenance unless they swim permitting water, relatively rich in oxygen, to flow past their gills at fairly rapid rates. Swimming abilities and energetics of swimming in fishes are of applied value especially in the design and use of tackle such as the trawl and also in the designing of fish passes or fish ways at dam sites of the rivers. Studies on the physiology of swimming in the mullet (*Liza macrolepis*) and the milk fish which are being carried out at this Institute, are yielding interesting results. Plate I shows the apparatus used in these studies. Preliminary observations on the oxygen consumption of *Liza macrolepis* showed that at intermediate swimming velocities the metabolic rate of tagged mullet (plastic opercle tag) was not markedly different from that of the untagged.

Studies on the internal mechanisms of fishes, not referred to earlier, such as the studies on the pituitary gland and the hormonal control of maturation and spawning in fishes are also of much practical value. Considerable work has been done in India in this field especially with reference to carps.

Knowledge of the food requirements and absorption of nutrients to estimate the conversion rate of food to fish meat are also useful in fish farming.

Physiological studies were initiated at this Institute in 1947 with the primary purpose of studying the physiological mechanisms of estuarine and marine animals of economic importance. Reference have already been made to the observations on the osmoregulatory capacities of the milk fish *Chanos chanos* and the Penaeid prawn *Metapenaeus monoceros*. Useful information has also been obtained on the energy requirements, as judged from the oxygen consumption, of the milk fish and the marine catfish, *Plotosus anguillaris* at various salinities and oxygen levels. Observations of value have been made on the relation of salinity on the spawning and settlement of the Indian backwater oyster, *Crassostrea madrasensis*.

Influence of various anaesthetics on the fingerlings of milk fish has also been studied, providing useful information on live-fish transportation and in the handling of fish during tagging. Presently the influence of various salinities and temperatures on the prawn, *Penaeus indicus* and the mullet, *Liza macrolepis*, and the swimming abilities, including the physiological effects of tagging, of certain fishes occurring around Mandapam are being studied.

Results obtained from such laboratory studies will have to be checked under field conditions before actual procedures are recommended, since it is common knowledge that the field conditions are more complex. A synthesis of knowledge gained from such laboratory and field studies could be successfully employed in the development of our aquatic resources especially with reference to their culture.

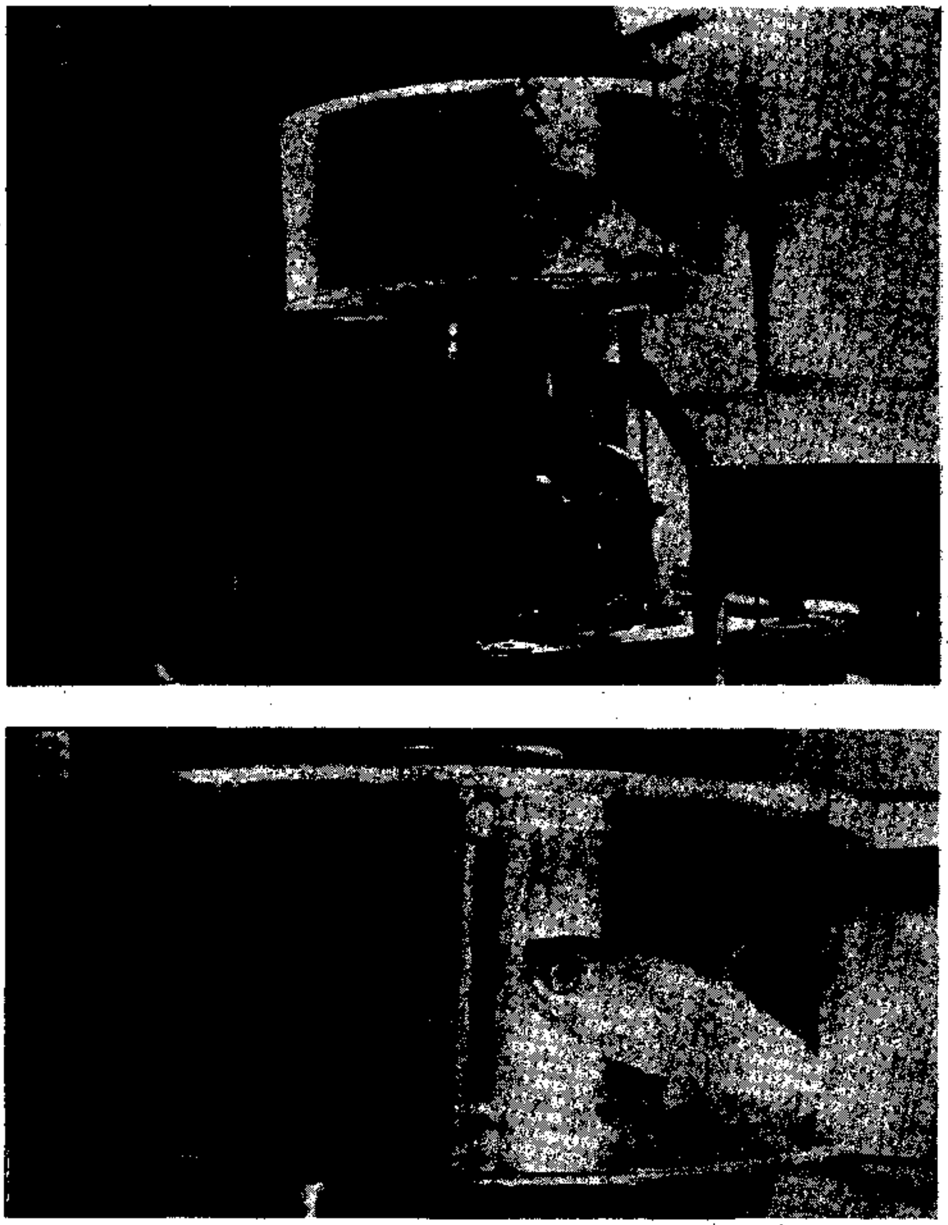

Plate I. A: Fry's respirometer which is in use in the physiology laboratory of the Central Marine Fisheries Research Institute. The annular chamber (transparent plastic) can be rotated on a turn-table at desired speeds. The apparatus is used in estimating the energetics of swimming in fishes.

B: Close-up of the activity – metabolism chamber. A milk fish, *Chanos chanos* measuring about 30 cm in length is shown swimming inside the chamber. Milkfish with their long and gracefully curved caudal flukes are good swimmers.

Corals

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Corals are objects of beauty and utility. They are found only in the sea, mainly in tropical and subtropical regions. Only very few, other than students of biology know that they are sedentary animals possessing a hard internal or external skeleton. They have attracted the attention of the biologists only recently and several problems related to them are still not explained to our fullest satisfaction. Earlier naturalists regarded them as marine plants, probably due to their sedentary habit and plant-like growth form. It was only in the latter half of the eighteenth century Peyssonnel proved the animal nature of corals. But even middle nineteenth century students of natural history assigned them a place only between animals and plants and were accordingly called 'zoophytes'.

Broadly speaking, corals fall into two groups, namely, the 'false corals' and the true or 'stony corals'. The false corals are again a heterogeneous grouping. They include the hydrocorals, Milliporina and Stylasterina with their calcarious skeleton; the blue coral (*Heliopora*) with a blue skeleton and several Gorgonaceans popularly called sea-fans, sea-whips, and sea-feathers with a skeleton in the form of scattered horny or calcarious spicules or a solid axial structure embedded in a fleshy coenenchyme. The arborescent, black or thorny corals (Antipatharia) with a central axial horny skeleton also belong to this category. The fleshy *Alcyonium* and its related genera *Sarcophytum* and *Lobophytum* are commonly called soft corals. The true corals (Scleractinia) possess an external calcarious skeleton, secreted by the outer epidermal calicoblast cells of the polyps, from dissolved materials obtained from the sea water. They are the commonest and most abundant of all kinds of existing corals. Those scleractinian corals that flourish in shallow areas and help in the formation of reefs are known as hermatypic corals. Ahermatypic corals are insignificant as reef-builders and they often flourish in deeper waters.

The stony corals were believed to have originated about 190 million years ago. Ever since their origin, they were actively engaged in the herculian task of building reefs; fighting successfully with several adverse conditions. A coral-reef is the net gain of the activity of very many million minute coral polyps, over several thousand years. The annual rate of growth of corals is very slow. Generally they may increase in size from a few millimeters to four or five centimeters, depending on the nature of the corallum and the prevailing environmental conditions. A coral-reef made of *Porites* alone, having a thickness of 150 feet, would have taken about 3000 years to attain so much thickness. Coral-reefs are restricted to the warmer seas, where they are scattered over an area of 190,000,000 square kilometers, as a belt around the globe, on either side of the equator between latitudes 35° 10′ N and 32° S. In the seas around India, we have all the three major types of reefs, namely the fringing, barrier and the Atoll. Barrier reefs and Atolls are seen in the Laccadives and the Maldives. At the south eastern end of the Indian Peninsula, there is a chain of well developed fringing reefs, starting from the Rameswaram Island and extending beyond Tuticorin. Fringing reefs also occur in the Gulf of Kutch at the western coast of India. Except these two coral formations, the coastal waters of India is devoid of any coral reefs, due to the large quantity of fresh water and mud brought by the great rivers. Ceylon has fringing reefs at its northern and southern sides. The reefs of Taprobane and the Great and Little Basses Reefs are seen respectively at the south-west and south-east of Ceylon. The Bay of Bengal is practically barren of any reef, but for the fringing reefs around the Andamans and the Nicobar Islands.

Stony corals exhibit bewildering variations in the form, size and mode of growth of their skeleton. (Pls. I and II). They may be either solitary as in *Fungia* with a single corallite (part of a corallum formed by a single polyp) or generally will be colonial with several corallites united together as in *Acropora*, *Montipora* and *Porites*. In size a coral skeleton may range from 1 to 2 mm in diameter, to enormous colonies several centimeters in width and height. A solitary corallum may be conical (turbinate), cylindrical, patellate cupolate or flabellate (fan-shaped); and may be attached or secondarily free. A colonial coral is said to be encrusting when it is closely adhering to its substratum. Rounded, undulate or hillocky masses with heavy skeleton as in *Porites* is called massive. Some possess a branching tree-like skeleton as in *Acropora*. In *Montipora foliosa* and *Echinopora lamellosa* the corallum is composed of several thin fronds arranged in the form of petals in a flower. A few generalities in growth forms are only stated above, but several other kinds may be recognised in a collection. The various corallites may remain independent of each other at the surface as in *Favia* or *Galaxea*, each with a definite circumscribing wall, or the adjacent ones may run together for a considerable length forming ridges and valleys as in the Indo-Pacific *Platygyra*, *Leptoria* and *Symphyllia*. In *Hydnophora* the ridges (collines) may further break up into conical elevations called monticules.

In living condition, the polyps protrude outside from their cavities with their tentacles extended (in some species tentacles are absent). Coral polyps are generally believed to be fully expanded only during night when they feed on zooplankton. But a good many species may be fully or partly expanded during day on a reef. The writer has noticed several corals with comparatively large polyps, like *Favia*, *Favites*, *Platygyra lamellina* and *Symphyllia* during day time with their polyps expanded, on the reefs of Gulf of Mannar and Palk Bay along the Indian coast. At several instances the small-polyped *Montipora foliosa* was also found with its blue or pinkish polyps expanded. Probably the best example of the coral polyps that expand under sunlight is met with in *Goniopora stokesi*. Under bright sunlight at a depth of a metre or so, this coral was noticed with polyps protruding four or five centimeters above the level of the corallum, completely concealing the latter from view.

In nature corals are highly coloured, the common colours being blue, pink, lilac, violet, eosine red or tan. But bleached and dried stony corals preserved in museums often appear white or in light hues of yellow or brown. Various parts of the same colony may sometimes have different colours. With a rich and varied assemblage of corals, along with several other brilliantly coloured animals such as sponges, molluscs and fishes, inhabiting in close association with the corals; a coral reef is an under water garden of bewitching beauty and a visit to one of them is an unforgetable event.

The sting from the nematocysts (stinging cells) of several coelenterates related to corals such as the Portuguese Man-Ó'-war (*Physalia*) and the Cubomedusa *Chironex fleckeri* of the Australian waters, are poisonous and lethal to man. Among the corals *Millipora* is known to cause agonising pain to man. The stony corals in this respect are harmless, since their nematocysts are not large enough to pierce the human skin. But the hard sketeton can cause minor cuts, if one steps on to it, bare footed. The septal teeth of *Symphyllia* are large and sturdy enough to inflict small wounds.

Man has found various uses for corals even from the very ancient time. They are still prized for their decorative value. At the corridors of the ancient Rameswaram temple in South India they are offered for sale, after being beautifully painted. The precious coral (*Corallum rubrum*) of the Mediterranian is a valuable marine product of commerce and in the Orient it is even classed among the precious stones. There are evidences of having trade of this coral with India and China even at the beginning of the Christian era and people exchanged emeralds, rubies and pearls for this, since it was believed to be a mysterious object "endowed with sacred properties". The Romans used to hang branches of corals around the neck of their children to safeguard them from danger. Even to modern times, it is worn in Italy as a preservative from the evil eye, and as a cure for sterility by ladies; though the belief is apparently ridiculous to modern thinking. The red-coral is used in medicine from ancient times and even now, the organpipe-coral (*Tubipora*) has a place in certain indigenous system of medicines in South India, probably as a substitute for the 'precious coral'. Ornaments made out of the axial skeleton of the black-coral is believed to be a remedy for rheumatism, by the people of Malay Archipelago and Japan.

The skeleton of stony-corals is of several use. In South India, living, dead and semi-fossilsed *Porites* (mainly *P. solida* and *P. somaliensis*) is exploited in large scale for various economic purposes. A labourer engaged in such work may earn four to six rupees a day at present. This 'coral-stone' is transported to different places where it is used as building blocks or to metal roads as a substitute for granite. *Porites* is also said to be used in Red Sea coasts for building purposes. Since it is made up of calcium carbonate, it can be used as a raw material for the preparation of lime, mortar and cement. In South India it is at present used in the manufacture of calcium carbide.

Corals play a very significant role in the formation of islands. Wherever a suitable platform is available, coral planulae will settle and begin to colonize. Their activity in the long run, will result in the formation of a reef, that grow upwards. They will be greatly assisted in their task by calcarious algae, Foraminifera, molluscans and by the remainings of several other marine animals. Later, the top portion of such reef may be exposed above the water, either by a fall in the sea-level or by upheaval of the sea-bottom by an earth tremor. The rain, wind and other natural agencies, later cause the disintegration of the solid limestone and formation of the sand. Sand and broken coral pieces may be piled up from the lagoon by the wind and wave action which help in the formation of land. Seeds deposited by the sea currents or dropped by sea birds by way of castings may germinate and form vegetation. It is interesting to note that several islands among the Laccadive-Maldive and the Chagos chain of Archipelagoes in the Indian Ocean and a number of oceanic islands in the Pacific are shaped out of coral reefs.

