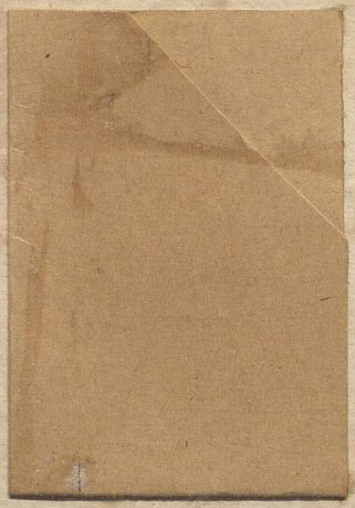

"FISHERIES OF THE WEST COAST OF INDIA"

With the compliments of the Editor

S. Jones,
Chief Research Officer,
Central Marine Fisheries Research Station,
Mandapam Camp,
South India.

Please acknowledge receipt.

1887

FISHERIES OF THE WEST COAST OF INDIA

...shed on the occasion of the opening of the new building of the Central Marine Fisheries Research Sub-Station at Calicut by Shri. M. V. Krishnappa, Union Deputy Minister for Agriculture, on 1st October 1958

Edited by

Dr. S. JONES

Chief Research Officer, Central Marine Fisheries Research Station
Mandapam Camp

FOREWORD

I am glad that this *Souvenir* containing a collection of articles on the varied aspects of Indian Fisheries is being issued at the time of the formal opening of the new building of the Central Marine Fisheries Research Sub-Station at Kozhikode. There is now widespread appreciation of the potentialities of developing the Indian Fishing Industry. I am aware that much more remains to be done to place this industry in such a position that it will make its full contribution to our national economy. The Central and State Governments are doing much in this direction and it is hoped that these efforts will be intensified in future years.

In a technological age, full development of natural resources is inextricably connected with the study and researches on those resources. Our emphasis on scientific research on fisheries is based on this acknowledged concept. Research institutions dealing with fisheries development should strive hard to obtain full knowledge of fisheries and to apply that knowledge to increase the yield and its better utilisation.

M. V. KRISHNAPPA,
Deputy Minister for Agriculture,
Government of India.

NEW DELHI,
12th September 1958.

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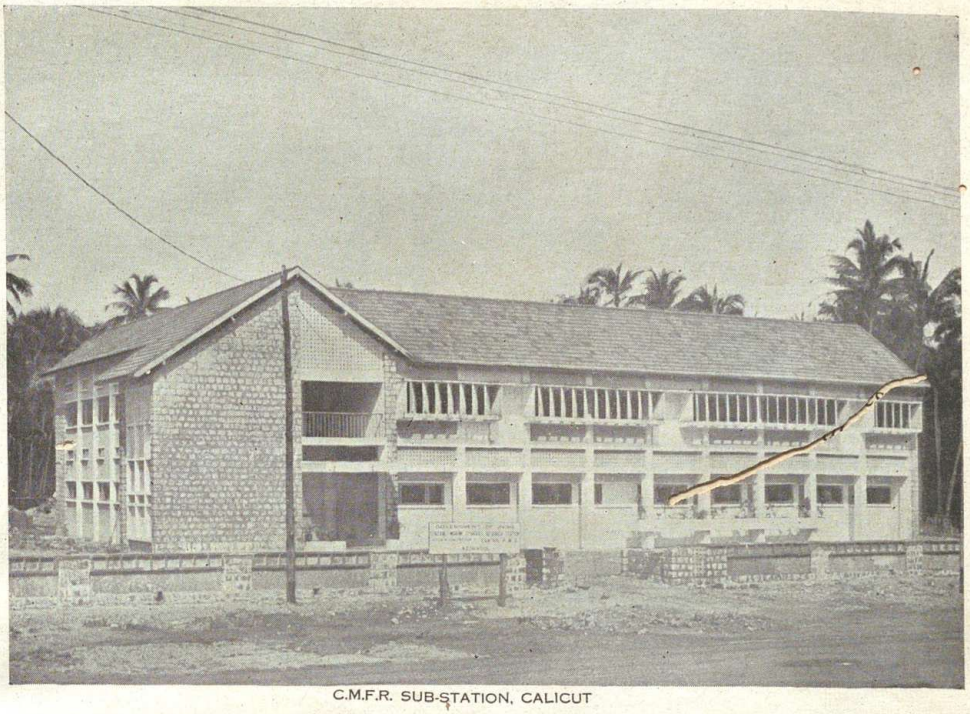

C.M.F.R. SUB-STATION, CALICUT

INDIAN FISHERIES—AN OVERALL VIEW

By N. K. Panikkar, M.A., D.Sc., F.A.Sc., F.N.I., F.Z.S.I., Etc.

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Resources

The fishery resources of India include marine, estuarine and freshwater fisheries consisting of a very large number of species. Our present sea fish production is of the order of 7–8 lakh tons per annum and it is estimated that another 3 lakh tons of fish are produced in inland waters. There is in addition a considerable amount of subsistence fishing. This production is high and places India among the first seven nations having annual production of over a million tons. This is, however, inadequate to meet the country's needs which may be roughly computed at about 40 lakh tons per annum. The national income from fisheries is estimated at about 60 crores of rupees per annum and overseas trade in fish and fish products secures for the country about 3–5 crores of rupees as foreign exchange.

Whether as regards natural resources, human material or commercial activity, the Kerala coast has an important place in Indian fisheries. The location of an important centre of research in the field of marine fisheries at Kozhikode is based on the very advantageous position which this area enjoys for systematic scientific studies on the major fishery resources of the West Coast of India.

Sea Fisheries

The sea fisheries resources comprise a large variety of fishes the most important of which are sardines, mackerel and prawns. Many other esteemed varieties exist, particularly pomfrets and seer fish. Fishing is generally confined to the narrow coastal belt of about 6–10 miles from the coast and production is in the hands of nearly a million fishermen. Coastal fisheries are largely seasonal which accounts for surplus production in some months with the attendant problems of transportation, marketing, processing and storage. Large-scale expansion of fishing in India depends on increased off-shore fishing activity which is being fostered by the mechanisation of the indigenous craft, introduction of small powered craft and by

off-shore fishing employing large modern fishing vessels. The West Coast of India at present accounts for over ~~two-thirds~~ three-fourths of our total sea fish production. Exploratory fishing has shown that there are rich deep sea fishing grounds off Kathiawar and extensive prawn resources exist off Bombay and Cochin.

Researches on marine fisheries have been going on at the Central Marine Fisheries Station, Mandapam, for the past ten years and as a result we now have a fairly accurate idea of our present sea fish production, important species, regions of the coast where they are found and their seasonal variations. Considerable progress has been made in the study of the biology of important commercial species and in the augmentation of coastal fishery resources by culture and farming practices. Latent resources in seaweeds and molluscan fisheries have been investigated to give some idea of their value in future development. Basic data on the productivity of the Indian seas, oceanographical conditions and their relation to fisheries are being obtained in an effort to understand and thereby foresee the magnitude and variations of the more important sea fisheries.

Inland Fisheries

The inland fisheries resources consist of the capture fisheries of the large number of rivers, lakes, irrigation dams, etc. and the culture fisheries in the thousands of fish ponds scattered throughout India. Fish cultural practices are particularly developed in Bengal, Bihar and Orissa, where there is an organised fish culture industry. Efforts in inland fisheries development lie in extending fish culture to all parts of India and in the adoption of scientific methods of fish farming. An acre of cultivated fish pond will yield, without artificial feeding, a quantity of about 1000 lb. of fish per acre per annum as against about 200 lb. from fish ponds not subject to cultural practices. Several lakhs of acres of water are now remaining fallow but with effort, all these could be brought to yield a regular harvest.

A major problem here is that the important culture fishes of India, *viz.*, the major carps, Rohu (*Labeo rohita*), Mrigal (*Cirrhina mrigal*) and Catla (*Catla catla*) do not breed in the confined waters where they are cultured. Fish culture industry is, therefore, dependent upon naturally occurring spawn and fry for stocking purposes. As the spawning period is confined to the monsoon months (June to August) and the spawning areas confined to certain portions of rivers or adjoining waters subject to flooding, the available fish seed is limited. Researches at the Central Inland Fisheries Station have helped to reduce the mortality of fish seed while they are

collected and transported. A promising line of work has been successfully opened up whereby the Carps have been induced to spawn in the ponds by the administration of pituitary hormone. Experiments and field trials have been successful and it is hoped to extend this work on a practical scale to various states.

The estuarine fisheries mainly consist of capture fisheries in the coastal tracts like Chilka and Pulicat Lakes, large numbers of backwaters on the coasts and estuaries of the larger rivers. Important estuarine fishes are Hilsa (*Hilsa ilisha*), milk fish (*Chanos chanos*), Bhekti (*Lates calcarifer*), mullets (*Mugil* spp.) and prawns.

Fisheries in the Plan

The Central and State Governments have taken several important measures for the development of Indian fisheries. The First Plan made a provision of Rs. 1 crore for Central Schemes and Rs. 4 crores for the State Schemes of which about Rs. 2·8 crores was actually spent. In the Second Plan there is a total allocation of Rs. 3·38 crores for Central Fisheries Schemes and about Rs. 8 crores for the State Fisheries Schemes. The major Central Schemes are (i) the expansion of fishery research, (ii) exploratory fishing in high seas, (iii) establishment of technological research, (iv) training, (v) fisheries extension activities, and (vi) fish transport by rail. Owing to the shortage of foreign exchange some of the schemes like large-scale exploratory fishing have had to be reduced, but in most of the other sectors work is in progress. The two fisheries research stations established in 1947, *viz.*, the Central Marine Fisheries Research Station at Mandapam and the Central Inland Fisheries Research Station at Calcutta, have made substantial progress in their programmes.

