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Two decades of Marine Fisheries Research

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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 indispensable 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. In spite 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 maximum 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 styliфера* 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. styliфера* 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 styliфера* 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 *Aristoeus 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, Porbunder 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*, *Thrissoctes mystax* and *Ilisha filigera* have been studied. In the catches of the white bait, *Anchoviella bagunensis* 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*, *Thrissoctes 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, (*Muruenesox 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 (*Pomadourus hasta*), some perches (*Pseudoperca 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*, *Munil cephalus*, etc.), the pomfrets *Parastromateus niger* and *Pampus argentus*, 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 pomadasysids 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 (*Auris* spp., *Euthynnus affinis affinis*, *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 *Hippolyasmata 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., *Cuthoni adyrensis*, *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 kempfi* 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 estuarine 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 unguicularis* 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, Ahmedabad, 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 level 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 quantitative 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 euphausiids 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 Institute 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 responsibilities 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.