Finally, coral-reefs are believed to act as natural barriers against sea-erosion, by permitting themselves to have the mighty breakers to break on them. It has been noted that at Nicobar Islands, in spite of the existence of the reef, there was clear indications of sea erosion. Another such instance is seen at the Palk Bay side of Mandapam in South India, where there is a well developed fringing reef, on an average 500 metres away from the shore, lying almost parallel to it. But the sandy shore is not completely free from the grip of erosion. It appears that protection from a reef against sea erosion is not absolute but only comparative. However, more work in this field is necessary to arrive at a definite conclusion.

EXPLANATION TO PLATES

PLATE I.

1. *Acropora formosa* (Dana), with arborescent corallum and small corallites from Mandapam (Palk Bay) x $\frac{3}{4}$. 2. *Favia velenciennesi* (Milne Edwards and Haime), with large polygonal corallites from Port Blair (Andamans) x $1\frac{1}{2}$. 3. *Porites compressa* Dana, a small calicled coral from Krusadai Island (Gulf of Mannar) x 6. 4. *Galaxea fascicularis* (Linnaeus), with large projecting corallites from Chetlat Island (Arabian Sea) x 1. 5. *Fungia horrida* Dana, a solitary coral, from Andamans x $\frac{2}{3}$. 6. *Dendrophyllia aurea* (Quoy and Gaimard), an ahermatypic colonial coral, Eosine red in living condition from Manauli Island (Gulf of Mannar) x 2.

PLATE II

1. *Porites somaliensis* Gravier, with massive corallum and small corallites from Manauli Island x $\frac{1}{2}$. 2. *Hydnophora microconos* (Lamarck), surface with several monticules from Chetlat Island x 1. 3. *Favia favus* (Forskal), a massive coral with large, very little projecting corallites from Mandapam (Palk Bay) x 1. 4. *Symphyllia radians* (Milne Edwards and Haime), surface with thick collines and deep valleys from Mandapam (Palk Bay) x $\frac{1}{2}$. 5. *Euphyllia glabrescens* (Chamisso and Esyenhardt), a branching type with large deep corallites from Minicoy x 1. 6. *Platygyra lamellina* (Ehrenberg , massive coral with thin collines and valleys from Mandapam (Palk Bay) x 1. (Photographs by Mr. Satyaprakash Ganshani).

PLATE I

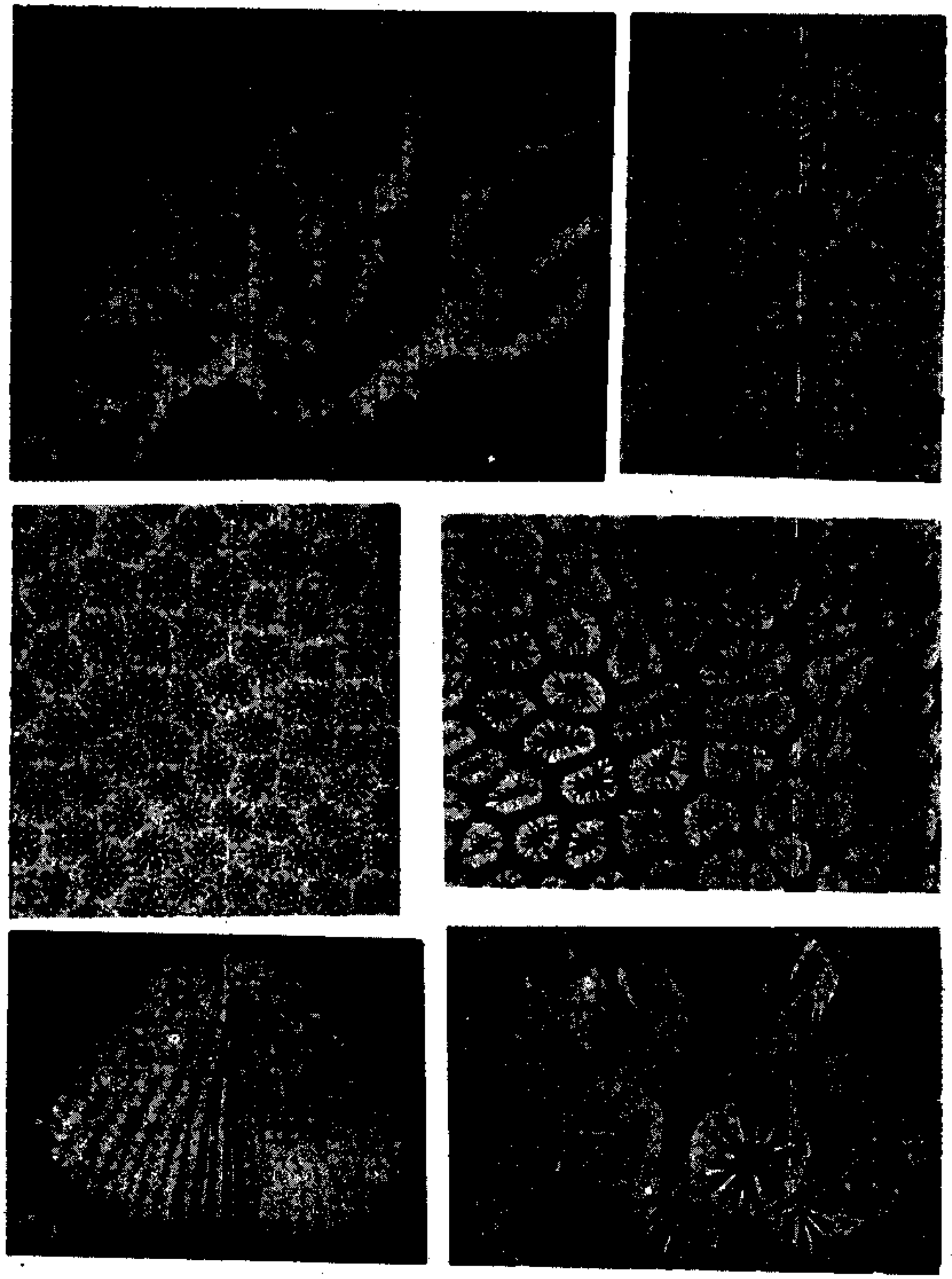
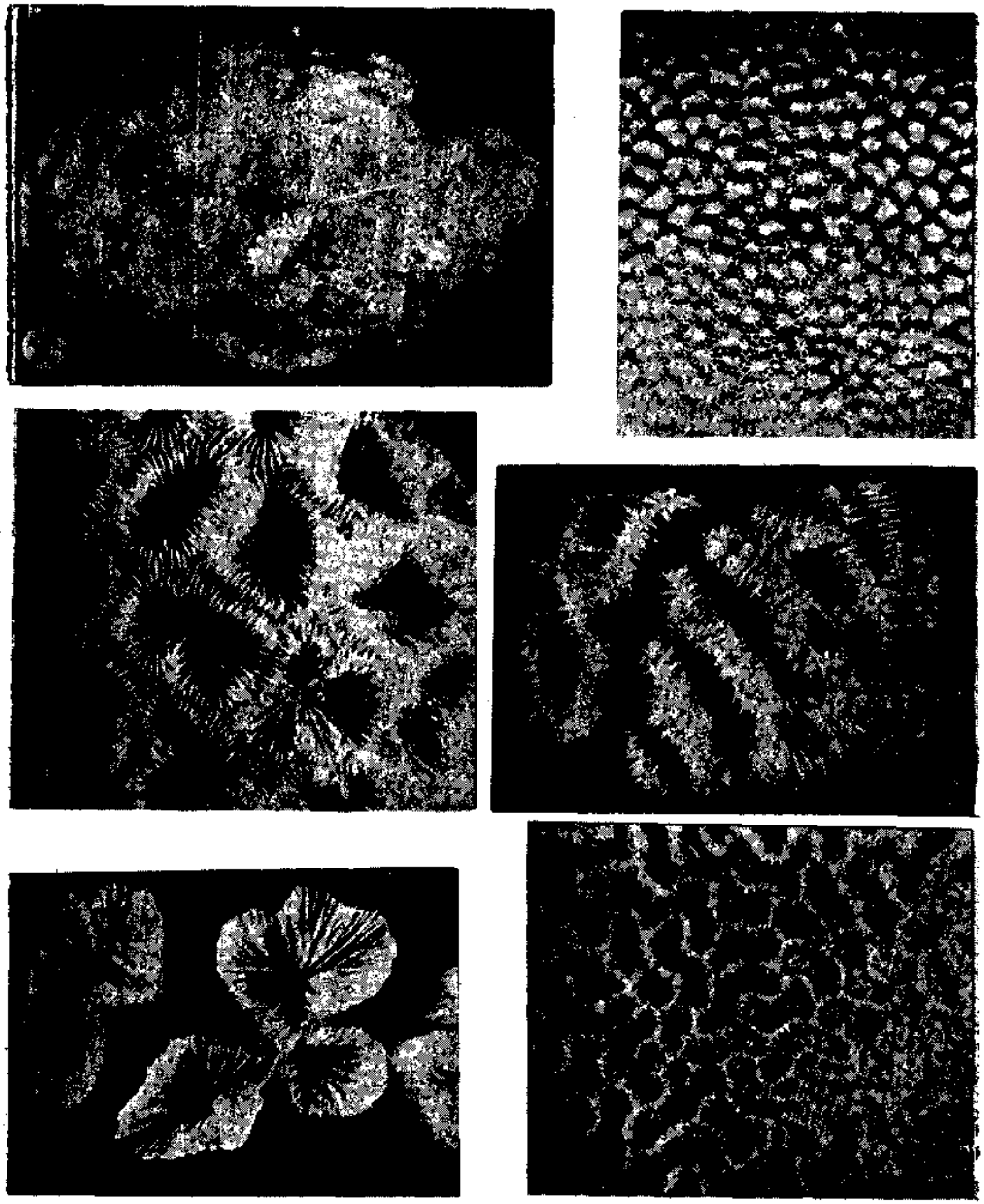


PLATE II



Seaweed Resources of India

By M. Umamaheswara Rao

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Seaweeds yield valuable phycocolloids like agar-agar and algin which are widely used in many industries. They are also utilised as food, fodder and fertiliser. Survey of natural seaweed resources and investigation of the chemical composition, methods of extraction, ecology, cultivation and other aspects related to their utilisation are therefore of utmost importance. Majority of the economic seaweeds come under three classes namely the Green algae (Chlorophyceae), the Brown algae (Phaeophyceae) and the Red algae (Rhodophyceae) and they are generally restricted to the relatively narrow littoral and sub-littorial belts of the marine environment.

In India several areas along the coast offer suitable environments for luxuriant growth of seaweeds of commercial value. Mandapam, Pamban, Rameswaram, Keelakarai, Tuticorin, Cape Comorin, Muttam and Colachel in Madras State, Visakhapatnam and its environs in Andhra Pradesh, Chilka Lake in Orissa, Okha, Dwarka and Veraval in Gujarat, Bombay and Ratnagiri in Maharashtra, Karwar and adjacent areas in Mysore, Varkala, Kovalam and Vizhingam in Kerala are some of the potential areas along the Indian coast for commercially valuable seaweeds. Laccadives, Andaman and Nicobar Islands are also noted for their rich seaweed resources. Reference is invited to the figure reproduced in the appendix for the general distribution pattern of economic seaweeds along the Indian coast.

On the basis of products obtained, Indian seaweeds may be broadly classified into three groups namely agarophytes, alginophytes and plants used for food, stock feed and ertilizer.

Agarophytes

Gelidiella acerosa, *Gracilaria lichenoides*, *Gracilaria crassa*, *Gracilaria corticata*; *Gracilaria follifera* and *Gracilaria verrucosa* are the principal agar-yielding plants of our country. There is variation among these agarophytes in their distribution and abundance. Considerable quantities of *Gelidiella acerosa* and *Gracilaria foltifera* occur in coral reef areas around Mandapam and also at Okha and Dwarka. *Gracilaria corticata* occurs on many intertidal rocky areas along the coast of India. *Gracilaria lichenoides* is plentiful in the Gulf of Mannar area and *Gracilaria verrucosa* is found growing abundantly in Chilka Lake. Working with some of these agarophytes a method has been developed at the Central Marine Fisheries Research Institute to extract good quality agar. Results obtained on the maximum yield of agar on dry weight basis and gel strength (gm./cm.^{2}) of 1.5% solution of *Gelidiella* and *Gracilaria* species are given below:

SPECIES	YIELD	GEL STRENGTH
Gelidiella acerosa	45%	300
Gracilaria lichenoides	43%	120
Gracilaria crassa	23%	140
Gracilaria corticata	38%	20
Gracilaria follifera	12%	15

Some algae for example, *Hypnea* and *Spyridia* yield viscous substances with very low gel strength, known as agaroids. These agaroids are soluble in cold water and are useful as stabilizers. Agar with satisfactory gel strength could be obtained from agaroids, especially from species of *Hypnea,* by chemical treatment.

ALGINOPHYTES

Sargassum moriocystum, Sargassum wightii, Sargassum swartzii, Sargassum johnstonii, Sargassum vulgare, Sargassum ilicifolium and other *Sargassum* spp., *Turbinaria conoides, T. oronata, T. decurrens, Cystophyllum muricatum, Hormophysa triquetra, Padina* spp.; may be mentioned as the representatives of the algin-bearing seaweeds of India. Of these, species *Sargassum* and *Turbinaria* are the valuable raw materials for the production of sodium alginate or alginic acid. Yield of algin from *Sargassum* and *Turbinaria* is about 20 to 25% of the dry weight and from other brown algae the yield is less than 20%. Mannitol and iodine could be extracted as by—products from these brown seaweeds, but yield of these compounds varies considerably with season and stage of development of the plant.

USES OF AGAR-AGAR AND ALGIN

Agar-agar and algin are colloidal carbohydrates accumulated in the cell walls of red and brown algae. They are used in food, confectionary and dairy industries as gelling, thickening and stabilising agents in the preparation of sweets, gellies, jams, desserts, ice-creams, sherbets etc. Agar is particularly used when firm gel is required and algin is extensively used for soft and viscous products. These seaweed colloids play an important role in pharmaceutical and cosmetic industries as emulsifiers, gel formers and body producers. In textile industry they are often used as sizing materials and as thickeners in dyeing and printing. Other uses of these compounds include the following: adhesives, clarification of liquor and water, leather finishing, dental impression compounds, insect sprays, paints etc. Sodium alginate and other salts are used in the manufacture of synthetic fibre for certain textiles and agar is used as lubricant in drawing tungsten wires and as culture medium for microbiological work.

EDIBLE SEAWEEDS AND THEIR NUTRITIVE VALUE

Seaweeds form an important part of the diet taken by the people of China, Japan and many other countries of the Western Pacific Region. *Ulva, Enteromorpha, Codium, Caulerpa, Hydroclathrus, Padina, Colpomenia, Sargassum, Turbinaria, Acanthophora, Laurencia, Gracilaria, Hypnea* and *Porphyra* are commonly used for food. These are eaten raw as salads, and cooked as vegetables. Certain fresh or processed varieties are used in the preparation of pickles with vinegar, soup, porridge and also for garnishing the dishes.