State Schemes for developing marine fisheries include the supply of engines to indigenous craft, supply of new and existing fishery requisites (boats, yarn, etc.) at subsidised rates, and provision of fish curing, storage and transport facilities. In the development of inland fisheries the schemes are meant for the reclamation of tanks and swamps for fish culture, collection and distribution of fish seed for stocking, establishment of nursery ponds, transport, storage and marketing of fish. Organisation of fisheries co-operatives also figure in some of the State schemes.

Training

It is realised that one of the essential requirements for modernising Indian fisheries is the establishment of training facilities for various categories of personnel. Apart from traditional methods of fishing the entire

approach to this subject is a new discipline to our country particularly in the field of application of mechanised methods and industrial practices. The Central Inland Fisheries Station is now giving a course in Inland Fisheries training to graduates who would become qualified to take fishery developmental activity in State Fishery administrations. With the operation of the Second Plan it has become more and more apparent that training facilities for administrative personnel in this country in the field of fisheries are inadequate and the Government of India has recently set up an Expert Committee to go into this question and make appropriate recommendations. The question of setting up higher training institutions for administrative and supervisory personnel on the one hand and for actual fishery operatives on the other is being actively studied by this Committee. Institutional training facilities should in the long run lead to the development of fisheries as a distinct discipline in applied science in this country on a par with Forestry, Agriculture and Veterinary Sciences.

In view of the rapid changes towards mechanisation of fishing craft special attention is being paid to training fishermen in the operation of mechanised craft and gear and in handling of engines. A small number of persons are trained in the deep sea fishing vessels belonging to the Government of India, where they complete a four-year course of study before being absorbed as Skippers of fishing vessels. Training in mechanised fishing for fishermen has been set up in fishing centres such as Veraval, Satpati, Mangalore, Calicut, Cochin, Tuticorin and Kakinada.

Technical Assistance

In the field of fisheries we have secured technical assistance from the Food and Agriculture Organisation of the United Nations, Technical Co-operation Mission of the U.S. Government and from the Government of Norway. The F.A.O. experts are contributing to fisheries development in various fields. They are in charge of specific projects with suitable Indian counterpart assistants. A fishing boat engineer, for example, has worked in maritime States of India and has helped in the designing of new types of small fishing craft suitable for certain regions of our coast. In this connection special attention is also being bestowed on the design of a suitable beach landing craft which can withstand the fury of the surf. This is a major problem on the East Coast of India where this peculiar characteristic of the coast has retarded the evolution of large local craft. Another activity has been in the designing of fishing harbours and ancillary facilities for accommodating fishing vessels in existing harbours. With the increasing tempo of deep sea fishing operations, advice on fleet management became

necessary and experienced specialists, therefore, were attached to deep sea fishing centres at Bombay, Cochin and Calcutta. Another field where specialist assistance has been sought is in technological work and in the organisation of marketing facilities.

The assistance from the Technical Co-operation Mission has been made mainly in the field of commodities for the modernisation of Indian fisheries. The commodities distributed have been engines for installation in indigenous craft, Nylon and other modern type of gear material and gear, ice plants and cold storage facilities. The most important contribution has been for exploratory fishing in the Indian seas. For this purpose various types of fishing vessels were supplied to the Central and State Governments. These vessels have been operated by the States for a few years but it has been found that the main purpose of exploratory activity could be better accomplished by management from a central pool. They have been re-organised into four fleets for exploratory work from Bombay, Cochin, Tuticorin and Vishakhapatnam. A specially designed research-*cum*-exploratory vessel will be taking up investigations on the estuarine resources of West Bengal particularly the Hilsa fisheries.

A joint Indo-Norwegian project has been set up in Kerala following a tripartite agreement between the United Nations, Government of Norway and the Government of India. The project is aimed to develop the fishing activities of a small area north of Quilon by an integrated approach to the various problems confronting the fishing communities. Here new designs of smaller boats have been developed and with engines these have been supplied to fishermen. A boat-yard builds the newly designed boats in large numbers. A cold storage and ice plant has been set up to deal with the increased catches that would come by the mechanised fishing activities. Larger type of schooners do exploratory fishing. A sales organisation for marketing the products in the interior is being organised. The social conditions of the fishermen are being bettered by improved water-supply, health services and sanitation. The whole project is an experimental approach to find out the best method of effecting large-scale changes in the economy of the fisherfolk through modernisation.

Fisheries Technology

A large part of our sea fisheries is seasonal and based on shoaling species like sardines and mackerel. This fact combined with the inadequacy of transportational facilities to send fish in good condition to the interior, has led to the development of a fish curing industry. The surplus marine catches

of fish are either directly sun-dried or salt cured and later sun-dried. Prawns are often boiled and sun-dried. Pit-curing and wet-curing by different methods are also practised throughout India, but the curing industry is best developed on the Kanara, Konkan and Malabar Coasts. Recently cold storage and ice plants have been established in various places and private industry has come into the field of freezing good quality prawns and fish. The bulk of cured fish produced in India is exported to Ceylon and other eastern countries and there is a growing market for frozen prawns in the United States. In addition, small quantities of fish meal, fish guano, fish manure and fish oil have been exported to other countries for many years.

In order to step up the quality of cured fish and to introduce new methods in the processing of fish, special attention is being paid to this subject in the Second Plan by the establishment of an institution for technological research at Cochin. The results obtained in this field of research will be directed to the improvement of fish products and for the development of suitable methods for inspection and quality control of the products for export. Technological research is also being extended to the problems of fishing craft and gear where intensive work on boat designing, improvement of existing fishing gear and introduction of new gear, are all engaging attention. The Craft and Gear wing of the Fisheries Technological Research Station was established at Cochin in 1957. The Processing Wing is now being set up.

Administration of Indian Fisheries

Fisheries has been looked upon for many years as a revenue department. It took many years to have it orientated as a development department and the pioneer efforts in this direction were made in the States of Madras, Bengal and Bombay. Other States are slowly following. The Travancore-Cochin part of Kerala had a fisheries department for many years. Some of the early researches relating to Indian fisheries were carried out at the West Hill Marine Biological Station at Calicut. A Fisheries Advisory Section was created in the Ministry of Food and Agriculture in 1944. In recent years administrative organisations to deal with fisheries have come into being in most States but much more remains to be accomplished, if fisheries development is to contribute its full share to national economy. The Central Government is, in accordance with the provisions of the Indian Constitution, paying special attention to fisheries research and fishing outside territorial waters.

In the international field India is a Founder-Member of the Indo-Pacific Fisheries Council. A Central Board of Fisheries has recently been estab-

lished to effect better co-ordination of activities in the States and the Centre and for taking decisions at policy level. A Standing Fisheries Research Committee reviews from time to time the problems of research to be taken up and those relating to the application of recent results of research. For the latter the Central Ministry of Food and Agriculture have set up an extension organisation with units located in different parts of the country. The Ministry of Community Development is also proposing to pay special attention to inland fisheries in Community Development areas and National Extension Service blocks.

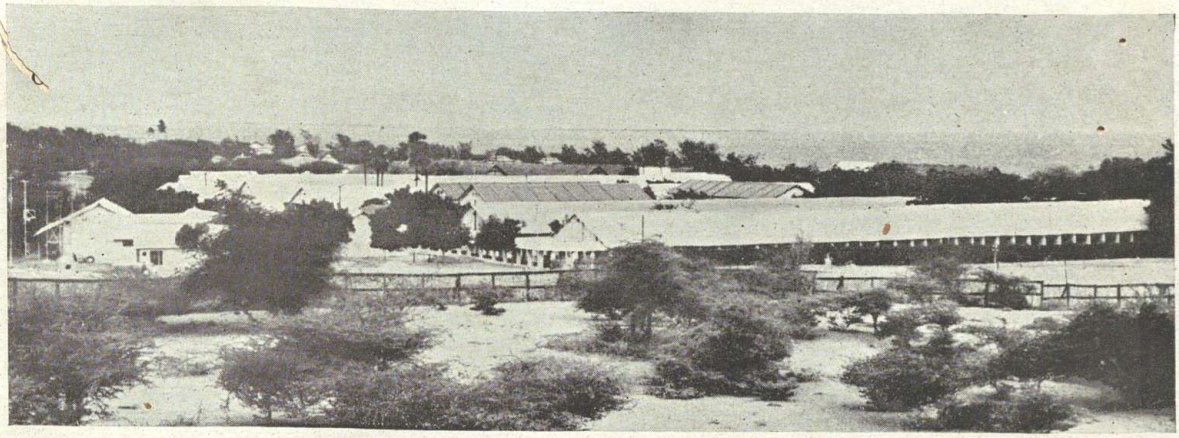
Although we are doing much in the field of developing our fisheries it is realised that much more remains to be done in this technical field which is somewhat new to the country. Unfortunately the fishing industry of India has been associated all these years with a section of people who are very poor and in a low position in the socio-economic fabric. Things are fast changing. With the various measures which the States and Central Governments have taken, the organisational activities developing among fishing communities and the interest taken by the public in the fishing industry, there is, however, reason to hope that this industry, which can play an important part in food production and commercial activities, will be placed on a stable footing.

PROGRESS OF MARINE FISHERIES RESEARCH

By S. Jones, D.Sc., F.A.Sc., F.Z.S.I.

Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp

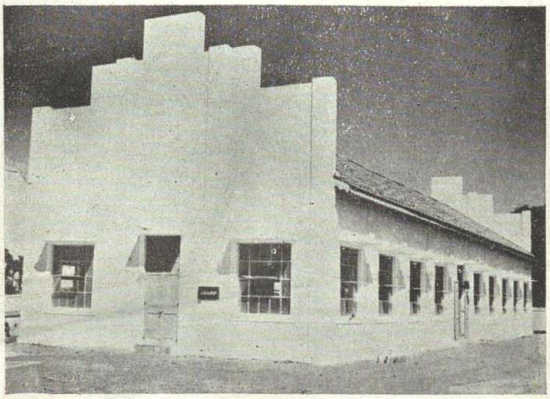
Fisheries Research is a comparatively recent development in the scientific research activities of the Nation. The need to take up research as a responsibility of the Centre so that the fishing industry could be fostered and developed along modern lines was realised as recently as during the Second World War when the whole country suffered very acute shortage of food. Fisheries had all along been a transferred subject and except for the enactment of the "Indian Fisheries Act" in 1897 very little direct interest was displayed by the Government of India for the next half a century for the development of fisheries. The various fisheries departments that came into existence in one form or other since the beginning of this century in the then existing provinces and native states were, with rare exceptions rather revenue minded than conservation minded, though a few of them evinced interest in the improvement of the socio-economic condition of the fishing communities. Instead of considering research as a long-term premium towards the creation of a sound industry vital to the nation, the administrators were generally inclined to view it as a commercial investment. The spadework of such pioneers as Hamilton Buchanan, Francis Day and H. S. Thomas, remained apparently ineffective until the zealous efforts of Sir Frederick Nicholson culminated in the creation in 1907 of a Fisheries Department in Madras, the province which then had the longest coast line in India. This Department had as its main objective the development of the pearl and chank fisheries of the east coast and the Sardine and Mackerel fisheries of the west coast. A Marine Experimental Station was established at Ennore in 1908 (subsequently shifted to Tanur in 1911), Madras Aquarium in 1909, the Experimental Marine Fish Farm near Tuticorin in 1914, the Marine Biological Station at Calicut in 1921 and field collecting station at Krusadai in 1928. The Marine Biological Station at Calicut near which the Central Marine Fisheries Substation is located was established for investigations on Sardines and Mackerel which constitute the main fisheries of the area.



A distant view of the Headquarters Buildings of the Central Marine Fisheries Research Station at Mandapam Camp (with the Gulf of Mannar in the background)

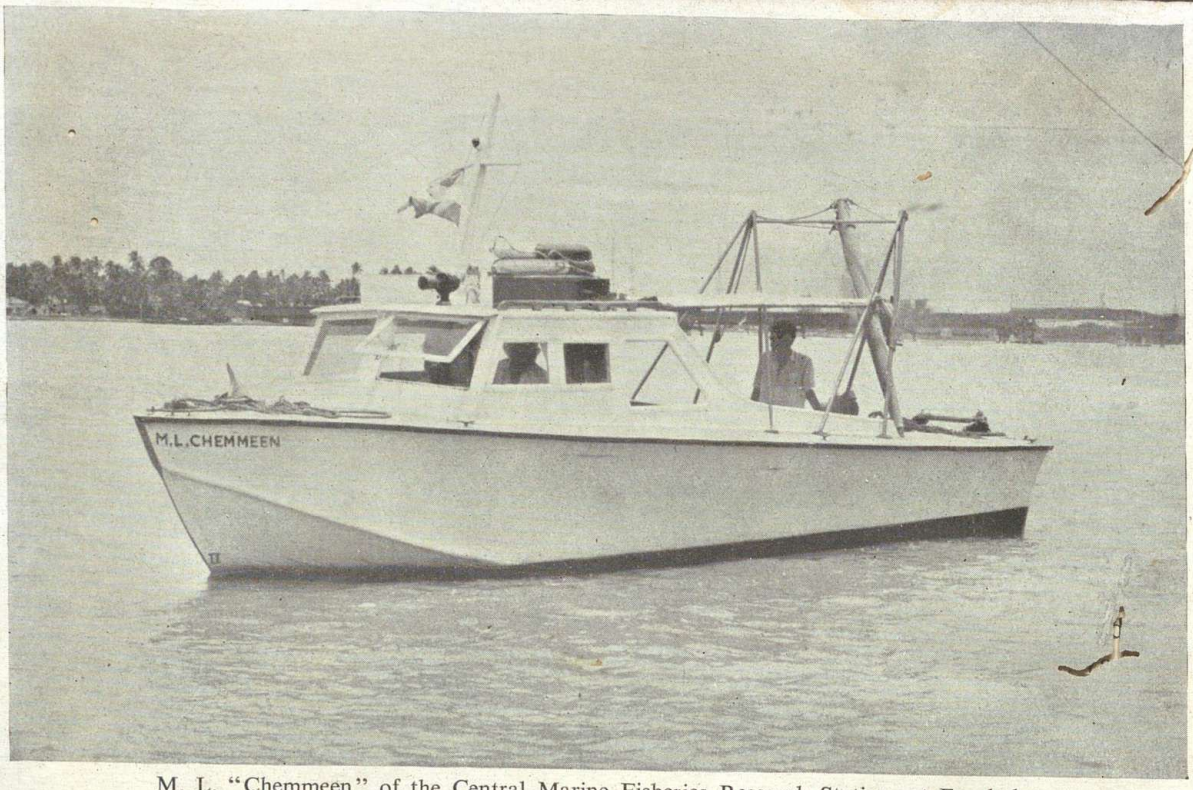
A portion of the Reference Museum at Headquarters

A portion of the Library of the Headquarters Station, Mandapam Camp

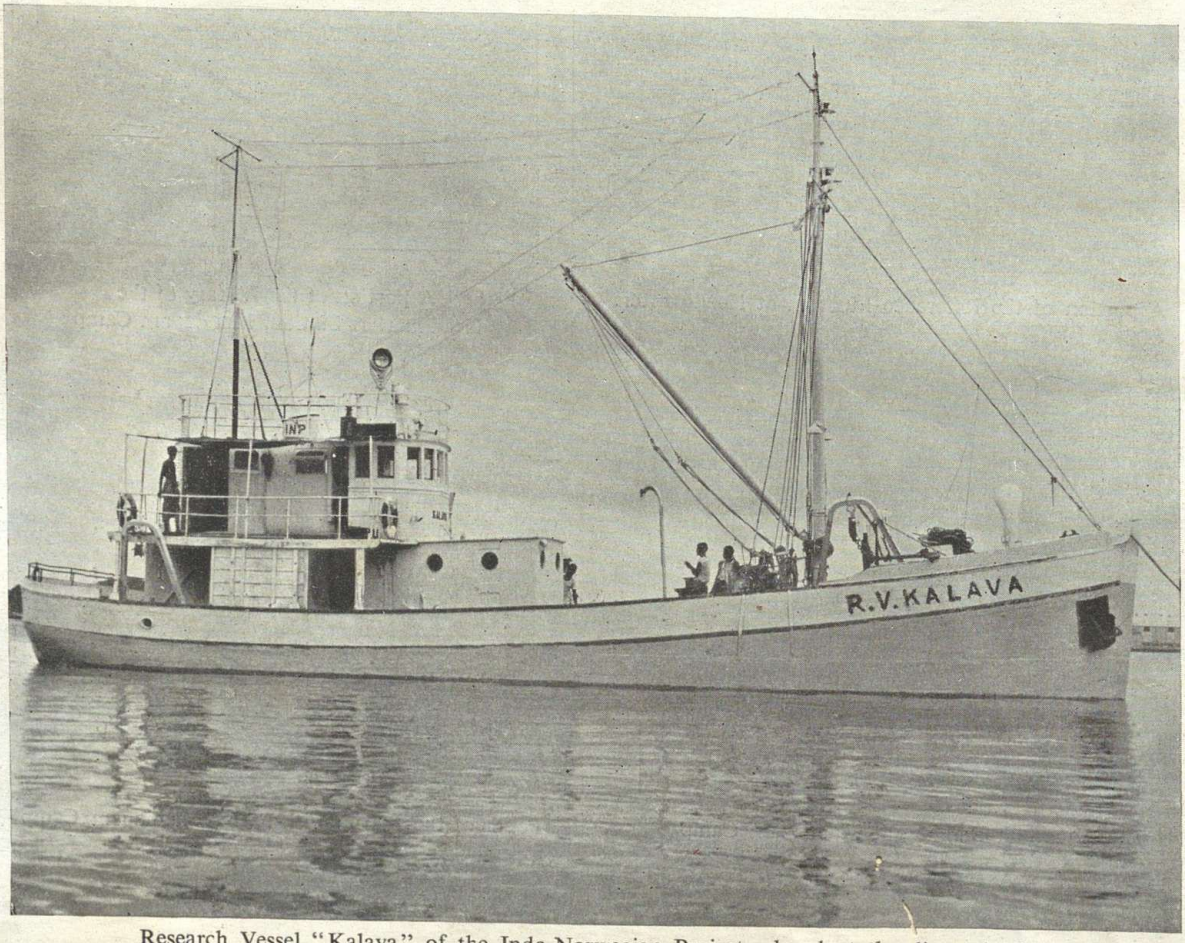


The Aquarium Building at Mandapam Camp

Ponds of the Marine Fish-Farm, Mandapam Camp



M. L. "Chemmeen" of the Central Marine Fisheries Research Station, at Ernakulam



Research Vessel "Kalava" of the Indo-Norwegian Project, placed at the disposal of the Central Marine Fisheries Research Station

In the course of the faunistic studies conducted by the Zoological Survey of India and by the surgeon naturalists attached to the Marine Survey of India, considerable information, especially on the systematics of fishes and on animal life associated with them was being added from time to time in the *Records of the Indian Museum*, *Memoirs of the Indian Museum* and in the *Investigator Reports*. Other contributions of special interest in marine ecology and fisheries are the *Reports on the Pearl Oyster Fishery of Cey'on* (1903–06) edited by Sir William Herdman, *The Report on the Zoology of Okhamandal* (1916) by James Hornell and the series of *Bulletins* published by the Madras Government Museum.