Nutritive value of seaweeds depends mostly on the protein, vitamin and mineral constituents present in them. Green and red algae are rich in proteins and high amounts of protein ranging from 20.12 to 25.48 mg./100 gm., have been found to occur in *Ulva fasciata, Ulva regida, Acanthophora muscoides* and *Centroceras clavulatum*. The Vitamin–C content of fresh Indian seaweeds, *Chaetomorpha brachygonia, Ulva reticulata, Padina, Hypnea musciformis, Gracilaria lichenoides* and *Laurencia papillosa*, has been found to vary from 5.0 to 8.6 mg./100gm. and in *Sargassum myriocystum* it exceeds that of lemon. Vitamin–A, Vitamin-B12 and Vitamin–B, are found to occur in many algae and the amounts are generally higher than the other vegetable and animal resources. Utilisation of seaweeds as food is very limited in our country though the natural resources are plentiful. Attempts should be made to popularise the use of edible seaweeds for human consumption.

Among the different edible algae given above, *Porphyra* is the most important seaweed and it contains 30 to 40% protein on dry weight basis. In this connection it may be of interest to note that *Porphyra* is cultivated in Japan on industrial scale to prepare an edible product known as "Asakusa-Nori". About 4000 to 5000 metric tons of dried material of this plant is produced each year for indigenous use and export, which approximately costs 28 million U. S. dollars. *Porphyra vietnamensis*, reported so far from Visakhapatnam coast, could therefore be a dollar–earning edible seaweed in our country. Leafy thallus occurs on this coast during a short period of 5 to 6 months and plants reach harvestable size from February to March or April. Attempts should be made to cultivate this alga following the techniques employed in Japan.

Seaweeds as stock and poultry feed

Experimental work done in other countries has shown the value of seaweed as stock and poultry feed. Because of the presence of vitamins, mineral and trace elements in significant amounts, health of the domestie animals is improved when seaweed meal is added to the daily rations. Washed and dried weeds of *Gracilaria, Hypnea, Sargassum* and *Turbinaria* are useful for the preparation of seaweed meal. The residue obtained after extraction of agar-agar can also be utilised as food for cattle and poultry.

Seaweeds as manure

Use of seaweeds as manure is a common practice in coastal areas throughout the world. They contain high amounts of water soluble Potash and other minerals which are readily absorbed by plants. Recent studies have shown that the carbohydrates and other chemicals present in seaweeds act as soil conditioners by improving the moisture-retaining capacity of the soils and control certain plant diseases. In field trials, conducted at the Central Marine Fisheries Research Institute to study the effect of *Hypnea* compost on Bhindi plants (*Hibiscus esculentus*), 73% increase in yield was observed. Remarkable results were obtained with tuberous crops such as sweet potato, tapioca and other vegetable and garden plants. In general all seaweeds and seagrasses like *Cymadocea*, *Diplanthera* and *Halophila* growing in littoral and sublittoral areas along the coast line could be utilised as manure. As the seaweeds are generally low in phosphorous and nitrogen, materials rich in these substances should be mixed in order to get a balanced fertilizer.

Seasonal variations in abundance and chemical contents of seaweeds

Ecological investigations carried out in many localities of the east and west coasts of India have revealed the existence of seasonal variations in abundance of different seaweeds. Peak growth periods of green, brown and red algae varied from place to place in relation to the local environmental conditions. It has also been found that the chemical composition of seaweeds alter with the seasonal changes in the vegetation. For instance, distinct monthly variations are reported in the sodium, potassium, calcium, magnesium and chloride contents of eleven species of algae common to Indian coast. In a preliminary study conducted at Central Marine Fisheries Research Institute on three species of *Gracilaria*, the seasonal variation in the yield of agar-agar ranged from 10 to 14%. In view of these seasonal fluctuations both in the availability and chemical content of the raw materials, collection of seaweeds must be done during periods of highest development to obtain maximum yield of raw materials and the end products.

Harvesting of seaweeds

Seaweeds such as *Enteromorpha*, *Ulva*, *Chaetomorpha*, *Padina*, some species of *Sargassum*, *Gracilaria corticata* and *Porphyra* occur in the intertidal region as regular bands from high water to low water and they can easily be harvested during low-tide periods. Other important seaweeds grow at different depths in the sublittoral zone depending upon the availability of light and substratum. These sublittoral seaweeds can be harvested only by skin diving. While harvesting the seaweeds, care should be taken not to destroy the basal portions or hold fasts. Indiscriminate harvesting of seaweeds not only affects the furture yield of raw material but also the quality of the final product. It is therefore necessary to harvest the fully grown plants during the periods of maximum development and sufficient time must be given between the two successive harvests for regeneration and further development of seaweeds.

Detailed investigations have been conducted by the Central Marine Fisheries Research Institute for the past twenty years on the utilisation of Indian seaweeds for the production of agar-agar, algin, seaweed meal and manure and on other problems related to the distribution of seaweeds, their resources survey, systematics, chemical composition and ecology. Valuable data were collected on the properties of Indian agar and agaroids extracted from species of *Gracilaria*, *Gelidiella*, *Hypnea*, *Sarconema*, *Spyridia* etc. A new pulp method was developed on cottage industry lines for the manufacture of agar-agar from *Gracilaria lichenoides* and it was applied to the other Indian agarophytes with considerable success. Alginic acid content of brown algae was determined and a method was worked out for bleaching crude alginic acid extracted from *Sargassum*. Different processes were developed for the preparation of seaweed meal from *Gracilaria lichenoides* and compost

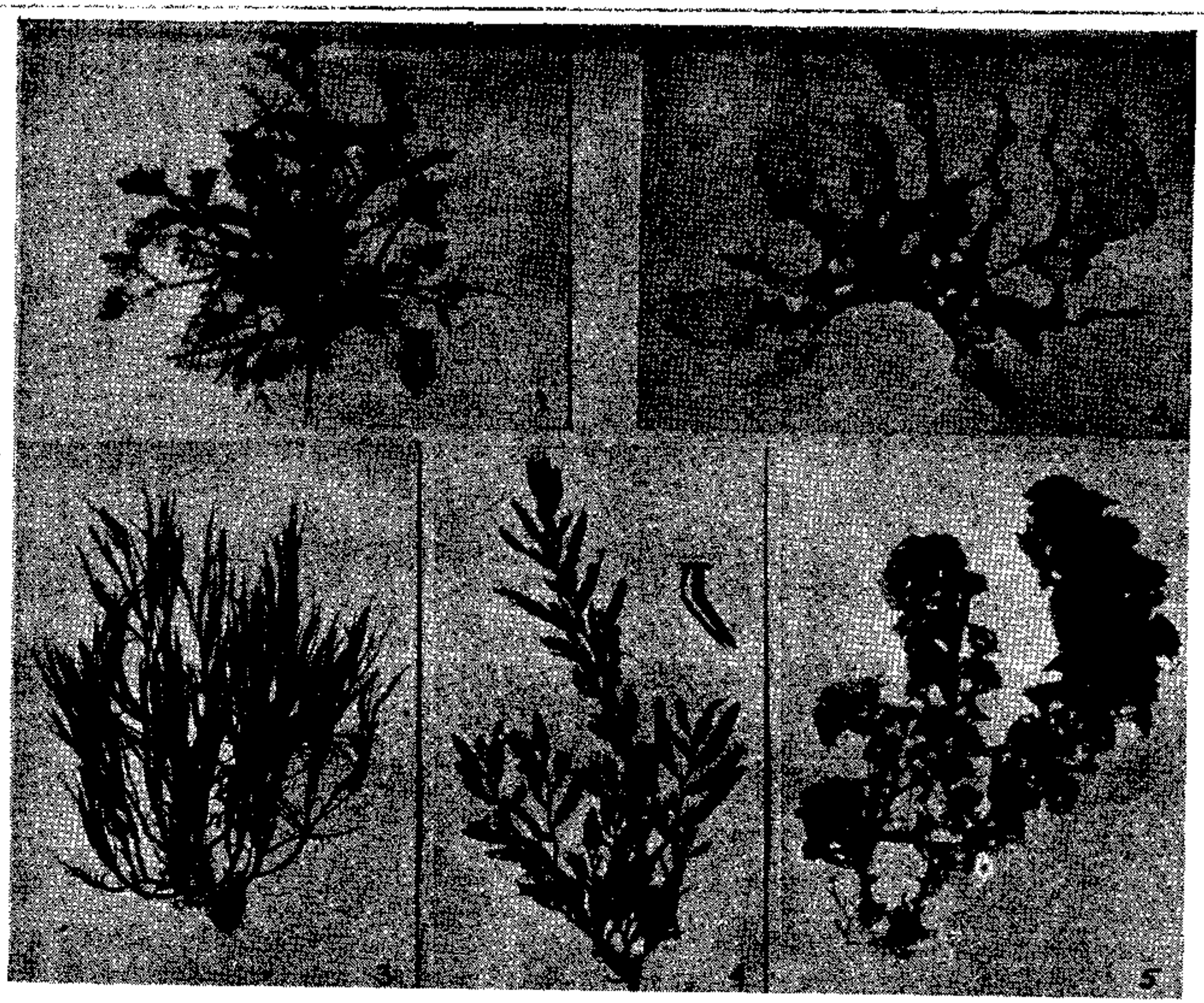

PLATE I. Some Indian seaweeds of commercial value. 1. *Gelidiella acerosa;* 2. *Porphyra vietnamensis;* 3. *Gracilaria lichenoides;* 4. *Sargassum wightii;* 5. *Turbinaria oronata.*

manure from algae cast up in quantities along the sea shore. Experiments were conducted on vegetable crops to study the effect of seaweed manure as mentioned in the earlier section. Distribution and abundance of agarophytes, and other economic seaweeds in the near shore waters of the Indian coast have been studied and quantitative surveys have been made in the Gulf of Mannar and Palk Bay near Mandapam. Detailed observations have been made on the algal flora of pearl beds off Tuticorin and on the morphology of *Padina gymnospora*. Mineral constituents of eleven species of algae common to the Indian coast were estimated. Studies on the water soluble constituents of *Gracilaria lichenoides* and the ionic composition of blue-green algae growing in saline lagoons have been carried out in detail. The colonisation and seasonal succession of marine algae have been followed in Palk Bay. The present studies that are being carried out on autecology and related aspects to cultivate the commercially important seaweeds, will help in increasing the production of raw materials. It may be stated to the credit of this Institute that the investigations on economic seaweeds conducted here have paved the way for the establishment of a seaweed industry in India and in the development of an export trade of seaweeds to foreign countries.

Statistics in Fishery Research and Survey

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In the present days of acute food shortage, the necessity of developing and expanding our fisheries need not be over emphasised. India with a coast line of over 3,000 miles and with extensive river systems and a large number of swamps, *bheels* and ponds spread over the country produces only about 1.5 million tonnes of fish a year and there is an immense scope of stepping up fish production.

Any developmental plan will require accurate statistics for depicting the condition of the industry and these may be grouped under three broad categories, namely (i) Potentialities (ii) Production and (iii) Utilisation, demand and supply. The scope of development will depend on the potentialities of fisheries which include the physical production factors like the availability of water resources for exploitation, the number of people engaged in fishing and allied industries and the equipment required for fishing and also the investment of money. Since the ultimate aim of any fishery developmental plan is for the betterment of the living conditions of the fishermen the data on their socio-economics are also necessary. The statistics on production comprises yield from marine and inland waters and also the quantity of manufactured products and by-products like shark liver oil, fish meal, fish manure etc. The contribution of fishery as a source of food could be assessed by production statistics. The statistics on supply, demand, preservation, transport, marketing system and prices will throw light on the mode of utilisation of fishery products. Derived statistics like production index on the basis of these data will judge the growth rate of the fishing industry and will ensure comparability with other industries. These statistics will also be helpful for the calculation of national income from the fisheries sector. These data can be collected either by census method or by sampling method and such collection may either be on an *ad hoc* or on continuing basis.

Apart from collecting data for describing the status of the fishing industry, biological statistics to determine the status of exploitable fishing resources are also essential. For this purpose the knowledge of either the absolute magnitude or some relative indices of abundance of various exploitable stocks is necessary so that the optimum sustained yield may be derived from these stocks, maintaining their level at the same time. Generally it is difficult to ascertain the absolute magnitudes of the different stocks and as such all statistical and mathematical models for studying fishery resources deal with relative indices of abundace. The essential data necessary for estimating these indices are the catch, its age, size composition and the input of effort. Some parallel data on length measurements of fish along with scale and otolith readings seem to be necessary for the prupose of estimating the growth, mortality and recruitment parameters. As has been pointed out earlier the catch and effort data have to be collected on a continuing basis either by census or sampling method. The data on effort can conveniently be collected in terms of either of the following: the number of persons engaged in fishing, days' absence from port, days or hours fished, number of crafts and tackles used. When, however, a fishery is being exploited by heterogenous group of fishing unit, as is generally the case in India, the effort has to be expressed in terms of a standard fishing unit. For this purpose specialised studies will be necessary to find out the efficiency factor of other fishing units in terms of the standard one. It may thus be seen that the minimum statistics necessary in fishery research may be grouped as follows:

(a) The independent variables.
- (i) quantity of fishing (effort).
- (ii) quality of fishing (selectivity),

(b) The dependent variables.
- (i) quantity of catch.
- (ii) catch per unit of effort.
- (iii) composition of catch.
- (iv) division of catch among different types of units

Fishing in India is not a large scale organised industry but is carried on by a large number of people economically and educationally backward for whom it sometimes forms the sole means of livelihood. The unorganised nature of the fishing industry coupled with the backwardness of the fishermen poses main difficulty in the scheme of collecting fishery statistics. No systematic attempt was made to collect fishery statistics on all India level during the pre-independence era and the report on the marketing of fish in the Indian Union published by the Directorate of Marketing and Inspection formed the only source of fisheries statistics in India. The report shows statistics on marine fish landings, marketable surplus of fresh water fish, prices prevailing in some producing and consuming centres for certain popular varieties of fish on a statewise basis. Details on utilisation of fish are also available in this report. But these data are mostly based on the trade enquiries and as such do not promise any high degree of accuracy.

In view of the paucity of data on marine fisheries and the great need for their collection, this Institute on its establishment in 1947 initiated the collection of Marine fishery statistics on scientific lines. The main objectives were as follows:

- (i) estimation of statewise and specieswise landings of marine fish in India.
- (ii) estimation of fishing effort.
- (iii) determination of size/age composition of landings

As it is not feasible to collect data on complete enumeration basis for a vast country like India where marine fishing is carried out in different types of units scattered over more than 1200 landing centres, attempt was made to evolve a suitable sampling scheme within the resources available with the Institute.

In 1948–49 villagewise data were collected on the total fishermen population, active fishermen, fishing units of different types, type of fish caught and general information on matters relating to fishing industry. This for the first time gave a complete list of fishing villages engaged in marine fishing and threw light on the potentialities of marine fishery. To bring about the nature of the changing pattern of fishing industry and its consequent impact on fishermen, surveys of fishing villages were undertaken during the 2nd and 3rd Five Year Plans.

The data collected through the periodic census of fishing villages, fishing population landing centres, craft and gear etc., constitute the frame for the sample survey for the estimation of fish landings and their composition. The sampling design was put into operation by this Institute from 1950 onwards and for the first time reasonably accurate estimates of marine fish landings and their composition were obtained. Initially the coast line of India was divided into 12 zones from the point of fishing practices and fisheries and zonal estimates were made. On the basis of experience gained the programme was gradually intensified and the catch figure with their composition were obtained with greater accuracy and for smaller geographic divisions. In addition, provision was made for the collection of data on effort spent to obtain such catches. Effort is estimated in terms of man hours as well as in number of different types of fishing units. With experience of field trials, it was possible to improve the sample design as time passed on and the present sampling scheme involving space-time stratification was introduced. From 1959 additional data on size composition of the catch of certain commercially important fishes viz, oil sardine, mackerel, Bombay duck and *Hilsa* are being collected. This enables to get the abundance of size and age composition of the catch leading to estimation of mortality parameters. Apart from these, length-data collected at specific centres along with scale and otolith readings are used to estimate the parameters of growth, mortality, recruitment of commercially important fisheries.

Thus from a begining in 1947 when practically no fishery statistics was available, the Institute has successfully developed sampling design to estimate species wise marine catch and the corresponding effort for each maritime state of India based on uniform concept and definition of various terms and survey items on all India basis. A high degree of accuracy is indicated by the low percentage error in the estimate of catch statistics which works out to the order of 5% at the all India level. Based on these data, some very useful work has already been done to assess the fishery resources of two of our most important fisheries namely mackerel and oil sardine. While calculating the national income from fisheries sector, the Government of India have found that this Institute is the only source from which various items of marine fisheries statistics can be obtained. Apart from catering to the domestic needs, this Institute is supplying fishery statistics to various international agencies. A perusal of FAO Year Book of Fishery Statistics indicates that India is the only country bordering the Indian Ocean which is having diversified data relating to marine fisheries. From the above brief sketch, it will be seen that during the last 2 decades this institute has filled up a great vacuum by building up a statistical system which now can supply most of the essential statistics needed for the development of the fishing industry and for the efficient management of our fisheries resources.

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Crustacea

Mollusca

Chaetognatha

Echinodermata

Coelenterata

Platyhelminthes

Polychaeta

NEW DISTRIBUTIONAL RECORDS

The new records listed below are previously not known from the seas around the mainland of India including the Laccadive Sea, Pakistan (West and East) and Ceylon. The Andaman-Nicobar Region is considered a separate geographical entity and the new records for the region are indicated with an asterisk. The reference numbers relate to the serial numbers of the entries in the bibliography of publications of the Central Marine Fisheries Research Institute, 1947 to 1967.

Pisces

Abudefduf cingulum (Klunzinger)	526
A. dickii (Lienard)	526
*Acanthocybium solandri (Cuvier and Val.)	300
Acanthurus elongatus (Lacépède)	591
A. philippinus Herre	591
Alepisaurus brevirostris Gibbs (1960)	511
Amblygobius albimaculatus (Rüppell)	559
Amphiprion chrysogaster Cuvier & Valenciennes	526
Anampses amboinensis Bleeker	526
Anarchias cantonensis (Schultz)	591
A. fuscus Smith	591
Anchoviella baganensis (Hardenberg)	186
A. bataviensis (Hardenberg)	186
Apogon leptacanthus Bleeker	526
Apogonichthys ocellatus (Weber)	526
Aspidontus tractus Fowler	559
Astronesthes lucifer Gilbert	525
Auxis tapeinosoma Bleeker (= A. thynnoides Bleeker)	173
A. thazard (Lacépède)	173
Bathygobius petrophilus (Bleeker)	559
Belone platyura Bennett	559
Benthodesmus tenuis (Günther)	525
Caesio pisang Bleeker	526
C. xanthonotus Bleeker	526
Callechelys nebulosus (Cuvier)	591
Callyodon capitaneus (Cuvier & Val.)	591
C. janthochir (Bleeker)	591
C. jordani (Jenkins)	591
C. niger (Forskal)	591
C. pectoralis (Cuvier & Val.)	591
C. scaber (Cuvier & Val.)	591
C. sexvittatus (Rüppell)	591
C. taeniurus (Cuvier & Val.)	591
Callionymus schaapi Bleeker	604
Chaetodon citrinellus (Cuvier & Val.)	559
C. meyeri Bloch and Schneider	559
Chromis nigrurus Smith	526
C. opercularis (Günther)	526
Cubiceps natalensis Gilchrist & Von Bonde	525
Cypselurus cyanopterus (Cuvier & Val.)	559
C. oligolepis (Bleeker)	559
Duymaeria flagellifera (Cuvier & Val.)	591
Echidna leucotaenia Schultz	591
Eleotriodes strigatus (Broussonet)	559
Epinephelus melanostigma Schultz	526
Epinnula orientalis (Gilchrist & Von Bonde)	573
Eupleurogrammus intermedius (Gray)	249
*Euthynnus affinis affinis (Cantor)	300
Gempylus serpens Cuvier	292
Grammatorcynus bicarinatus (Quoy & Gaimard)	300
Gymnocaesio argenteus (Bloch)	526
Gymnosarda unicolor (Rüppell)	300
Gymnothorax javanicus (Bleeker)	591
G. monostigmus (Regan)	591
G. petelli (Bleeker)	591

NEW GENERA AND NEW SPECIES

Reference is given to the serial numbers of the entries in the bibliography of the publications of Central Marine Fisheries Research Institute, 1947 to 1967. Asterisk indicates also a new genus.

Chloromonadineae

Hornellia marina Subrahmanyan 92 (*new genus)

Euglenineae

**Protoeuglena noctilucae* Subrahmanyan 84

Chrysophyceae

Ruttnera pringsheimii Subrahmanyan 387

Platyhelminthes

**Engraulicola forcipopensis* George (K. C.) 321
Gastrocotyle indica Subhapradha 41
Staphylor his gigas Samuel 57
**Telegomatrix pellona* Ramalingam 115
**Vallislopsis contorta* Subhapradha 41

Polychaeta

Ancistargis brevicirris Rangarajan 475
Augeneriella hummelincki sub. sp. *indica* Banse 251
Dorvillea mandapamae Banse 251
Nothria mannarensis Rangarajan & Madhaven 395
Oriopsis coalescens Banse 251
Scyphoproctus variabilis Rangarajan 447

Crustacea

**Asterocomes indica* Rao (C. A. P.) 416
Asteropontius littoralis Ummerkutty 389
A. sewelli Ummerkutty 389
Bomolochus sardinellae Bennet 471
Cryptopontius graciloides Ummerkutty 389
C. orientalis Ummerkutty 389
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Appendices

APPENDIX I

Statistics of marine fishermen population and fishing craft
(Based on sample surveys during 1961-62)

S. No.	State	No. of marine fishing villages	Marine fishermen population	No. of active marine fishermen	No. of fishing crafts	Average annual marine fish landing during 1961-65 (in tonnes)
1.	West Bengal	26	2311	606	108	10180
2.	Orissa	156	33630	8828	2786	
3.	Andhra	321	136893	47700	19772	65391
4.	Madras	363	214868	56586	29661	116248
5.	Kerala	279	333822	74241	20667	262648
6.	Mysore	131	51636	8963	6357	52919
7.	Maharashtra	265	103535	20698	7894	123458
8.	Gujarat	256	82242	11732	3179	92834

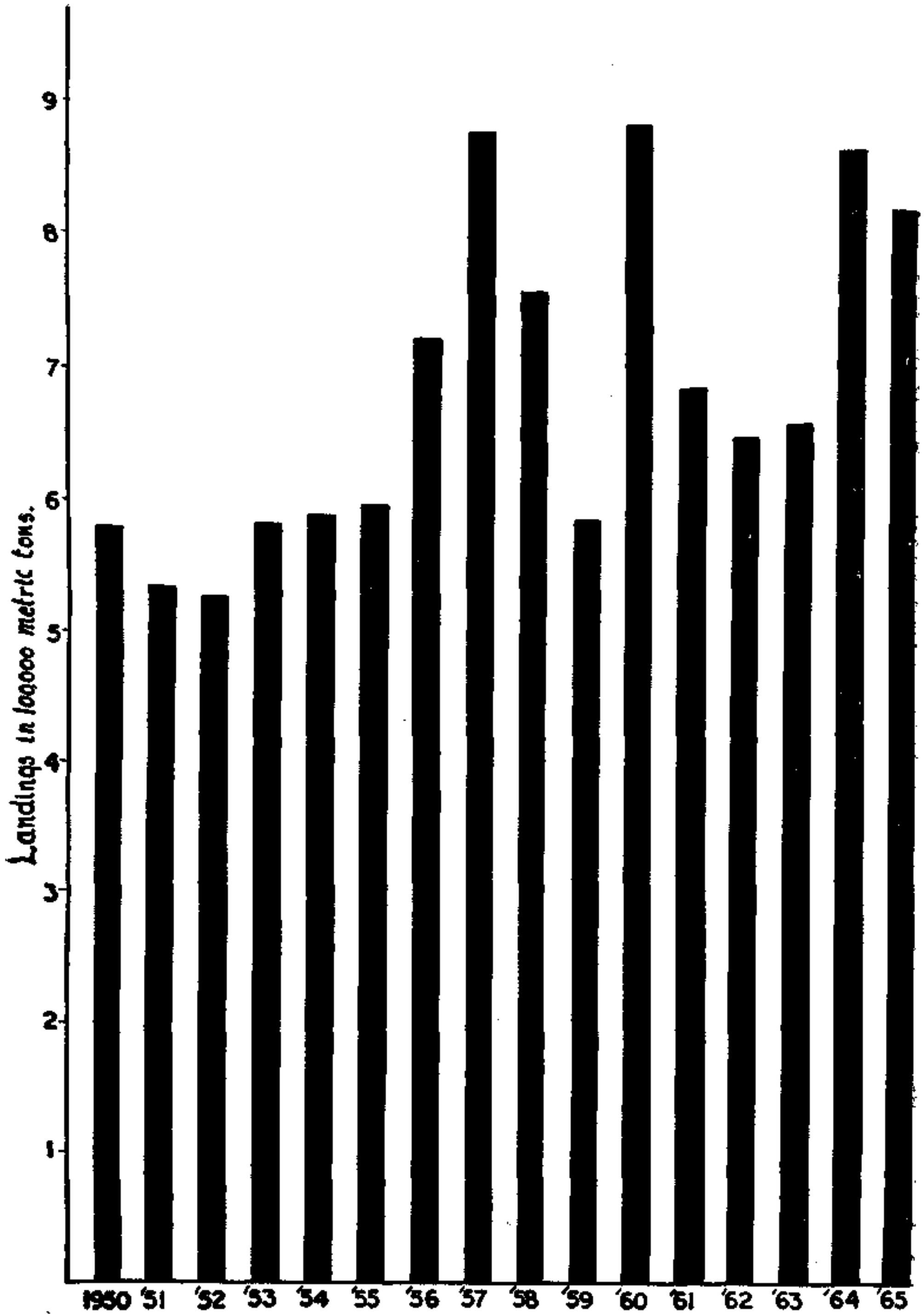
APPENDIX III

Exports of Marine Products from India 1960-1966

			1960	1961	1962	1963	1964	1965	1966
1.	Frozen Prawns	Q	1211165	1462656	2238190	3966899	5870031	7028121	8783545
		V	5866123	7366872	10820276	21203766	31518242	41421834	88791851
2.	Canned Prawns	Q	319510	621773	969923	1231274	1073927	1148002	1523327
		V	1784047	4222907	6558924	7575594	6991927	9505799	18656606
3.	Frozen Lobster Tails	Q	..	..	39763	53304	41304	111600	80802
		V			226364	312721	371021	1274517	1474477
4.	Frozen Crab Meat	Q	..	..	..	..	..	864	1325
		V						4498	7682
5.	Shark Fins and Fish Maws	Q	298420	292250	349567	341552	378071	243974	139440
		V	2073754	2229494	3442145	3050943	2881985	2032547	1339721
6.	Dried Prawns	Q	..	..	..	2808675	3008650	1702270	1463142
		V				9324698	8996764	5446894	5270682
7.	Dried Fish	Q	10201331	8804194	3963227	8703745	10173565	4430990	6552756
		V	20665068	13844799	4549967	13720942	15786581	6521827	13245714
8.	Frozen Fish	Q	..	..	..	10808	3208	8147	1986
		V				37023	11509	30083	24967
9.	Fish Pickles	Q	..	..	..	6061	9182	5070	4960
		V	..	..	..	38555	58178	33017	74613
10.	Prawn Powder	Q	..	..	..	255015	511187	104011	81487
		V	..	..	..	84363	125768	66553	53471
11.	Fish Bones	Q	..	..	..	421	7715	7968	17345
		V				11139	18890	37184	50384
12.	Turtle meat	Q	..	..	..	8861	11575	476	2518
		V				81206	58504	12324	60423
13.	Beache-de-mer	Q	..	..	..	3049	1275	24974	21886
		V				7529	2550	21125	39631
14.	Sea Shells	Q	101772	44401	11535	4834	..	2016	4570
		V	208863	115314	33926	5667		4429	80144
15.	Prawn Pickles	Q	..	..	..	..	683	885	1782
		V					2805	3175	12512
16.	Fish Oil	Q	..	..	..	..	..	69527	49560
		V	..	..	..	..	..	66552	60348

Q = Quantity; V = Value in Rupees. Source: Marine Products Export Promotion Council, Ernakulam.

APPENDIX II-B



Total Marine Fish Landings (1950–1965)

APPENDIX IV

Export of prawns and lobsters from India 1953—1966

	Frozen prawns		Canned prawns		Frozen Lobster Tails	
	Quantity (Kg.)	Value (Rupees	Quantity (Kg.)	Value (Rupees)	Quantity (Kg.)	Value (Rupees)
1953	13268	57740				
1954	60600	272893				
1955	48145	294002				
1956	190186	1096716				
1957	496410	2133546				
1958	779526	3790200				
1959	1049527	4923203	372850	2323667		
1960	1211165	5866123	319510	1784047		
1961	1462656	7366782	621773	4222907		
1962	2238190	10820176	969923	6559924	39763	226364
1963	3966899	21203766	1231274	7575594	53304	312721
1964	5870031	31517242	1073927	6991927	41304	371021
1965	7028121	41421834	1148002	9505799	111600	1274517
1966	8883545	88791851	1523327	18656606	80802	1474477

APPENDIX V

Progressive increase of mechanised fishing boats in the maritime states of India. *

The mechanisation of the indigenous craft and building of other suitable vessels fitted with diesel engines for fishing operations has been initiated in 1947, soon after the cessation of World War II. The Maharashtra took a great lead in introducing power driven indigenous craft for the first time in the country and the state has now over 2000 mechanised fishing boats. On the Indian coasts in all there are over 5000 mechanised fishing boats. The following table shows stage by stage increase of mechanised vessels in different states. A note on mechanisation of fishing crafts in Maharashtra, by the Director of Fisheries is also appended. It is also hereby acknowledged that state-wise figures of mechanised craft have been received through the courtesy of the respective Directorates of Fisheries.