In the Report of the Industrial Commission of 1916–18 it was recommended that scientific officers should be attached to the Zoological Survey of India, to give advice on fisheries to the local governments and other bodies evidently with the object of making the above institution the centre of fisheries research and development in the country. In the meanwhile a number of State Fisheries Departments and Universities had initiated research on fish and fisheries. Some of the work had necessarily to be of a desultory character in view of the practical difficulties encountered by technical personnel involved. The establishment of the Department of Marine Biology and Fisheries in the University of Travancore (now Kerala) in 1938 within a year of inception of the University itself is significant in that this helped to establish a place for fisheries study and research in the activities of Indian Universities. Other Universities like Madras, Calcutta and Bombay had their own Zoology Departments where post-graduate work was carried out on fish and fishery subjects also. Investigations relating to fisheries and other cognate subjects have been in progress in recent years in the Fisheries Departments of Bombay and Kerala States and in the Institute of Science, Bombay. During the war and since then the Indian Council of Agricultural Research has also sponsored a number of research schemes relating to fish and fisheries.

As indicated already, the Second World War poignantly brought to light the extent of our dependance for foodstuffs on external sources and the need for a scientific approach for the judicious exploitation of our own resources. The memorandum on the post-war development of Indian Fisheries submitted by Dr. Baini Prasad in 1943 gave the initial momentum for the formation of fishery research institutes under the Government of India and the Fish Sub-Committee of Policy Committee on Agriculture, Forestry and Fisheries endorsed in its report in 1945 the proposals contained therein. It was decided by the Government of India to organise *ab initio* and build up Central

Fisheries Research Institutes for marine and inland fisheries investigations on the lines recommended by Lt.-Col. Dr. R. B. Seymour Sewell in 1946. The Central Marine Fisheries Research Station came into existence in 1947 with its temporary headquarters at Madras and the Central Inland Fisheries Research Station at Calcutta.

The eleven years period between now and the inception of the Central Marine Fisheries Research Station in 1947 in two rooms of the Madras University Zoological Laboratory at Madras has witnessed the development of the institution into a stable organization dealing on scientific lines with various problems of marine fisheries which had remained in comparative neglect for a long time although fisheries rank high in our national wealth. The Institution was declared permanent with effect from the 13th October 1953 and the development programmes implemented by the Government of India under the First and Second Five-Year Plans have enabled this Research Station to have a certain amount of expansion.

The work of the Institution has a region-wise and subject-wise distribution and consequently the activities are largely decentralised being carried out in the various Substations, Units and Centres *pari passu* with the progressive establishment of out-stations indicated elsewhere (*see* page facing contents).

The principal function of the Institute is centred on fishery biological studies. This is because the successful development and conservation of the fisheries of the country require, as an essential preliminary, the collection of detailed information on the distribution, abundance, habits, life-histories, food, rate of growth, age, migrations, etc., of fish in general and the important food fishes in particular. Availability of exact information on these aspects alone would make it possible to develop the fisheries in such a manner as to obtain the maximum sustainable yield from them and at the same time conserve the stocks at optimum level. In any fishery investigation the fish concerned has to be studied in relation to its environment and in view of lack of essential information on the various environmental factors, a certain amount of attention had also to be paid during the initial stages on getting this basic information.

Of the estimated total landings of marine fish in India, which in 1957 reached a record of nearly 900,000 tons, about 80% is landed along the west coast. The most important among the west coast fishes are the sardines, mackerel and prawns and as such, even from the start special attention had to be paid to the study of their biology and fisheries. The programme of

investigations was progressively expanded during the First and Second Five-Year Plans particularly on the mackerel, the sardines and prawns. Investigations on offshore fisheries, on the fishery resources of the Laccadive area and on the pelagic fisheries of our seas have also been envisaged and are under implementation.

The Indian Mackerel constitutes the most important pelagic fishery in India, contributing about 5–10% of the total marine fish landed on our coasts. Though present both on the west coast and east coast it forms a major fishery only along the coast of Kerala and Mysore. Valuable information on the concerned species, *viz.*, *Rastrelliger canagurta* has been collected both at Karwar and at Kozhikode. The state of maturity of this fish in different months of the year is known now and the food and feeding habits of mackerel entering commercial catches have been studied. Studies on fecundity, age, growth, spawning periodicity, etc., are in progress. Racial studies on mackerel have been initiated and in addition to the samples received from different parts of India, specimens from Siam, Malaya, Philippines and Indonesia are also being examined at Mandapam. These and other studies are being continued (i) with the aim of ascertaining the areas where commercially successful fishery for the species could be set up, (ii) for obtaining information for predicting the natural fluctuations in its fishery and (iii) to devise ways and means for regulating the fishing operations and stabilizing the fishery.

Among the clupeoid fishes which contribute the bulk of the marine fish production of the country, the oil-sardine of the west coast, *viz.*, *Sardinella longiceps*, ranks as the most important commercial species. It is much esteemed as a valuable food fish and is used extensively for the manufacture of oil, guano and meal. The fishery for this fish has been erratic for several decades past. For a proper understanding of the basic prime factors influencing the fluctuations in its fishery, detailed information relating to the food and feeding habits, sex composition, seasonal changes in the gonads, maturation, life-history, age and rate of growth, etc., has been collected. These studies have brought to light that fluctuations in the availability of certain food organisms in the area has been partly responsible for the extreme annual fluctuations in its fishery. The programme of work has recently been expanded to include recruitment studies also and cover more centres. Similar investigations on other important sardines of the west and east coasts are in progress.

Prawns constitute the third group of commercially important fishes (*sensu lato*). The main investigations are on the biology of the Penaeid

prawns that constitute the economically important species. Valuable data have been collected on all the species which make up the bulk of the commercial catches along the south-west coast. A species selected for more intensive study is *Metapenaeus dobsoni* which is common along both the eastern and western coasts of India and is the most abundant species in the backwaters of Kerala. The above studies point to the possibility of shoals of prawns occurring in waters deeper than those at present exploited by fishermen. Experiments in prawn farming have been carried out first at Narakkal near Ernakulam (in Kerala) and they are now conducted at Vaikom, further south. Various aspects of the biology of prawns are under study at Ernakulam, Calicut, Mangalore and Bombay.

Data relating to shark fishing grounds, fishing seasons, details of different kinds of craft and tackle, distribution of species, constitution of catches, sex-ratio, breeding grounds and general biology, composition of catch as a whole and in different areas, disposal of sharks, etc., have been collected.

Economic biology of oysters and edible clams of the east coast has been studied and data collected on the reproduction of the oyster and the rate of growth. The biology of three other clams, *Katelysia*, *Meretrix* and *Donax* has also been studied. The squid fishery of the Ramnad District has been investigated.

To mention a few among other items of fishery biological work carried out, the Bombay-duck fishery at Bombay and factors affecting the fishery have been studied. The ribbon-fish fishery of the Madras Coast has been studied similarly and valuable data gathered. A preliminary study of fish populations of the Malabar Coast (Calicut) has been carried out. The work has brought out the importance of the Malabar Sole (*Cynoglossus semifasciatus*) fishery and the factors probably controlling inshore fishery populations. The silver-belly fishery and the seer-fish fishery which are very important around the Rameswaram Island have been investigated in detail. The tuna fishery, especially of the Laccadive Archipelago, is under investigation.

Marine biological studies play an important role in marine fisheries research. This is because, apart from the study of the fish themselves, full knowledge of their environment, *i.e.*, the *milieu* in which they live, their food, predators, etc., is very essential as they constitute important factors contributing towards the success or failure of a fishery. But, these latter form a very complex problem as will be clear from what is stated below. Plankton organisms (minute plant and animal organisms floating in the sea) constitute the sole food of the larval fish and a large number of adult fishes too. But

the types of plankton that occur in a particular area and their seasonal abundance or otherwise is determined by a large number of other factors like the nutrient salts present, temperature, salinity, upwelling, ocean currents, etc. Therefore a thorough knowledge of the water masses and the plankton productivity of an area is of great importance in the development of fisheries.

Qualitative and quantitative studies on the plankton occurring in the inshore waters in the Gulf of Mannar and Palk Bay at Mandapam have been in progress and some very interesting and informative results have been obtained from there and from similar studies at Calicut. Plankton studies on a small scale have also been in progress in Karwar and Bombay. With increasing facilities, these studies will be extended to other centres and over the offshore waters. Fish eggs and larvæ occurring in the plankton collections at Mandapam have been studied and the results published.

The hydrological and related investigations are mainly directed towards the study of the chemical composition of seawater, its variations from place to place and season to season and the manner in which variations affect the fisheries of a particular area. The main emphasis is on the study of the distribution and seasonal variations of the inorganic nutrient salts such as phosphates and nitrates which influence the fertility of a particular marine environment. The nutrient salts control the growth and reproduction of the minute floating plants, which form the food of the smaller animals. The fish feed on these small animals and thus link up the food cycle in the sea. The inorganic nutrient salts, therefore, are responsible for primary productivity and are able to affect indirectly through the elaborate 'food chain,' the seasonal abundance or otherwise of fisheries. Records of the occurrence and distribution of these nutrient salts from place to place and from season to season maintained over a number of years will be essential for predicting the relative abundance or scarcity of fisheries in different localities and in different seasons.

Another important aspect is the study of water movements with the help of a knowledge of salt content and temperature variations. Ocean currents play an important role not only in the distribution of the nutrient elements but also in distribution of various marine elements including fish eggs and larvæ. Thus the appearance of a particular fishery in a particular region could be ascribed not only to the biological conditions governed by the presence of the nutrient salts, etc., but also to the incursion of a new body of water into the environment. Some very useful data along these lines have already been collected and studied at Madras, Mandapam, Bombay, Kozhikode and Karwar.