* Figures for West-Bengal and Orissa not available

Table: Progressive total numbers of mechanised/motorised fishing vessels in various maritime states of India.

Year	Gujarat		Maharashtra	Goa	Daman	Diu	Mysore	Kerala		Madras	Andhra	Laccadive	Pondichery	Andamans	Govt. of India agencies	Total
	a	b						c	d						e	
1947-48			1													
1948-49			3													
1949-50																
1950-51			9													
1951-52			15													
1952-53																
1953-54																
1954-55																
1955-56			678					16								
1956-57										13						
1957-58										31						
1958-59										46						
1959-60										69						
1960-61	73	190	1286					152		76						
1961-62	209	419					64			109						
1962-63	274	567					67			162						
1963-64	367	612		7	1	10	141			216						
1964-65	419	633		9	5	15	179			249						
1965-66	476	671	1866	15	11	21	225	590		366						
To date	488		2030	18	30	23	265	715	29	467	238	45	18	3	33	
	488	671		18	30	23		715	29							
Total	1159		2030		71		265	744		467	238	45	18	3	33	5073

a — mechanised fishing boats.

b — motorised fishing boats.

c — smaller mechanised and motorised boats.

d — large to medium mechanised boats.

e — includes large to medium exploratory fishing vessels operated by Government of India offshore Fishing Station, C.I.F.T., C.I.F.E., and C·I.F.O.

APPENDIX VI

MECHANISATION OF FISHING CRAFT IN MAHARASHTRA

(By the Courtesy of the Directorate of Fisheries, Maharashtra)

Maharashtra long realised that the most effective method of tackling the problem of augmentation of fish production was the use of motive power in the indigenous fishing craft, which depended largely on wind and tide for their propulsion. Motorisation of the native fishing craft was, therefore, assigned the foremost place by government in its plans for development of marine fisheries. A beginning was made in March 1947 when the Fisheries Deparment built and operated the M. L. *TAPASE* and offered two improved types of mechanised vessels to fishermen's co-operative societies in March 1948. They were given on the basis of 50 per cent as loan and 50 per cent as subsidy on the cost of the entire fishing vessel built by Government, the loan being returnable in five years. This number increased hardly to nine in 1950. Though this beginning was slow and rather laborious, as the fishermen were required to be convinced and persuaded because mechanisation, which was from their point of view, a complicated method in place of the age-old simple method of operating sails for propelling their vessels. However, they soon realised the advantages of motorisation. The number of mechanised vessels which was 15 in 1951 gained considerable momentum and rose to 678 at the end of the First Five Year Plan (1955-56) and reached 1,286 at the end of the Second Five Year Plan (1960-61). The progress, though slackened on account of difficulty of foreign exchange, continued unabated making up a total of 1,866 at the end of the Third Five Year Plan (1965-66), the present figure being 2,030 at the beginning of 1967.

Maharashtra has in all 9,130 boats out of which 2,530 boats vary from 3 to 18 tons in berthen. Of this latter category 2,030 boats are mechanised, their total mechanised tonnage being in the neighbourhood of 17,000 tons. The designs of vessels of Maharashtra is not, however, changed materially as the ones which were being adopted by the fishermen were quite sound and scientific. Some of the F.A.O. Naval Architects who visited and inspected the boats stated that technically there was hardly anything to suggest by way of improvement. A report on the Satpati type of fishing boat, which was critically tested in the shape testing tank at the Central Water & Power Research Station, Khadakwasla, indicated that the design was satisfactory. The boats being all plank built and strong could easily take the engine and thus take full advantage of mechanization without changing their design.

Though many of these vessels have not given up their traditional methods of fishing, viz., bag net (dol) fishing and gill-netting, more than 120 boats have now taken to trawling both in the Ratnagiri and Bombay areas. Mechanisation has increased the cruising range from its original 15 miles (of sailing craft) to 60 to 70 miles, some of the boats staying out for 3 to 4 days. Though all mechanised boats do not take to new methods of fishing they fish for larger number of days, use more number of nets, larger or longer nets and return to port at the right time for marketing, thus claiming better rates for their produce. This has given the fishermen increased returns which may vary from 60 to 80 per cent of their former catches. Consistently increasing prices of fueloil, marine engines and fishery requisites are working heavily on the fishermen's minds but mechanisation of fishing craft has come to stay in Maharashtra and increasing number of fishermen are coming forward for engines to mechanise their boats, both for social as well as economic reasons.

Government have so far spent Rs. 247.28 lakhs on mechanisation during the past three plans. Out of this amount, Rs. 146.96 lakhs is as loan and Rs.100.32 lakhs as subsidy.

APPENDIX VII

Tagging of the spiny lobsters, mackerel and oil sardine

After preliminary trials on experimental tagging, lobsters with suture tags were first released in March 1965 at Muttom in Kanyakumari District and at Mandapam. Subsequently tagged lobsters have been released at other centres also. The recoveries of the tagged specimens have been encouraging. For oil sardine and mackerel the opercular tags tried in 1965 were found best suited. Release of tagged mackerel and oil sardine was commenced towards the end of 1966. Some particulars of the tagging already carried out are given in the accompanying tables. The handbills and posters issued in connection with the tagging programme follow.

1. SPINY LOBSTER

Species: Panulirus homarus (LATR.)

Type of Tag used: PLASTIC SUTURE TAG

Station and date	No. Tagged and released	Place of release	Number recovered	Maximum period between release and recapture (Days)
Muttom		2 km. west of		
8-3-65	9	Muttom Light House	..	..
9-3-65	26	..	11	273
11-3-65	55	..	18	308
26-3-65	17	..	1	230
28-3-65	16	..	2	212
29-3-66	14	..	1	286
Mandapam		Off Hare Island		
28-3-65	6		..	..
3-4-65	4	..	1	118
		Near C.M.F.R· Jetty		
8-4-65	1	Gulf of Mannar	..	..
5-5-65	1	..	..	..
		Near Pullivasal		
1-6-65	4	Island	..	..
7-9-65	2	..	1	106
31-1-66	1	..	..	..
Thikkoti		4 km. Wwst of		
7-9-66	15	Tikkoti Light House	1	78
8-9-66	78	..	..	..
9-9-66	38	..	3	76
		Species: Panulirus ornatus **(Fabr.)**		
Mandapam				
27-3-65	2	Off Hare Island	..	..
28-3-65	4	..	..	..
3-4-65	6	..	1	111

Contd.

Station and date	No. Tagged and released	Place of release	Number recovered	Maximum period between release and recapture (Days)
		Near C.M.F.R.I. Jetty		
5-4-65	1	Gulf of Mannar	..	..
8-4-65	6	..	..	..
5-5-65	4	..	..	..
1-6-65	14	Near Pullivasal Island	1	118
7-9-65	16	..	..	..
31-1-66	5	..	..	..
		Species: Panulirus versicolor **(Latr.)**		
Mandapam				
3-4-65	2	Off Hare Island	..	..
		C.M.F.R.I. Jetty		
8-4-65	1	Gulf of Mannar		..
		Species: Panulirus polyphagus **(Herbst.)**		
Thikkoti		4 km. west of		
7-9-66	14	Thikkoti Light House		
8-9-66	17	..	..	..

2. MACKEREL *(Rastrelliger kanagurta)*
RELEASED WITH OPERCULAR TAGS

Station and date	No. tagged and released	Place of release	Remark
Karwar			
27-11-1965	30	Off Karwar Head	
20-1-1966	25	Karwar Bay	
21-1-1966	33	Do.	
23-11-1966	110	Off Karwar Head	
9-12-1966	178	Do.	
3-2-1967	112	Karwar Bay	3 recovered on 5-2-1967 and one on 8-2-1967.
Total	488		
Mangalore			
30-1-1967	50	Off Tannirbavi	
31-1-1967	50	Off Bockapatna	
1-1-1967	37	Off Kodikal	
Total	137		
Ernakulam			
21-1-1967	28	Off Vypeen	
25-1-1967	13	Off Narakkal	
Total	41		
Grand total	666		

3. OIL SARDINE (*Sardinella longiceps*)

RELEASED WITH OPERCULAR TAGS

Station and date	No. tagged and released	Place of release	Remarks
Mangalore			
20-1-1967	169	Off Tannirbavi	
30-1-1967	9	Do.	
31-1-1967	6	Off Bockapatna	
1-2-1967	1	Off Kodikal	
6-2-1967	316	Off Ullal	
7-2-1967	300	Do.	
9-2-1967	400	Off Uchila	
14-2-1967	300	Off Ullal	
Total	1501		
Ernakulam			
20-12-1966	105	Off Narakkal	
23-12-1966	96	Off Kannamali	
28-12-1966	215	Off Narakkal	
4-1-1967	235	Do.	
7-1-1967	181	Do.	
18-1-1967	144	Off Kannamali	
21-1-1967	199	Off Narakkal	
25-1-1967	310	Do.	
25-2-1967	1	Off Malipuram	
Total	1486		
Grand Total	2987		

TAGGED LOBSTER RELEASED

(TO STUDY THE MOVEMENT & GROWTH)

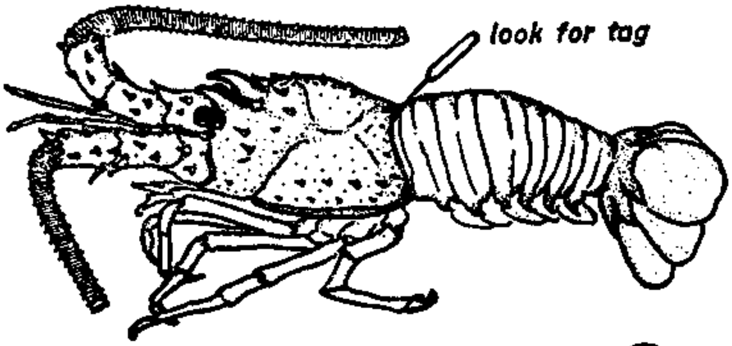
IF RECOVERED PLEASE RETURN TO

The Officer-in-Charge, Central Marine Fisheries Research Sub Station

MANGALORE, CANNANORE, KOZHIKODE, ERNAKULAM, NEENDAKARA

WITH INFORMATION ON DATE AND PLACE OF CAPTURE.

COLLECT Rs. 2/- for each lobster returned



അടയാളപ്പെടുത്തിയ

(ചിറ്റാക്കൊഞ്ചൻ)

ചിറ്റാക്കൊഞ്ചിന്റെ വളർച്ചയും

സഞ്ചാരപരിധിയും പഠിക്കുവാൻ

കേന്ദ്ര മത്സ്യ ഗവേഷണ വകുപ്പ് അവയെ അടയാളപ്പെടുത്തി വിട്ടിരിക്കുന്നു.

അടയാളമുള്ള **കൊഞ്ചുകളെ** കിട്ടുന്നവർ

പിടിച്ച സ്ഥലവും തിയ്യതിയും കാണിച്ച് അടുത്ത കേന്ദ്ര മത്സ്യ ഗവേഷണ വകുപ്പാഫീസിൽ ഏല്പിച്ചാൽ

ഓരോന്നിനും 2/-ക വീതം നൽകപ്പെടും

[illegible]

സെൻട്രൽ മറൈൻ ഫിഷറീസ് സ്റ്റേഷൻ, മംഗലാപുരം, കണ്ണൂർ, കോഴിക്കോട്, എറണാകുളം, നീണ്ടകര

TAGGED LOBSTER RELEASED

(TO STUDY THE MOVEMENT & GROWTH)

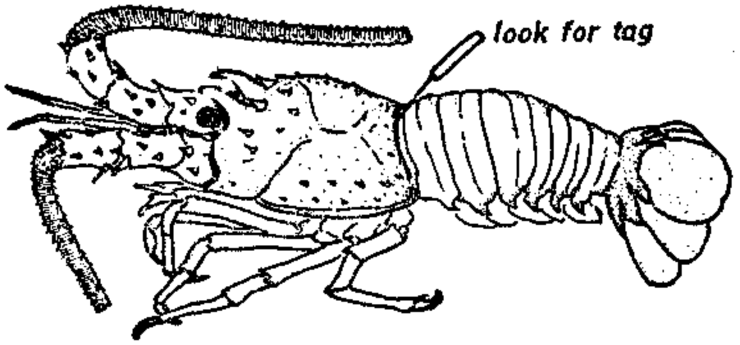
IF RECOVERED PLEASE RETURN TO

The Officer-in-Charge, Central Marine Fisheries Research Centre,

CAPE COMORIN/COLACHEL/VIZHINGAM.

WITH INFORMATION ON DATE AND PLACE OF CAPTURE.

COLLECT Rs. 2/- for each lobster returned



அடையாளமிடப்பட்ட
கல் இரால்

கல் இரால்களின் வளர்ச்சியையும் கடலில் அதன்
போக்கு வரத்துக்களையும் அறிவதற்காக
மத்திய அரசாங்க மீன் ஆராய்ச்சி நிலையம் அடையாளமிடப்பட்ட
கல் இரால்களை கடலில் விட்டிருக்கிறது

மேற்கண்ட கல் இரால்கள் கிடைத்தால் பிடித்த இடமும் தேதியும்
குறிப்பிட்டு அருகிலுள்ள மத்திய மீன் ஆராய்ச்சி நிலைய அலுவலகத்தில் சேர்த்தால்
ஒவ்வொன்றிற்கும் ரூ 2/- வீதம் அளிக்கப்படும்

அனுப்ப வேண்டிய விலாசம்
சென்டிரல் மெரீன் பிஷரீஸ் ரீஸர்ச் சென்டர்
கன்னியாகுமரி, குளச்சல், விழிங்கம்.

NOTICE.

In order to study the rate of growth and movement of the spiny lobster *(Panulirus homarus)* the Central Marine Fisheries Research Institute has tagged and released several lobsters in the sea off Kerala Coast. Red plastic tags are attached behind the head on the upper aspect of the lobster and they bear a serial number.

Those who come across such marked lobsters may kindly note the place and date of capture and hand over the lobster to the nearest office of this department.