The extreme paucity of fisheries statistics in India and the great need for their collection and interpretation have been pointed out by several experts and committees in the past. Survey of fishery resources is most essential since any well-planned programme of fisheries conservation, development and exploitation will have to depend on a proper assessment of the actual yield, extent of fisheries exploited and their potentialities. For this, accurate statistical data should be maintained over a long period of time on the seasonal and regional variations and the principal species constituting the catches as also of the yield per unit of effort. The Fishery Survey Assistants and Field Assistants who have been given necessary preliminary training are in charge of the different zones and centres into which the entire coastline of India has been divided. The data collected by these Assistants are analysed and studied at the Headquarters Station.

A complete census of the marine fishing villages was first carried out in 1948 and the number of boats, nets, etc., employed in the fishing industry has been computed. Resurvey and re-enumeration are being carried out periodically to keep the figures up-to-date as far as possible. For the past eight years the total annual marine fish landings in India have been estimated on the basis of sampling techniques developed at the Research Station. This work is being continued and extended to cover various aspects of the problem.

There is every reason to believe that an appreciable part of our sea fisheries resources lies in the offshore areas but these remain to be explored and exploited. Well-established and flourishing sea fishing industry exists in Europe and America and also in Japan in the east. The idea of setting up a self-supporting offshore fishing industry in India had long been entertained. But the trawling experiments carried out sporadically during the past half a century or more by the State Governments of Bengal, Madras and Bombay had not given encouraging results as a commercially successful enterprise and had therefore to be given up. In 1946 the Government of India set up the Deep Sea Fishing Station at Bombay for carrying out exploratory fishing operations and for charting of fishing grounds. These activities have now been extended to Cochin and the question of setting up similar deep sea fishing units at other selected centres is now under consideration. Encouraged by the results of these experimental operations the Government of West Bengal have set up a power fishing unit at Calcutta for carrying out deep sea fishing operations at the head of the Bay of Bengal. Some commercial enterprises like the New India Fisheries at Bombay have also now ventured into the power fishing industry.

The Offshore Fisheries Research Unit of the Central Marine Fisheries Research Station was set up at Bombay in 1953. This Unit has already collected and studied, in collaboration with the Deep Sea Fishing Station, very valuable data relating to the areas of operation of the power fishing vessels and the catches made by them. The biological and oceanographical data relating to power fishing operations at Cochin are handled by the Offshore fisheries staff of this Research Station who are stationed there and similar work at Calcutta by the Research Unit at that Centre. Based on these studies the pattern of distribution of fish in the various fishing grounds is being charted and revised charts to indicate the fishing grounds are being printed. It is hoped that when the full complement of scientific staff sanctioned for offshore fisheries studies is recruited, it would be possible to intensify and expand the investigations to other centres and also into the oceanic waters which now remain unexplored and unexploited. Offshore fisheries work is being carried out in very close collaboration, not only with the Deep Sea Fishing Station on whose exploratory fishing vessels our staff carry out their work, but also with the Fisheries Technological Research Station, now being set up, where gear and tackle suitable for the different species of fish and their environment will be devised, as also appropriate techniques for the processing, preservation and utilisation of the increasing catches that are likely to be obtained.

The significant role technological studies play in fisheries development needs no emphasis. Fish is a highly perishable commodity more especially in a tropical country like India. Its preservation from the time of catch to the time of consumption presents several problems. What are the bacteriological and chemical changes taking place in the fish flesh between the time of catch and arrival at ports ? How best could these changes be prevented ? What are the economically feasible optimum conditions under which the material could subsequently be stored till it reaches the consumer ? How best could the natural flavour, texture and nutritive value be maintained during freezing and storage ? These are a few of the several problems requiring investigation. They are receiving attention in the Fisheries Technological Division of the Central Marine Fisheries Research Station and some interesting results have been obtained.

The modern trend is to have as many ice factories and freezing and cold storage plants as possible. All the same in India problems of preservation, transport and marketing still remain to be solved and the fish not utilized in the fresh condition are preserved by adopting the indigenous methods of dry-salting, wet-salting, pit-curing, etc., to meet the demands of inland

markets. Basic problems like the keeping quality of products obtained from each of these processes, quality and levels of salt to be used in each case and during different seasons, indices for correct assessment of spoilage, etc., are therefore some of the important technological aspects now receiving attention in this Research Station.

Recent investigations have shown that high quality fish protein could be prepared from fish waste. The new technique recently evolved at this Institute for preparation of odourless fish flour from the flesh of fish which are not ordinarily looked upon as food fish, indicates the possibilities of making available to our people, whose basic diet is deficient in protein, a product with rich protein content. There are several byproducts of economic importance that could be obtained from fish such as the vitamin-rich liver oil, fish body-oil, etc. The economic utilization of seaweeds is another aspect on which a considerable amount of work has been carried out in this Research Station and some results of practical value have already been obtained.

One way of increasing fish production on our coastal regions, and more particularly to obtain supplies during what is recokned as the off-season for fisheries, is the development of marine fish farms along coastal regions utilizing the extensive swampy areas which are at present unused. Large-scale fish farms of this type have existed for long in Italy and southern France in Europe and in Indonesia, the Philippines and Hawaii in the East. In principle the work consists in conversion of swampy areas into marine fish ponds with permanent connections with the sea controlled by sluice gates and by bunding the fish ponds into various sections for nursery, stocking and maturing purposes. As a pilot venture, an experimental marine fish farm has been constructed at Mandapam where observations are under way. A considerable amount of research work has also been done on the physiology of adaptation in *Chanos* or milkfish as it is more commonly known, as also on the prawn *Metapenæus*. Owing to their exceptional powers of adaptation these forms together with the mullets are likely to prove very useful in the development of marine fish farms on our coasts.

In conclusion it may be stated that the Institution actively collaborated with various international and national bodies like the Indo-Pacific Fisheries Council, the Central Board of Geophysics, etc. The co-operation and help extended by the authorities of the Indo-Norwegian Project, Quilon, by placing one of their vessels at our disposal for research purposes has enabled the Research Station to conduct cruises in various areas on the West Coast for fishery biological and oceanographic studies. A special scheme sanctioned

by the Ministry of Scientific Research and Cultural Affairs and funds provided by them have enabled the collection of seawater samples and oceanographic data from different parts of the Arabian Sea and the Bay of Bengal and their study. Research training and facilities for research work have been given to a number of Indian and foreign research workers.

The old saying that Rome was not built in a day is particularly applicable to fisheries development. Fishery Research is highly complex; its problems are many-faceted but closely inter-linked. It is essentially a long-range activity. The opening of the new Substation at Calicut is yet another milestone, marking a new step forward in the progress of marine fisheries research in India.

RECENT ADVANCES IN INLAND FISHERIES RESEARCH

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The inland fishery resources of India are vast and varied. There is an extensive river system all over the country with a vast network of irrigation canals, reservoirs and tanks. There are, in some areas, large numbers of swamps, *bheels* and ponds. There are also vast brackishwater lakes and extensive estuaries. In addition to these water resources in the plains, there are in the Himalayan region and some parts of South India a number of lakes and hill streams at high altitudes. All these waters support a variety of good species of fishes. Potentially the inland fishery resources of India are among the richest in the world, but little attention has been paid so far to develop them. There are practically no conservation measures in force on capture fisheries of the rivers, lakes and estuaries and the culture fishery operations in the impounded waters are either absent or ineffective. Large masses of fertile cultivable waters are at present lying fallow. In spite of these, fish production from the inland fisheries of India is appreciable indicating the richness of the fisheries. There is, however, an immense scope for stepping up fish production if suitable measures are undertaken to develop the fisheries. If all these fisheries are to be fully developed it is necessary to investigate many intricate problems confronting them. This would entail extensive researches on different problems.

Inland fisheries research has not received adequate attention in India. Some pioneer work has, however, been done during the pre-independence period by the Departments of Fisheries in Madras, the Punjab and Bengal. There are also reports of fisheries surveys conducted in Mysore and the then Hyderabad States. The Calcutta University and several other institutions and departments have conducted investigations on the hydrobiology of inland waters and bionomics of major food fishes. Only a brief account of the recent advances made in inland fisheries research is given in this article.

Since independence there is a greater appreciation of the need to develop the fisheries of the country to step up fish production. Several State Fisheries

Departments, some Universities and also Central Fisheries Institutions have since undertaken researches on different aspects of fisheries. Fisheries research in its modern concept, specially in relation to the dynamics of fish populations, has been initiated in this country only recently. Concerted effort has been made in the State of Orissa in regard to reclamation of a number of swampy areas for construction of fish farms. Studies have been undertaken in regard to the collection, transport and rearing of the spawn of major carps. The nutritional value of various items of food of fishes are also being studied. The West Bengal Directorate of Fisheries has carried out studies on nutritive value of raw and sedimentary sewage in relation to fish production. Experiments have been carried out on fry production and fry and spawn transport with a view to minimise the mortality rate. In Madhya Pradesh special attention is paid to the location of spawning grounds and fish collection centres both in the rivers and in the bundh type of tanks. Madras has established a freshwater biological station at Bhavanisagar, where hydrobiological studies and studies on fish bionomics are being conducted. In Kerala the Estuarine Research Station at Ernakulam is conducting studies on the bionomics of *Mugil cephalus* and *Chanos*. Fisheries investigations have been initiated in the Malampuzha Reservoir.

The University of Lucknow has been carrying out researches on a number of problems relating to biology of food fishes and ecology of inland waters. The Annamalai University has initiated extensive investigations on the Vellar estuary. Shri Venkateshwara University has undertaken hydrobiological survey of the Krishna estuary and also studies on respirative physiology of fish and prawns. In Mysore University a number of experiments relating to introduction of spawning in fishes by pituitary hormone treatment and studies on the cytochemical structure of the pituitary gland are being conducted. The University of Madras, Bombay and Andhra are, however, carrying out intensive investigations on problems of marine biology and fish bionomics.

In order to conduct scientific investigations for a proper appraisal of the inland fishery resources of India and to evolve suitable methods directed towards their proper conservation, management and development on an all-India basis, the Government of India established the Central Inland Fisheries Research Station at Calcutta in 1947. This institution has undertaken investigations on different aspects of inland fisheries. As part of the Second Five-Year Plan programme 14 research projects have been undertaken and the institution has since expanded considerably. The scientific work is broadly divided into four main divisions—Pond Culture, Riverine

and Lacustrine and Estuarine. The work of the Pond Culture Section is concentrated at present in Orissa. The experiments in pond culture are mainly directed towards evolving suitable scientific methods in regard to management of culture fisheries and the investigations are being conducted at the experimental fish farm of the Station at Cuttack and also in a number of selected fish farms in different parts of Orissa. On the basis of experimental work undertaken so far it has been possible to evolve and standardise suitable techniques for successful rearing of carp fry to fingerling state reducing the percentage of mortality to a very low level. This has helped in increasing the production of fish seed for cultural operations. The results of these investigations have proved to be of great help in developing culture fisheries in several States of India. Experiments are also being conducted on the suitability or otherwise of introducing some of the non-indigenous species for cultural purpose in India. Investigations on efficiency and economics of different types of manures for increasing the productivity of fish ponds, the role of soil in pond productivity, the various methods of controlling rank growth of vegetation in different types of waters are also in progress.

Fish breeding experiments conducted at the Pond Culture Substation at Cuttack have proved to be very successful. In order to obviate the difficulties involved in collection and distribution of spawn of major carps from rivers, experiments to induce spawning in major carps by pituitary hormone treatment were undertaken. During the fish breeding season of 1957 all the major carps were successfully made to breed by hormone treatment. The experiments were intensified during 1958 at a large number of centres particularly in Assam and Orissa. In order to make rapid progress in this work, brief training courses for the State Fisheries Officers and the Fisheries Extension Officers were conducted at Cuttack, Joysagar and Allahabad and reports have been received on the success in such experiments from Orissa, Andhra Pradesh, Madhya Pradesh and Uttar Pradesh. The Pond Culture Section has also been providing technical assistance to some of the State Fisheries Departments to help them to locate and collect fish seed and demonstrate the improved cultural techniques.

The Riverine and Lacustrine Section, which is stationed at Allahabad, is mainly engaged in the investigations on the fish and fisheries of the Ganga River system. The biology of a number of riverine fishes of economic importance has been studied in detail. An intensive programme of survey to assess the fisheries of the Ganga River system has been undertaken. This Section is also engaged in locating the breeding grounds of carps in various

river systems and assisting the State Governments in exploiting them. Studies were also undertaken to standardize an economical method of transporting carp in oxygen filled containers. The rapid industrialization in the country and consequent establishment of a number of industrial installations along the rivers has given rise to the problem of river pollution, on account of the discharge of industrial effluents, domestic sewage, etc., which seriously affect the fishery resources of these waters. The Section has been investigating the extent of damage caused to fisheries by such pollution in selected areas and recommending remedial measures. A separate Water Pollution Unit has been established which is now conducting such studies. A Unit for investigation of river problems of the riverine systems of Narmada-Tapti and Godavari-Krishna has recently been established. Surveys in connection with the construction of multi-purpose river valley projects, for the purpose of formulating suitable measures of development in the reservoirs and river basins have been a regular programme of work of the Section.

A Lacustrine Research Unit has been established near the Tungabhadra Reservoir in Mysore State for the purpose of formulating suitable measures of fisheries development in the reservoirs and river basins. This Unit is at present conducting studies on hydrobiological aspects and the fish populations of the Tungabhadra Reservoir. The project authorities have undertaken extensive stocking operations in the reservoir with suitable species of fishes.

The Estuarine Section of the Institute stationed at Calcutta is carrying out investigations on the capture and culture fisheries of the brackishwater areas. Basic studies on the biology of a number of important groups of estuarine fishes such as the Hilsa, Mullets, Threadfins and Prawns have been conducted. A programme of investigations to assess the magnitude of fish population of the Hooghly and Matlah estuaries in West Bengal and Mahanadi estuary in Orissa as also the factors affecting the fluctuations of the fisheries in them, including hydrobiological features, is now in operation. Hilsa affords a fishery of very great importance in India, Pakistan and Burma. On account of its importance and the marked fluctuations observed in its catches from year to year, Hilsa fisheries of the region has formed a feature of special interest at this Station. A National Hilsa Research Unit has been established in the Section to conduct detailed investigations on Hilsa fisheries in different parts of India. Considerable progress has been achieved in recent years in studies of the population structure and life-history of the fish.

There is vast scope for development of brackishwater fish culture on a commercial scale in the estuaries and coastal areas of the country. With

a view to developing scientific methods of culturing these fishes, observational and experimental studies have been undertaken in the Section. The role of soil in the productivity of brackishwater ponds and the factors governing the growth and multiplication of algæ which form the food of many cultivated fishes are being studied now. An experimental brackishwater fish farm is being established. Detailed investigations on the assessment and suitable methods of exploitation of the potentially rich fisheries of the Sundarbans areas of West Bengal are being undertaken. A 54 feet research vessel is being obtained for these investigations under the T.C.M. aid.

A separate research unit to investigate the fisheries of the brackishwater lake of Chilka (Orissa) which is believed to be getting depleted has been established under the Second Five-Year Plan. Considerable progress has been made in regard to assessment of the fisheries of the lake and also investigations on the bionomics of the major fishes and prawns of the lake.

For the first time in India an attempt has been made to collect statistics of fish catches from inland fisheries. A large number of survey centres along the Hooghly, Matlah and Mahanadi estuaries and also the Ganga River system have been established. Suitable sampling techniques have been evolved and the data on fish catches are being collected.

THE ARABIAN SEA—MARINE BIOLOGY OF THE WEST COAST

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The Arabian Sea, the ancient *Mare Erythraeum*, forms the north-western section of the Indian Ocean bounded east by India, north by Pakistan and Persia, and west by Arabia and the " horn " of Africa. It has two important branches, the Gulf of Aden connecting with the Red Sea through the strait of Bab-el-Mandeb and the Gulf of Oman leading to the Persian Gulf. The chief islands in the Arabian Sea are Socotra and the Laccadives. The coasts, except for the region between Karachi and Bombay, are steeply tilted and fall into deep water. Consequently, the continental shelf along the west coast of India, except off the Kathiawar and Bombay coasts, is relatively narrow, varying from 15 to 65 miles, whereas off Kathiawar and Bombay it exceeds at certain places 180 miles.

Marine biological and oceanographical studies on the west coast of India may be said to have had their beginning sometime towards the second half of the 19th century. Considerable information has been collected by the ' Investigator ' particularly on the deep-sea fauna, and the various foreign expeditions have added their quota to our knowledge of the area.

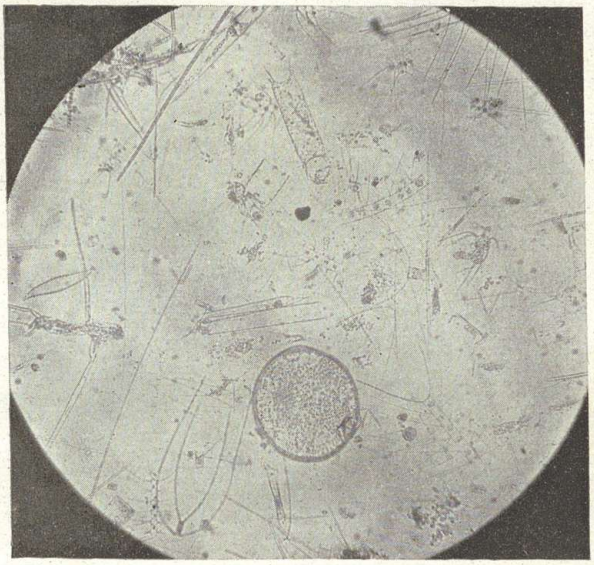
In the first decade of the present century, investigations on the fauna of the Maldive and Laccadive Archipelagoes and the Okhamandal coast of Kathiawar were carried out. These were supplemented by some observations on the bottom and mid-water fauna made during the course of experiments on fishing by ' Margarita ' and ' William Carrick '. More recently a rather extensive survey of the deep-sea fauna of the Arabian Sea has been conducted by the John Murray Expedition (1933–34). In the inshore and littoral zones studies include (1) the bottom fauna off the Travancore Coast and Calicut, (2) a general study of the littoral fauna of the Karwar Coast and the neighbouring islands, (3) plankton of the Bombay, Karwar, Mangalore, Calicut, Cochin and Trivandrum Coasts and (4) a general survey of the marine flora of the west coast.

The Littoral Fauna

The seacoast offers a great variety of habitats such as the rocky coast with tide pools, the numerous backwaters, estuaries, bays, mud flats and the sandy beaches. The littoral fauna particularly is rich and varied but it should be regretfully admitted that of the large assemblage of species only a fraction can be said to be known to science. Our knowledge particularly of the invertebrate fauna is extremely poor and several of the lower invertebrates have been hardly touched upon. The faunal elements include (1) species that belong to the circumtropical marine littoral fauna, (2) species that are common to the Indo-Pacific region as a whole, (3) species common to the Indian seas, Red Sea and South African Seas and (4) species endemic to Indian waters.