Addresses of this department in this region are:

1. **Central Marine Fisheries Research Unit, Bolar, Mangalapuram.-1.**
2. **Central Marine Fisheries Research Unit, Beach Road, Cannanore.**
3. **Central Marine Fisheries Research Sub-Station, West Hill, Kozhikode-5.**
4. **Central Marine Fisheries Research Sub-Station, Pallimukku, Ernakulam-6.**
5. **Central Marine Fisheries Research Centre, Neendakara**

For each tagged lobster returned with the necessary information a sum of Rs. 2/- will be paid

The success of this project will largely depend on the public cooperation in returning the tagged specimens. It is therefore requested that full cooperation is extended by one and all to make this endeavour a success.

Government of India,
Central Marine Fisheries Research Institute,
Mandapam Camp, South India

വിജ്ഞാപനം

(കേന്ദ്ര മത്സ്യഗവേഷണ വകുപ്പ് പ്രസിദ്ധപ്പെടുത്തുന്നത്)

ചിററാകൊഞ്ചിന്റെ വളർച്ചയും കടലിൽ അതിന്റെ സഞ്ചാരപരിധിയും മററും പഠിക്കുവാൻ അവയെ കേന്ദ്ര മത്സ്യഗവേഷണ വകുപ്പ് അടയാളമിട്ട് കടലിൽ വിട്ടിരിക്കുന്നു. കേരളത്തിൽ കൊഞ്ചു പിടിക്കുന്ന എല്ലാ സ്ഥലങ്ങളിലും അവയെ കണ്ടെത്താൻ സാദ്ധ്യതയുണ്ട്. കൊഞ്ചിന്റെ തലയുടെ പിന്നിൽ മുതുകത്ത് (പടത്തിൽ കാണിച്ച പോലെ) നമ്പ്ര് ഇട്ട ചുവന്ന പ്ലാസ്റ്റിക്ക് നാട കെട്ടിവിട്ടിട്ടുണ്ട്. ഇപ്രകാരം അടയാളപ്പെടുത്തിയ കൊഞ്ചുകളെ കിട്ടിയാൽ പിടിച്ച സ്ഥലത്തിന്റെ പേരും തിയ്യതിയും കാണിച്ച് അവയെ അടുത്തുള്ള കേന്ദ്രമത്സ്യഗവേഷണ വകുപ്പാഫീസിൽ ഏല്പിക്കുവാൻ അപേക്ഷ. അങ്ങിനെ ഏല്പിക്കുന്ന ഓരോ കൊഞ്ചിനും 2ക വീതം നൽകപ്പെടും

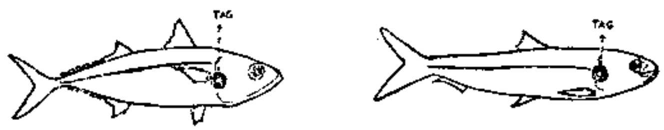
താഴെ പറയുന്ന ആഫീസുകളിൽ കൊഞ്ചുകളെ ഏല്പിക്കാവുന്നതാണ്.

1. സെൻട്രൽ മറീൻഫിഷറീസ് റിസർച്ച് യൂണിററ്; ബോളാർ മംഗലാപുരം-1.
2. സെൻട്രൽ മറീൻഫിഷറീസ് റിസർച്ച് യൂണിററ്, ബീച്ച്റോഡ് കണ്ണൂർ.
3. സെൻട്രൽ മറീൻഫിഷറീസ് റിസർച്ച് സബ്സ്റ്റേഷൻ. വെസ്റ്റ്ഹിൽ. കോഴിക്കോട്-5.
4. സെൻട്രൽ മറീൻഫിഷറീസ് റിസർച്ച് സബ്സ്റ്റേഷൻ പള്ളിമുക്ക്, എറണാകുളം-6.
5. സെൻട്രൽ മറീൻഫിഷറീസ് റിസർച്ച് സെൻറർ, നീണ്ടകര.

അടയാളമിട്ട കൊഞ്ചുകളെ തിരിച്ചു കിട്ടുന്നതിനെ ആശ്രയിച്ചിരിക്കും ഈ പദ്ധതിയുടെ വിജയം. ആയതിനാൽ നിങ്ങൾ ഓരോരുത്തരും വേണ്ടവിധം സഹകരിച്ച് ഈ സംരംഭത്തെ വിജയിപ്പിക്കുവാൻ അഭ്യർത്ഥിച്ചുകൊള്ളുന്നു.

കേന്ദ്രസർക്കാർ
കടൽ മത്സ്യഗവേഷണ സ്ഥാപനം
മണ്ഡപം, തെക്കെഇന്ത്യ

Please look out for Tagged Mackerel & Oil Sardine



Mackerel and oil sardine marked with coloured plastic tags have been released in the sea along the West Coast of India to study their movements and growth. Your co-operation in making the project a success is solicited.

You may collect RUPEES THREE for a fish with tag and RUPEE ONE for a single tag, on returning these to the nearest office of the CENTRAL MARINE FISHERIES RESEARCH INSTITUTE at Bombay/Ratnagiri/Karwar/Mangalore/Cannanore/Calicut/Ernakulam/Neendakara/Vizhingam/Colachel/Cape Comorin or the SURVEY STAFF of this department in the area.

When tag/tags sent by post, please give the following information.

1. Name and address of the sender: ____________
2. Place and date of capture: ____________
3. Length of fish (in inches or centimetres): ____________

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE,
MANDAPAM CAMP. (Madras State)

निशाण चिकटविलेले बांगडे व तारले यांवर कृपया लक्ष असूंद्या

बांगडे व तारले यांची हालचाल व वाढ अभ्यासण्याच्या हेतुने त्यांच्यावर प्लॅस्टिकची रंगीत निशाणें (वरचे चित्र पहावे) चिकटवून हिन्दुस्थानच्या पश्चिम किनाऱ्यावरील समुद्रांत सोडून दिले आहेत. ही योजना यशस्वी करण्याकरिता आपल्या सहकार्याची याचना करीत आहोत.

सेंट्रल मरिन फिशरीज रिसर्च इन्स्टीट्यूटच्या—मुंबई/रत्नागिरी/कारवार/मंगळूर/कॅनानूर/कालिकत/एर्नाकुलम/नींदकरा/विजिगम/कोलाचल/कन्याकुमारी — मधील कचेरीत, किंवा त्या विभागांत ह्या खात्याच्या सर्व्हे अधिकाऱ्यांकडे जर आपण निशाणसहित मासा आणून दिले तर आपल्याला तीन रुपये, व फक्त निशाण आणून दिले तर एक रुपया मिळेल.

निशाण/निशाणें पोस्टाने पाठविल्यास कृपया खाली दिल्याप्रमाणे माहिती पुरवावी.

१. पाठविणाराचें नांव व पत्ता ____________
२. मासा पकडलेल्या दिवसाची तारीख व ठिकाण ____________
३. माशाची लांबी (इंचामध्ये किंवा सेंटिमिटरमध्ये) ____________

सेंट्रल मरिन फिशरीज रिसर्च इन्स्टीट्यूट,
मन्डपम् कॅम्प. (मद्रास स्टेट)

ಕ್ಲಿಪ್ ತೊಡಿಸಿದ ಬಂಗುಡೆ, ಬೂತಾಯಿ ಅಥವಾ ತಾರಲಿ ಮೀನುಗಳ ಮೇಲೆ ಲಕ್ಷ್ಯವಿರಲಿ.

ಬಣ್ಣದ ಪ್ಲಾಸ್ಟಿಕ್ಕಿನ ಕ್ಲಿಪ್ ತೊಡಿಸಿದ ಬಂಗುಡೆ, ಬೂತಾಯಿ ಅಥವಾ ತಾರಲಿ ಮೀನುಗಳನ್ನು (ಮೇಲಿನ ಚಿತ್ರ ನೋಡಿರಿ) ಅವುಗಳ ಚಲನವಲನೆ ಮತ್ತು ಬೆಳವಣಿಗೆಯ ಅಧ್ಯಯನಕ್ಕೋಸ್ಕರವಾಗಿ ಭಾರತದ ಪಶ್ಚಿಮ ಕರಾವಳಿಯ ಸಮುದ್ರದಲ್ಲಿ ಬಿಡಲಾಗಿದೆ. ಈ ಯೋಜನೆಯು ಯಶಸ್ವಿಯಾಗಲು ನಿಮ್ಮ ಸಹಕಾರವನ್ನು ಕೋರಲಾಗಿದೆ.

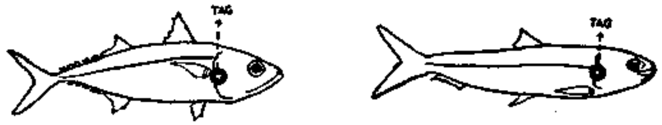
ನೀವು ಮೀನು ಸಹಿತ ಕ್ಲಿಪ್ಪಿಗೆ ರೂ. ಮೂರನ್ನು ಮತ್ತು ಪ್ರತಿ ಕ್ಲಿಪ್ಪಿಗೆ ರೂ. ಒಂದನ್ನು ಅತಿ ಹತ್ತಿರ ಇರುವ ಸೆಂಟ್ರಲ್ ಮರೀನ ಫಿಶರೀಜ್ ರಿಸರ್ಚ್ ಇನ್‌ಸ್ಟಿಟ್ಯೂಟಿನ ಕೇಂದ್ರಗಳಾದ ಮುಂಬಾಯಿ, ರತ್ನಾಗಿರಿ, ಕಾರವಾರ, ಮಂಗಳೂರು, ಕಣ್ಣಾನ್ನೂರು, ಕಲ್ಲಿಕೋಟೆ, ಎರ್ನಾಕುಲಂ, ನಿಂದಕರಾ, ವಿಜಿಂಗಮ್, ಕೋಲಾಚಲ್, ಕನ್ಯಾಕುಮಾರಿ ಅಥವಾ ಸರ್ವೆ ಅಧಿಕಾರಿಗಳಿಗೆ ಹಿಂತಿರುಗಿಸಿ ಪಡೆದುಕೊಳ್ಳಿರಿ.

ಅಂಚೆಯ ಮೂಲಕ ಕ್ಲಿಪ್/ಕ್ಲಿಪ್ಪುಗಳನ್ನು ಕಳುಹಿಸಿದ್ದಲ್ಲಿ ಈ ಕೆಳಗಿನ ವಿವರ ಒದಗಿಸಬೇಕಾಗಿ ಬಿನ್ನಹ:—

1. ಕಳುಹಿಸಿದವರ ಹೆಸರು ಮತ್ತು ವಿಳಾಸ: ____________
2. ಹಿಡಿದ ಸ್ಥಳ ಮತ್ತು ದಿನಾಂಕ: ____________
3. ಮೀನಿನ ಉದ್ದಳತೆ (ಇಂಚುಗಳಲ್ಲಿ ಇಲ್ಲವೆ ಸೆಂಟಿಮೀಟರುಗಳಲ್ಲಿ): ____________

ಸೆಂಟ್ರಲ್ ಮರೀನ ಫಿಶರೀಜ್ ರಿಸರ್ಚ್ ಇನ್‌ಸ್ಟಿಟ್ಯೂಟ್,
ಮಂಡಪಮ್ ಕ್ಯಾಂಪ್. (ಮದ್ರಾಸ್ ಪ್ರಾಂತ್ಯ)

Please look out for Tagged Mackerel & Oil Sardine



Mackerel and oil sardine marked with coloured plastic tags have been released in the sea along the West Coast of India to study their movements and growth. Your co-operation in making the project a success is solicited.

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When tag/tags sent by post, please give the following information.

1. Name and address of the sender: ....
2. Place and date of capture: ....
3. Length of fish (in inches or centimetres): ....

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE,
MANDAPAM CAMP. (Madras State)

ಕ್ಲಿಪ್ ತೊಡಿಸಿದ ಬಂಗುಡೆ, ಬೂತಾಯಿ ಅಥವಾ ತಾರಲಿ ಮೀನುಗಳ ಮೇಲೆ ಲಕ್ಷ್ಯವಿರಲಿ.

ಬಣ್ಣದ ಪ್ಲಾಸ್ಟಿಕ್ಕಿನ ಕ್ಲಿಪ್ ತೊಡಿಸಿದ ಬಂಗುಡೆ, ಬೂತಾಯಿ ಅಥವಾ ತಾರಲಿ ಮೀನುಗಳನ್ನು (ಮೇಲಿನ ಚಿತ್ರ ನೋಡಿರಿ) ಅವುಗಳ ಚಲನವಲನೆ ಮತ್ತು ಬೆಳವಣಿಗೆಯ ಅಧ್ಯಯನಕ್ಕೋಸ್ಕರವಾಗಿ ಭಾರತದ ಪಶ್ಚಿಮ ಕರಾವಳಿಯ ಸಮುದ್ರದಲ್ಲಿ ಬಿಡಲಾಗಿದೆ. ಈ ಯೋಜನೆಯು ಯಶಸ್ವಿಯಾಗಲು ನಿಮ್ಮ ಸಹಕಾರವನ್ನು ಕೋರಲಾಗಿದೆ.

ನೀವು ಮೀನು ಸಹಿತ ಕ್ಲಿಪ್ಪಿಗೆ ರೂ. ಮೂರನ್ನು ಮತ್ತು ಪ್ರತಿ ಕ್ಲಿಪ್ಪಿಗೆ ರೂ. ಒಂದನ್ನು ಅತಿ ಹತ್ತಿರ ಇರುವ ಸೆಂಟ್ರಲ್ ಮರೀನ ಫಿಶರೀಜ್ ರಿಸರ್ಚ್ ಇನ್ಸ್ಟಿಟ್ಯೂಟದ ಕೇಂದ್ರಗಳಾದ ಮುಂಬಾಯಿ, ರತ್ನಾಗಿರಿ, ಕಾರವಾರ, ಮಂಗಳೂರು, ಕಣ್ಣಾನ್ನೂರು, ಕಲ್ಲಿಕೋಟೆ, ಎರ್ನಾಕುಲಂ, ನೀಂದಕರಾ, ವ್ಹಿಜಿಂಗಮ್, ಕೋಲಾಚಲ್, ಕನ್ಯಾಕುಮಾರಿ ಅಥವಾ ಸರ್ವೆ ಅಧಿಕಾರಿಗಳಿಗೆ ಹಿಂತಿರುಗಿಸಿ ಪಡೆದುಕೊಳ್ಳಿರಿ.

ಅಂಚೆಯ ಮೂಲಕ ಕ್ಲಿಪ್/ಕ್ಲಿಪ್ಪುಗಳನ್ನು ಕಳುಹಿಸಿದ್ದಲ್ಲಿ, ಈ ಕೆಳಗಿನ ವಿವರ ಒದಗಿಸಬೇಕಾಗಿ ಬಿನ್ನಹ:-

1. ಕಳುಹಿಸಿದವರ ಹೆಸರು ಮತ್ತು ವಿಳಾಸ: ....
2. ಹಿಡಿದ ಸ್ಥಳ ಮತ್ತು ದಿನಾಂಕ: ....
3. ಮೀನಿನ ಉದ್ದಳತೆ (ಇಂಚುಗಳಲ್ಲಿ ಇಲ್ಲವೆ ಸೆಂಟಿಮೀಟರುಗಳಲ್ಲಿ): ....