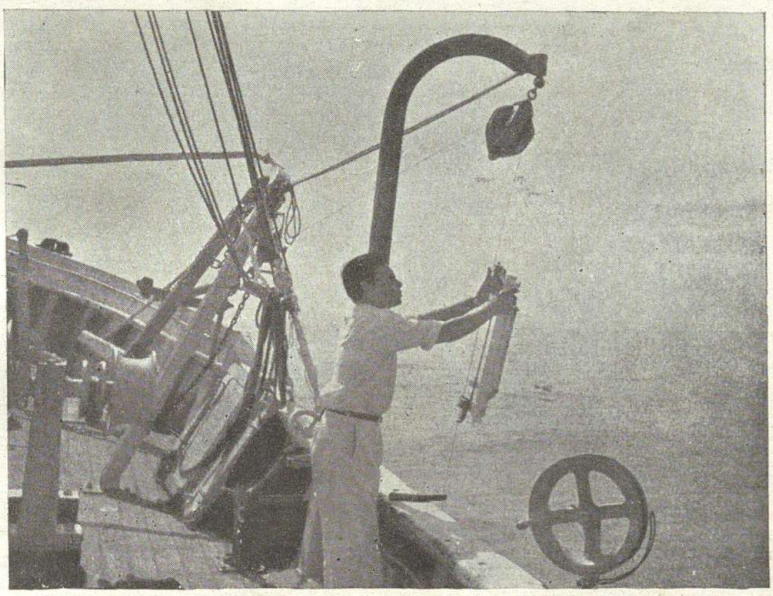
To a casual observer the vast stretches of sandy beach may appear to be poor in animal life but a closer examination of the intertidal region reveals several species of animals inhabiting the area. The inhabitants of these surf-swept sandy beaches usually bury themselves in the sand and some of them are able to burrow with extraordinary rapidity. Bivalves, gastropods, polychætes including the interesting archiannelids, crabs, mole crabs which swiftly burrow backwards, the delicate brittle stars, etc., are commonly seen. Sometimes great numbers of starfish are seen scattered on the beach. So also animals like *Physalia*, *Porpita*, *Janthina*, large jellyfishes, ctenophores, etc., are occasionally cast up on the beach. Hopping about on the sandy beaches are the jumping hordes of amphipods which when closely pursued dig rapidly into the sand, head first, and disappear quickly. Still further up, inhabiting the rather dry areas just above the surf level are the ocypod crabs which can be seen moving about with great alacrity and diving into the nearest hole when chased.

In the rocky regions where the coast is shallow, extensive areas are exposed during low tides revealing the strangest forest in miniature one could imagine. The rocks and their crevices and the tide pools offer shelter to numerous animals and the variety and richness of life in such environments is incredible. Crabs, molluscs, starfishes, sea-urchins, crinoids, fishes and in addition several encrusting and attached forms such as hydroids, polyzoans, sponges, barnacles, mussels, oysters, tube dwelling polychætes, beautifully coloured anemones, alcyonarians and ascidians are the common groups which one cannot miss. These animals of the rocky-intertidal zone are characterized by interesting physiological processes which offer methods of attachment, ways and means of surviving wave shock or of coping with



Photomicrograph of a phytoplankton community containing *Chætoceros, Rhizosolenia, Biddulphia, Thalassionema, Coscinodiscus,* etc.

Photomicrograph of a zooplankton community containing copepods, chætognaths, young Lucifers, larvæ of lamellibranchs, gastropods, polychætes, etc



Getting ready to lower the Nansen Reversing Water Bottle, a device used for taking water samples and measuring temperatures at subsurface levels. (Taken on board R. V. *Kalava.*)

an alternate exposure to air and water and techniques of offence and defence, all intensely specialized to meet the crowded environment.

The estuaries and backwaters along the coast are highly productive and the animal life is particularly rich. In the estuarine habitat there is a mixture of a small number of animals of freshwater origin, such as the Palæmonid prawns, Hydrobiid molluscs and fishes of the family Cichlidæ which have become adapted to saltwaters. With the exception of echinoderms and brachiopods all other marine invertebrate groups are found in the estuaries. There are several fishes of commercial importance and amongst the invertebrates particular mention may be made of the prawns and shrimps, oysters and clams.

In the mud flats, which get exposed during low tides, are numerous burrowing animals such as the burrowing sea anemones, polychætes, molluscs, crabs and some of the air-breathing fishes. Extensive beds of window-pane oysters are found in the shallow mud flats of Okhamandal and to a smaller extent off the Bombay and Malabar coasts.

The lower part of the eulittoral zone and the sublittoral zone are inhabited by numerous animals, the composition and the size of the communities varying from place to place. Survey of the bottom fauna along the Kerala Coast within the 10 fathom line has shown clear zonation even within this narrow limit and considerable differences in the quality and quantity of the fauna between the zones. Definite associations of animals in relation to the texture of the ground have been noticed. Off the coast of Travancore, over 150 species of animals have been recorded of which a large number belongs to Foraminifera, Mollusca and Crustacea while off Calicut about 35 species have been recorded. Further north, along the coast of Saurashtra amongst the rich and varied fauna mention may be made of two invertebrates of importance—the pearl oysters and the sacred chank. The former are usually found in that zone which marks the low-tide seaward fringe of the shore reefs and the latter a little farther out within the 10 fathom line. The distribution of these chanks along the west coast is peculiar in that southwards we find no trace of them until we come to the southern part of the coast between Vizhingam and Colachel, where they contribute to a small fishery.

The extensive damage done by the boring molluscs or 'ship worms' such as *Teredo*, *Bankia* and *Martesia* and the organisms which form fouling communities on wharf pilings, bottom of ships, boats, buoys and other submerged structures is well known. The fouling communities can be broadly

divided into two categories, (1) exposed and (2) protected, depending on the degree of protection from surf. This classification is arbitrary and relative and there will be considerable overlapping. The majority of the fouling organisms come under the groups molluscs, polychætes, crustaceans, coelenterates, polyzoans and ascidians. Distinct communities are formed each community having a more or less distinct pattern and within the community there will invariably be a regular sequence.

Faunistically the Laccadive Archipelago is of considerable importance. The islands appear to be the remains of eroded atolls, raised only a few feet above the sea-level, and formed entirely of coral rock and coral sand. Of the many genera of corals found in the area about 10 may be said to be the chief reef-builders. Apart from these, the area is rich in a variety of fauna particularly those forms which are characteristic of coral reefs. Various species of tunnies frequent the waters around the islands and they form a very important fishery especially in Minicoy.

Deep Sea Fauna

The fauna of the deeper waters of the Arabian Sea is equally interesting. After the work of the Survey Ship ' Investigator ' was discontinued in 1926, by far the most detailed survey made of the deep-sea fauna has been by the John Murray Expedition. The primary object of this expedition was to explore the fauna of the deep water below 100 fathoms in the area lying west of the Laccadive and Maldive Archipelagoes so as to form a continuation of the earlier investigations of the ' Investigator '. These investigations have shown that the fauna in general is rich, particularly in fishes, crustaceans, echinoderms and gorgonians and the interesting feature is that amongst the deep-sea decapods are several species which are represented in the littoral marine fauna of the temperate waters, by similar or even identical species.

In the Arabian Sea there are azoic regions at deeper depths. Throughout these azoic areas the bottom deposit consists of a greenish mud that in some areas contains a high percentage of hydrogen sulphide while the supernatant water is almost entirely devoid of oxygen. These conditions have been attributed to the putrefaction of organic matter of which the mud contains a relatively high percentage. Nevertheless, as the dead bodies of the planktonic organisms sink to the bottom and accumulate in the mud, they also provide nutrient for large numbers of other animals in the zone above and below the azoic region where there is sufficient oxygen to support life.

Plankton

It has been known for several years that the waters along the west coast of India produce great quantities of plankton. The origin of the

high percentage of organic matter in the bottom deposit mentioned above is from the amazingly rich zooplankton that is present along the African and Arabian coasts and extending eastward towards India, during the months of the south-west monsoon and shortly after. The cause of this rich plankton is to be found in the upwelling of deep water all along the coasts of East Africa and Arabia under the influence of the south-west monsoon wind. This upwelling water is rich in nutrient salts and provides the necessary conditions for a rich growth of phytoplankton that is followed by a rich crop of zooplankton. Detailed planktological investigations at Bombay, Calicut and Trivandrum have shown that the inshore plankton is a bewildering variety of life rich in species and individuals.

The primary phytoplankton maximum along the west coast in general, coincides with the south-west monsoon but off Bombay the maximum seems to be during January-February. There may also be secondary peaks and detailed work on planktonic diatoms has brought out that while only one or two general peaks can be made out from the total number of different species, there are varying individual peaks for several species even in months other than the collective peak periods. The important diatoms are *Chætoceros*, *Rhizosolenia*, *Bacteriastrum*, *Coscinodiscus*, *Fragilaria*, *Asterionella*, *Thalassiothrix*, etc.

The phytoplanktonic maxima are invariably followed by an increase in the zooplankton. Copepods, cladocerans, *Noctiluca*, chætognaths, siphonophores, hydromedusæ, etc., appear in varying numbers showing in most cases distinct peak periods. In addition to these a variety of larval forms are encountered. Amongst these particular mention may be made of the larvæ of coelenterates, polychætes, polyzoans, nemertians, decapods, lamellibranchs, gastropods and echinoderms. Eggs and larvæ of clupeoids, carangids and flatfishes and the post-larval forms of several species of fish also have been recorded.

The importance of a detailed study of the composition and fluctuations of plankton in relation to the fisheries has been well recognised. Some general observations on the relation between plankton and oil-sardines and on the correlation of the Malabar and South Kanara fisheries with plankton were made by the Madras Fisheries Department. Detailed work on this important aspect was taken up at the Central Marine Fisheries Research Station. The investigations conducted so far appear to show a striking relation between *Fragilaria* and oil-sardines and the possibility of using *Fragilaria* for forecasting the magnitude of the fishery. Another important observation is the possible relation between the larvæ of the polychæte

Prionospio pinnata and the Malabar sole fishery. The success of the fishery may depend to a considerable extent on the breeding and settling of the polychæte which forms one of the main items of food of the soles.