ಸೆಂಟ್ರಲ್ ಮರೀನ ಫಿಶರೀಜ್ ರಿಸರ್ಚ್ ಇನ್ಸ್ಟಿಟ್ಯೂಟ್,
ಮಂಡಪಮ್ ಕ್ಯಾಂಪ್. (ಮದ್ರಾಸ ಪ್ರಾಂತ್ಯ)

ഈ മീനുകളെ ശ്രദ്ധിക്കുക

അയിലയുടെയും മത്തിയുടെയും വളർച്ചയും സഞ്ചാരപരിധിയും പഠിക്കുവാൻ അവയുടെ ചെകിളകളിൽ നിറമുള്ള പ്ലാസ്റ്റിക് അടയാളം കൊളുത്തി (ചിത്രം നോക്കുക) കടലിൽ വിട്ടിരിക്കുന്നു. ഈ സംരംഭത്തിന്റെ വിജയത്തിന് നിങ്ങളുടെ സഹായ സഹകരണങ്ങൾ അഭ്യർത്ഥിച്ചുകൊള്ളുന്നു.

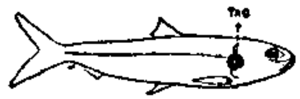
ഇത്തരം അടയാളമുള്ള മീനുകളെ കണ്ടുകിട്ടുന്നവർ ബോംബെ, രത്നഗിരി, കാർവാർ, മംഗലാപുരം, കണ്ണൂർ, കോഴിക്കോട്, എറണാകുളം, നീണ്ടകര, വിഴിഞ്ഞം, കൊളച്ചൽ, കന്യാകുമാരി എന്നിവിടങ്ങളിലുള്ള കേന്ദ്ര മത്സ്യ ഗവേഷണ വകുപ്പിന്റെ ആഫീസുകളിലോ സർവ്വേ ഉദ്യോഗസ്ഥന്മാരെയോ ഏല്പിക്കുകയാണെങ്കിൽ അങ്ങിനെ പ്ലാസ്റ്റിക് അടയാളത്തോടുകൂടിയ ഓരോ അയില/മത്തിക്ക് 3 രൂപാ വീതവും, ഓരോ വെറും പ്ലാസ്റ്റിക് അടയാളത്തിനു 1 രൂപാ വീതവും ലഭിക്കുന്നതാണ്.

പ്ലാസ്റ്റിക് അടയാളം മാത്രം തപാലിൽ അയക്കുന്നവർ താഴെ കൊടുത്തിരിക്കുന്ന വിവരങ്ങൾ കൂടി അറിയിക്കേണ്ടതാണ്.

1. അയക്കുന്ന ആളിന്റെ പേരും മേൽവിലാസവും
2. മീനിനെ കണ്ടെത്തിയ സ്ഥലവും തീയതിയും
3. മീനിന്റെ നീളം (ഇഞ്ചിലോ സെന്റിമീറ്ററിലോ)

സെൻട്രൽ മറൈൻ ഫിഷറിസ് റിസർച്ച് ഇൻസ്റ്റിറ്റ്യൂട്ട്,
മണ്ഡപം ക്യാമ്പ് (മദ്രാസ് സ്റ്റേറ്റ്)

Please look out for Tagged Mackerel & Oil Sardine



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3. Length of fish (in inches or centimetres): ____________

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE,
MANDAPAM CAMP. (Madras State)

ഈ മീനുകളെ ശ്രദ്ധിക്കുക

അയിലയുടേയും മത്തിയുടേയും വളർച്ചയും സഞ്ചാരപരിധിയും പഠിക്കുവാൻ അവയുടെ ചെകിളകളിൽ നിറമുള്ള പ്ലാസ്റ്റിക് അടയാളം കൊളുത്തി (ചിത്രം നോക്കുക) കടലിൽ വിട്ടിരിക്കുന്നു. ഈ സംരംഭത്തിന്റെ വിജയത്തിന് നിങ്ങളുടെ സഹായ സഹകരണങ്ങൾ അഭ്യർത്ഥിച്ചുകൊള്ളുന്നു.

ഇത്തരം അടയാളമുള്ള മീനുകളെ കണ്ടുകിട്ടുന്നവർ ബോംബെ, രത്നഗിരി, കാർവാർ, മംഗലാപുരം, കണ്ണൂർ, കോഴിക്കോട്, എറണാകുളം, നീണ്ടകര, വിഴിഞ്ഞം, കൊളച്ചൽ, കന്യാകുമാരി എന്നിവിടങ്ങളിലുള്ള കേന്ദ്ര മത്സ്യ ഗവേഷണ വകുപ്പിന്റെ ആഫീസുകളിലോ സർവ്വേ ഉദ്യോഗസ്ഥന്മാരായോ ഏല്പിക്കുന്നാണെങ്കിൽ അങ്ങിനെ പ്ലാസ്റ്റിക് അടയാളത്തോടുകൂടിയ ഓരോ അയില/മത്തിക്ക് 3 രൂപാ വീതവും, ഓരോ വെറും പ്ലാസ്റ്റിക് അടയാളത്തിനു 1 രൂപാ വീതവും ലഭിക്കുന്നതാണ്.

പ്ലാസ്റ്റിക് അടയാളം മാത്രം തപാലിൽ അയക്കുന്നവർ താഴെ കൊടുത്തിരിക്കുന്ന വിവരങ്ങൾ കൂടി അറിയിക്കേണ്ടതാണ്.

1. അയക്കുന്ന ആളിന്റെ പേരും മേൽവിലാസവും
2. മീനിനെ കണ്ടെത്തിയ സ്ഥലവും തീയ്യതിയും
3. മീനിന്റെ നീളം (ഇഞ്ചിലൊ സെൻടിമിററിലോ)

സെൻട്രൽ മറൈൻ ഫിഷറിസ് റിസർച്ച് ഇൻസ്റ്റിററ്യൂട്ട്,
മണ്ഡപം ക്യാംപ് (മദ്രാസ് സ്റ്റേററ്)

தேடுங்கள்! அடையாளமிட்ட கும்பளா, மத்தி மீன்களை

கும்பளா, மத்தி ஆகிய மீன்களின் வளர்ச்சி, நடமாட்டம் ஆகியவைகளை ஆராய இம்மீன்களில் வர்ணபிளாஸ்டிக் அடையாளம் இணைத்து (படத்தைப் பார்க்கவும்) மேற்குக் கடற்கரையிலிருந்து கடலில் விடுக்கப்பட்டுள்ளன. இத்திட்டம் வெற்றி பெற உங்கள் ஒத்துழைப்பைக் கோருகிறோம்.

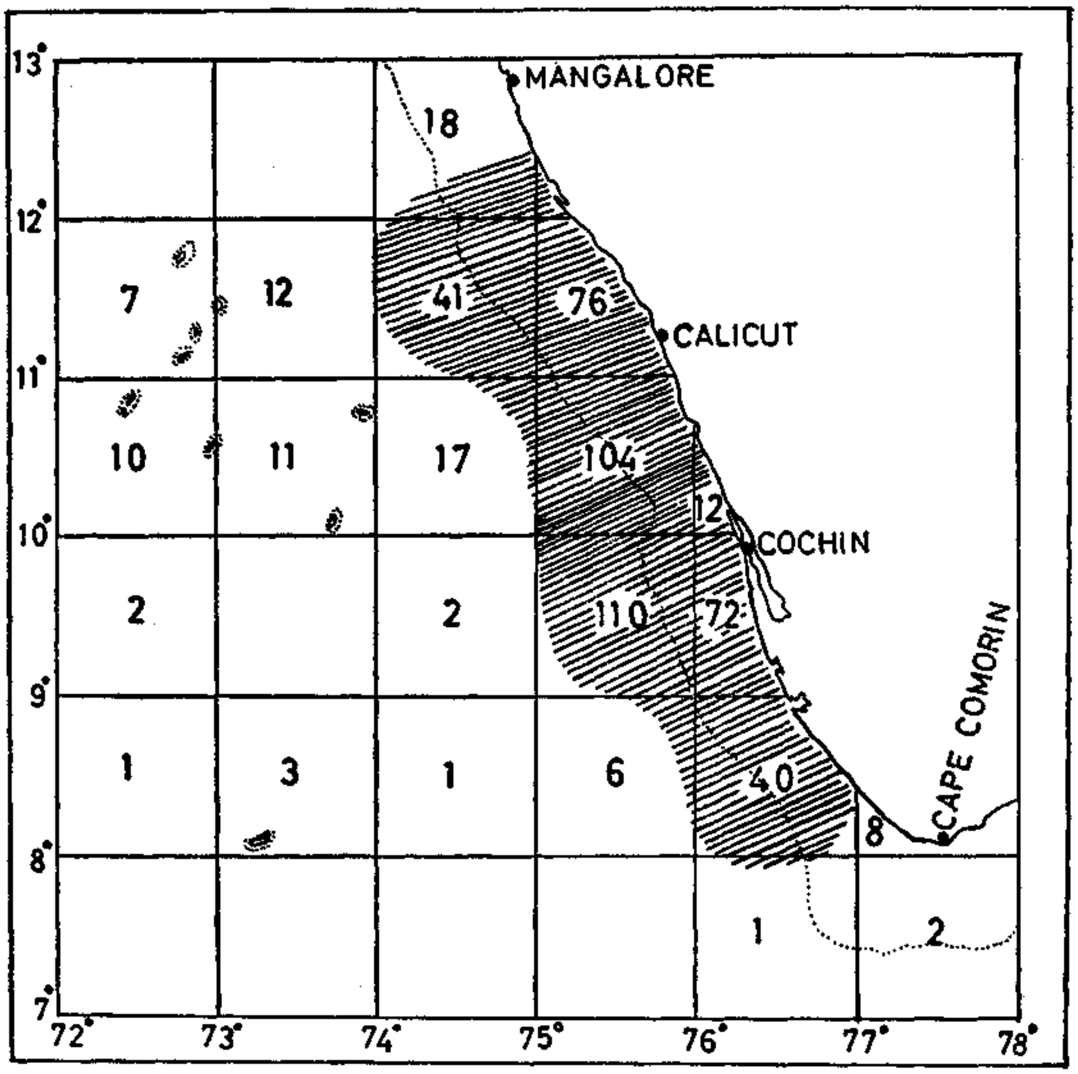
ரத்னகிரி, கார்வார், மங்களூர், கண்ணனூர், கோழிக்கோடு, எர்ணாகுளம், நீண்டகரா, விழிங்கம், கொளச்சல், கன்யாகுமரி, ஆகிய இடங்களில் உள்ள மத்திய அரசாங்க கடல்மீன் ஆராய்ச்சி நிலையங்களில் அல்லது இந்த ஆராய்ச்சி நிலயத்தின் சர்வே அதிகாரிகளிடம் நீங்கள் கொடுக்கும் அடையாளத்துடன் கூடிய ஒவ்வொரு மீனுக்கும் ரூ. மூன்றும், தனியான அடையாளம் ஒன்றிற்கு ரூ. ஒன்றும் பெற்றுக் கொள்ளுங்கள்.

பிளாஸ்டிக் அடையாளத்தை தபால் மூலம் அனுப்பும் போது கீழ்க்கண்ட விபரங்களைக் கொடுக்கவும்.

1. *அனுப்புவோரின் பெயர், விலாசம்.* ____________
2. *கிடைத்த இடம், தேதி.* ____________
3. *மீனின் நீளம் (அங்குலம் அல்லது சென்டிமீட்டரில்)* ____________

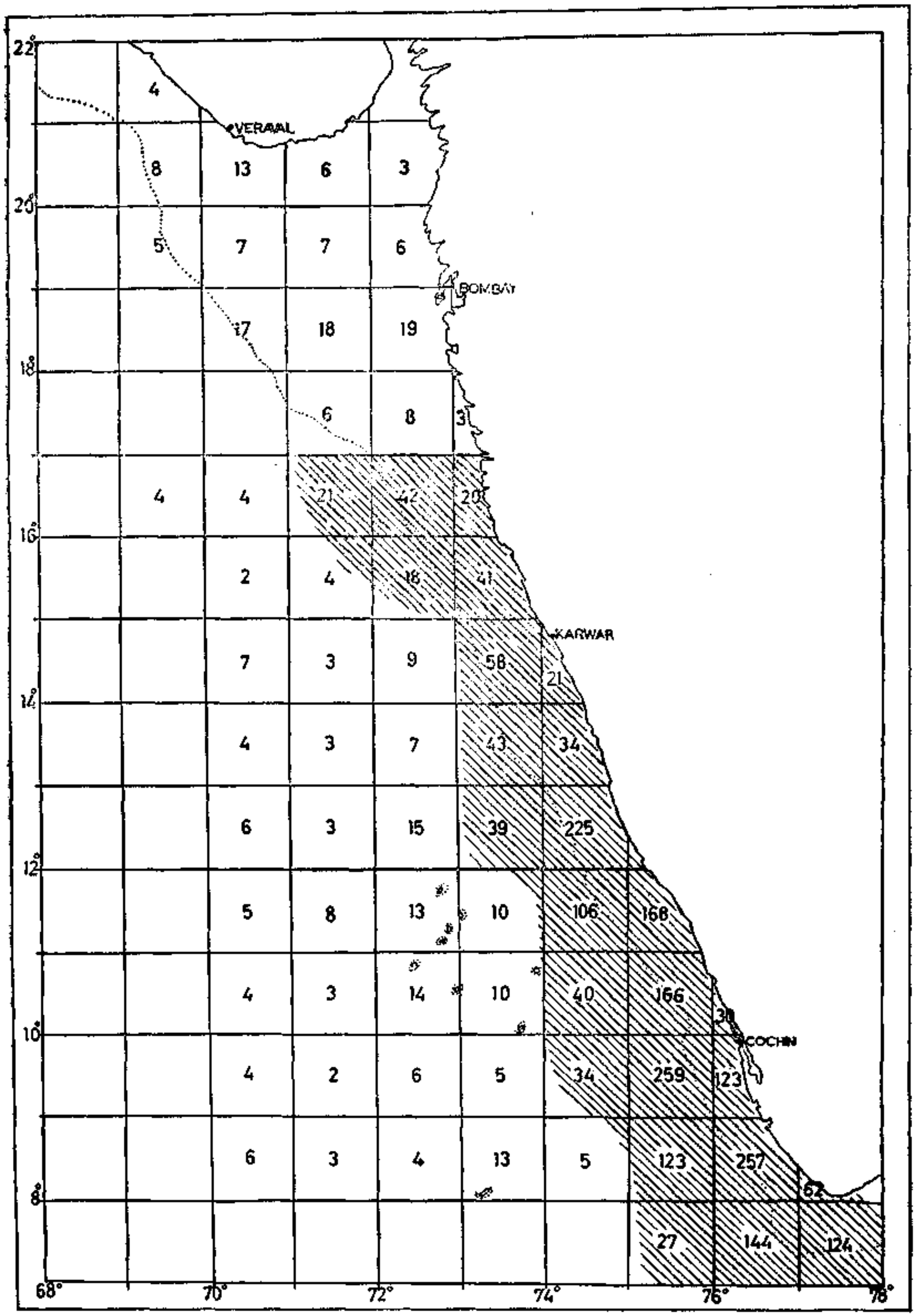
சென்ட்ரல் மெரைன் ஃபிஷரீஸ் ரிஸர்ச் இன்ஸ்டிட்யூட்,
மண்டபம் கேம்ப் (மதராஸ் ஸ்டேட்).

APPENDIX - IX



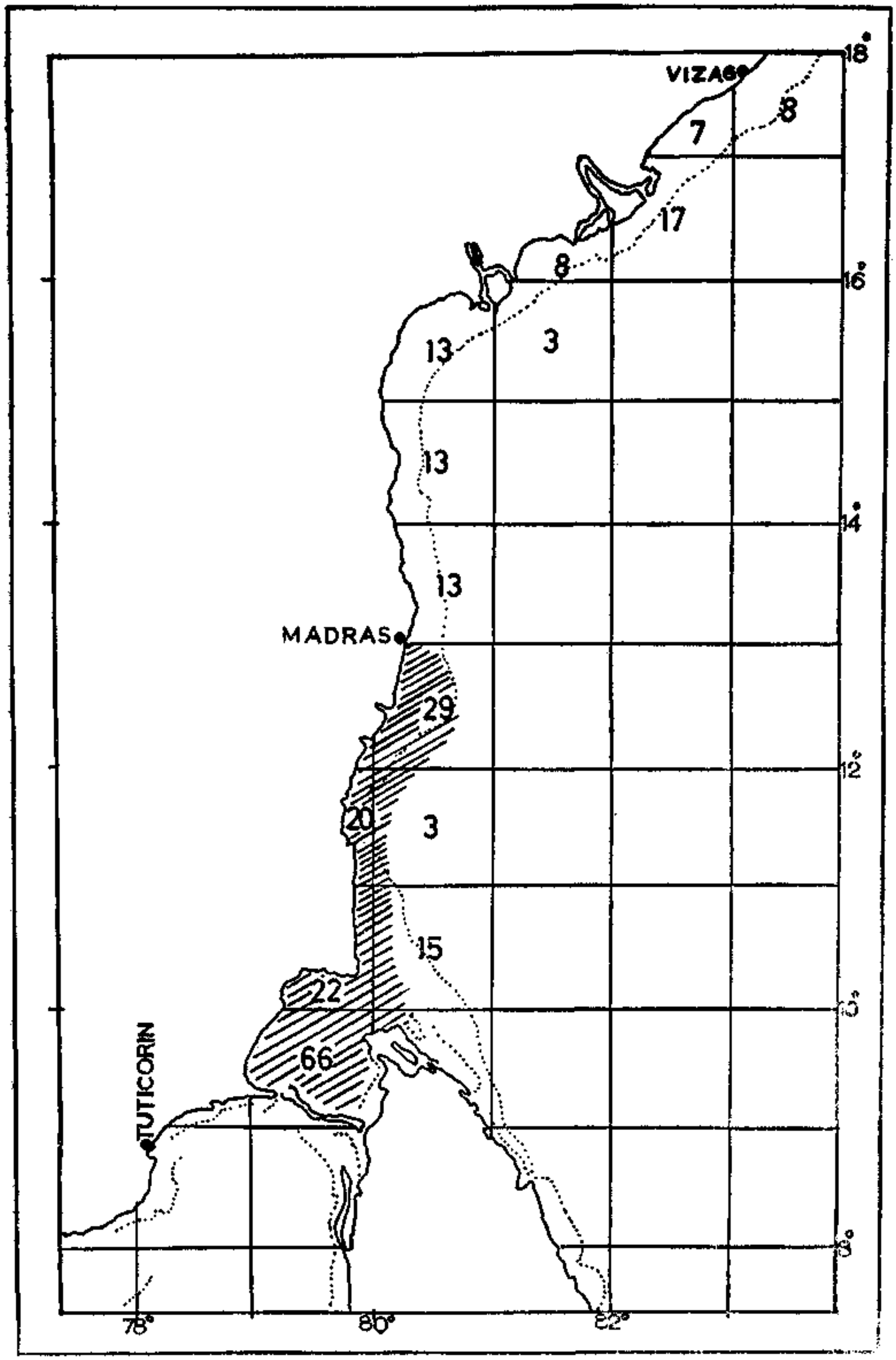
Area and intensity of coverage by R. V. *KALAVA*. The number of hydrographic stations worked out in each degree square are indicated in the respective squares. Intensively covered area is shown by shading. A total number of about 550 stations were worked out by the vessel during 1957–1961.

APPENDIX - X (i)



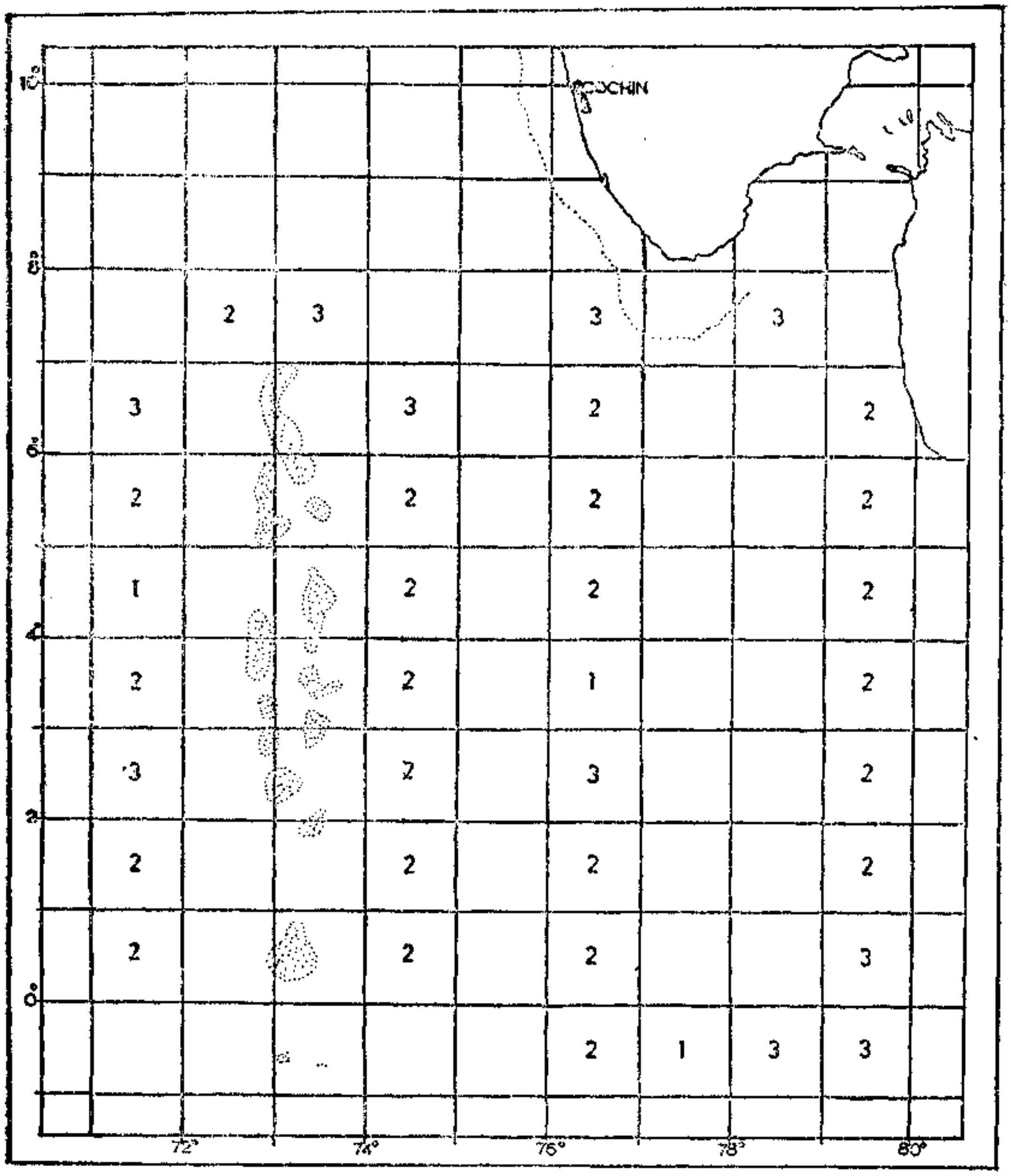
Area and intensity of coverage by R. V. *VARUNA* in the Arabian Sea 1962–1966. The hydrographic stations worked out by the vessel in each degree square are indicated therein. Intensively covered area is shown by shading.

APPENDIX - X (ii)



Area and intensity of coverage by R. V. *VARUNA* in the Bay of Bengal. Number of stations worked out in each degree square is indicated and intensively covered area shown by shading.

APPENDIX - X (iii)

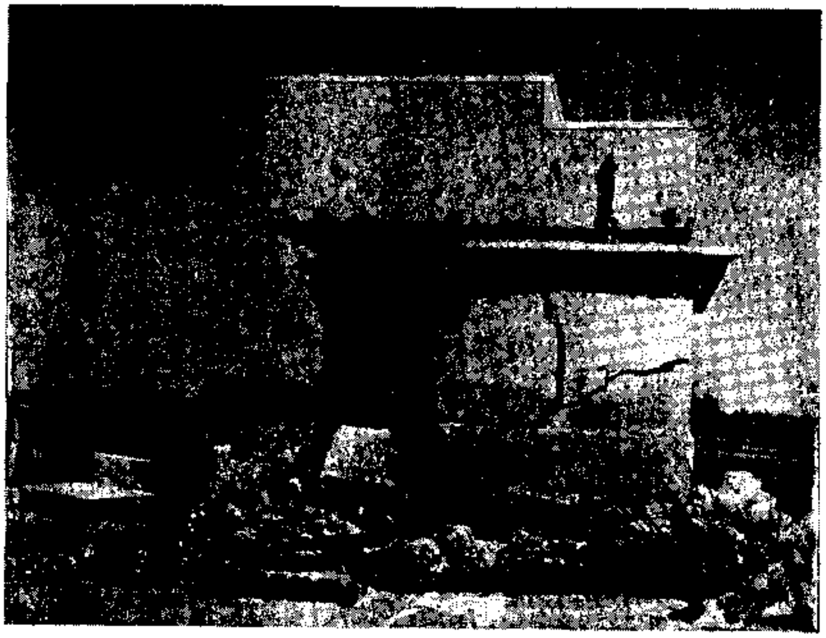


Number of stations covered by R. V. *VARUNA* in each degree square in the Indian Ocean. A total of about 2900 stations were worked out by R. V. *VARUNA* during the years 1962-1966.

Cyclone Havoc – December 1964, in the Institute's campus (Mandapam Camp)

Part of the main building damaged

Damaged Staff Quarters

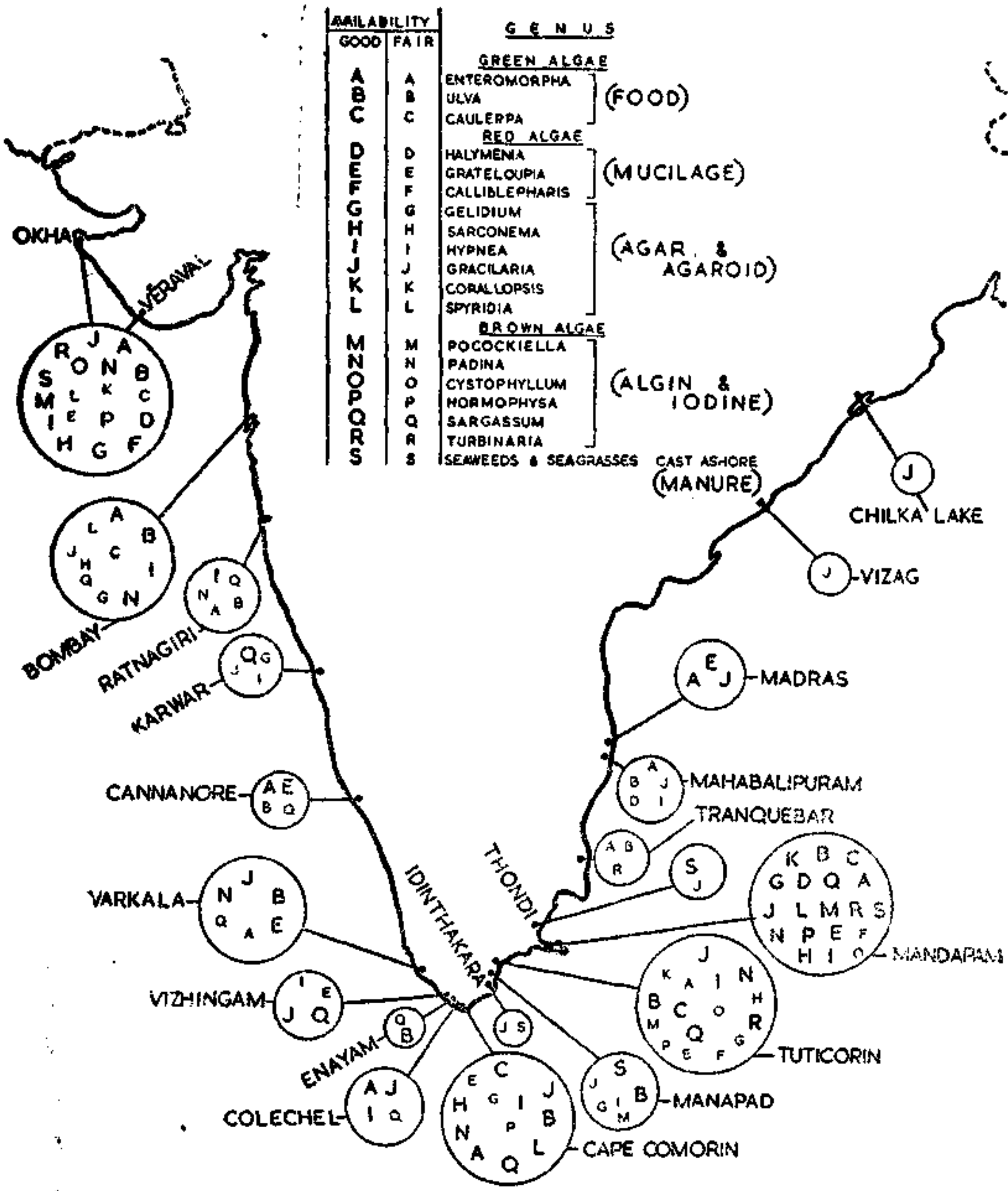


Damaged Field Laboratory

Uprooted avenue trees

APPENDIX - XII

SEAWEED RESOURCES



Distribution of the economic seaweeds along the Indian coast
(after Thivy, 1958, Fisheries of the West Coast of India)