Wide-spread planktonic outbursts of small flagellates, the blue green alga, *Trichodesmium*, and *Noctiluca* are common along the west coast. These cause either abrupt set-backs in fisheries, as in the case when *Noctiluca* swarms, or mortality of fishes. It has now been established that the flagellate which causes mortality of fishes along the west coast is *Hornellia marina*. These outbursts coincide with the seasons when there is an enrichment of surface waters by upwelling or other physical agencies.

Nekton

In the assemblage of animals comprising the nekton are the adult fishes, squids, whales, dolphins, porpoises, etc. Economically the most important group is the fishes. Prawns may also be included as nekton although they are usually in the border line approaching either benthic or planktonic life. The west coast of India is rich both in fishes, particularly the pelagic shoaling fishes like sardines and mackerel, and in prawns.

Marine Bacteria

The only work on the marine bacteria of the west coast of India has been conducted by the Madras Fisheries Department. Observations were made on certain bacterial groups in the inshore and offshore waters of Tellicherry and in the offshore waters of Calicut. As a result of these investigations bacteria belonging to the genera *Micrococcus*, *Bacillus*, *Achromobacter*, *Flavobacterium*, *Sarcina*, *Paracolobactrum*, *Pseudomonas*, *Corynebacterium* and *Alcaligenes* were recorded.

Marine Algæ

Our knowledge of the geographical distribution of marine algæ of the Indian waters is still too limited; but in general it could be said that the flora of the Arabian Sea is the richest.

Broadly speaking, the Arabian Sea could be considered to consist of three littoral floral zones, the first extending along the Okhamandal coast up to Veraval; the second from Bombay down to Karwar and the third the Cape Comorin coast. Of these, the latter two have a distinct tropical and sub-tropical marine vegetation, while the former has, in addition, an equally well-represented temperate flora. The algal flora of the Okhamandal coast form a parallelism to the algal flora of the West Indies; the flora of both these areas show a considerable likeness to areas at present very distant.

Of the three algal zones of the Arabian Sea, the littoral flora of the Okhamandal coast is the richest and the largest. The algal flora of the Bombay coast down to Karwar is not very luxuriant. This is particularly so in the Bombay shore, because the environs of Bombay are highly polluted waters. The few forms met with are mostly confined to the Kolaba area, Back Bay, Malabar Hill, Bandra and Santa Cruz. Ratnagiri and Karwar have a fairly good littoral vegetation, mostly of the brown tropical algin yielding seaweeds and the hardy red ones. The Okhamandal coast consisting of the Dwaraka reef and the Porbandar reef and the Cape Comorin area are the best collecting grounds of economically important seaweeds along the Arabian Sea.

The flora of Cape Comorin coast has again a full luxuriance of tropical forms, showing close resemblance to the Pacific flora probably due to former open connexion with the Pacific. The marine algal flora of the southern part of the Arabian Sea coast is also found in the flora of Ceylon as well as in the flora of the Indo-Malayan Archipelago; while, many of the forms of the northern part of the Arabian Sea are not met with in the southern littoral flora.

Apart from the littoral vegetation, no data are available on the deep water forms of the Arabian Sea.

Mud Bank

A characteristic feature of the Malabar coast is the formation of the mud bank. Soon after the monsoons fine particles of silt become distributed in the coastal waters and with the decline in strength of the winds and currents, this silt settles in the form of fine mud forming a bank extending from about the region of Alleppey to the areas north of Calicut. The mud bank is fluid and movable and exists often at sub-surface levels. Investigations recently conducted by the Central Fisheries have conclusively demonstrated that large quantities of nutrients, especially phosphates, are found in the interstitial waters of these mud particles. Apart from the dissolved phosphates there is also a large quantity of adsorbed phosphates which are released into the waters when the mud bank is agitated. Thus, the mud bank acts as a reservoir of nutrient salts contributing to the production of rich plankton which in turn is responsible for the rich fisheries of the area.

Oceanographical Background

Oceanographically the west coast of India remains one of the least explored regions. But available information has shown that oceanographically

it is an extremely interesting region. Four main types of water can be identified along the west coast of India, (1) the Indian equatorial water, (2) the Red Sea water, (3) the Indian Central water and (4) Antarctic or sub-antarctic water. The general oceanic concept that deep moving waters come to the surface when confronted with submarine ridges is generally employed in the explanation of the richer areas in the Arabian Sea. The monsoons play an important role in the water movements. In consequence of the changes that are set up in the surface circulation by the south-west monsoon and the increase in the strength of the Somali current, water of high fertility is swept round the northern part of the Arabian Sea and down the West Coast of India. Recent investigations conducted by the Central Marine Fisheries Research Station along the Malabar Coast have shown that with the retreating south-west monsoon and the prevalence of north-westerly winds the waters are transported away from the coast leading to upwelling up to a depth of 50 to 75 m. and to a mean distance of 60 miles off the coast. The coastal turbulance and upwelling on the one hand and the upwelling of deep moving waters rich in nutrients between or near the Laccadive-Maldive Archipelagoes on the other contribute to the high productivity of the waters of the area. Investigations have also shown a number of eddy formations round about Calicut and the circulation pattern and thermal structure show that the region off Calicut serves as a transition zone between the northern and southern water masses.

In conclusion, it may be said that our present knowledge on the marine biology of the west coast of India has indicated clearly that it is a highly productive area with a rich and varied fauna and flora and further that in areas where there is constant replenishment of nutrient salts the production may even exceed that of most temperate waters.

THE SARDINES

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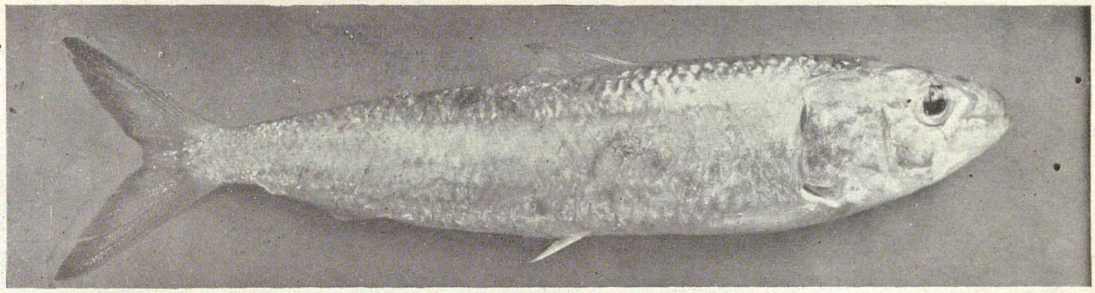
The clupeoid group, which contributes about a third of the total marine fish production in our country is constituted mainly by such valuable fishes as sardines, anchovies, whitebaits, etc. Of these, the sardines are represented in our waters by 9 species of which some, like *Sardinella longiceps*, *S. fimbriata*, *S. gibbosa* and *S. albella*, occur in large shoals and form important fisheries along both the coasts of India.

Sardinella longiceps, popularly known as the oil-sardine, ranks as one of the best known among our commercially important fishes and is extensively used as food in the fresh and cured conditions. Its bye-products are valuable; oil is extensively used in the jute, leather, soap and other industries and by the fishermen as a specific against weathering and ship-worm attacks in boats; and guano is used as fertiliser for tobacco, coffee, tea and other cash crops.

The existence of this fishery has been known from time immemorial. As early as 1320, Odoric noted when he visited Ceylon, that ' there are fishes in those seas that come swimming towards the said country in such abundance, that for a great distance into the sea nothing can be seen but the backs of fishes which, casting themselves on the shore, do suffer men for the space of three daies to come and take as many of them as they please '. Nieuhoff and Dussumier also noted that the sardines were abundant in these waters and that they were utilised as manure for paddy and coconut plantations since they were found unfit for curing owing to the high oil-content of the fish. Day also emphasised that owing to the ignorance of the abundance and the uses of the oil-sardines, they were mostly captured to manure the land and for feeding the livestock, the quantity actually consumed being very little when compared with the abundance of the catches. He also observed that ' it is only of late years, since animal oil has become so dear, partially due to a deficiency of that of the whale, that attention has been directed to the immense shoals of sardines, which are found off Malabar and Ceylon '. The demand for fish oil from Europe and elsewhere gave an impetus to the sardine-oil industry and the industry and the trade which were nonexistent

before, rapidly developed during the early years. The average annual export value of sardine-oil from Malabar was well over £ 7,000 in the sixties of the 19th century. Day emphasised the adverse effects of this growing sardine-oil trade on the valuable fishery and observed that ' it must be left for future years to demonstrate whether the present increase of fish-oil trade is a healthy or unhealthy stimulus due to the present high prices; for if the latter, the fisheries are being overworked, and the future loss will be great '. He also suggested that a ' thorough examination into the fish captured as to whether the young are, or are not, used for salting or fish-oil, are objects which it would be very important to ascertain '. A decline in the sardine-oil production was noted during the later years which was partly caused by the erratic and undependable nature of the oil-sardine fishery.

Another phase in the exploitation of the oil-sardine fishery may be said to have commenced with the beginning of this century when Nicholson helped the revival of the sardine-oil industry by the introduction of an improved method for the extraction of the oil. The practice till then in vogue was very crude and primitive, the products were of a very inferior quality and the residue was generally thrown into the sea. A low grade fertiliser was also prepared during those days by allowing the fish to rot and dry on the beach. Large quantities of valuable oil, injurious to the crop, were wasted by this method and the product was also found deficient in the valuable nitrogen and phosphate contents. Nicholson estimated that 52,250 metric tons of oil-sardines were annually dried on the beach and 6,250 metric tons of oil worth 10 lakhs of rupees were totally lost during every season. With a view to stop this wasteful procedure, Nicholson, after some preliminary experiments, recommended the adoption of an improved method by which the sardines were boiled in open pans over a fire and the boiled sardines were then pressed in coir bags in indigenous screw presses to separate the oil. The residue in the bag was, later on broken up and dried in the sun to form the guano. He also advocated the installation of a number of such small factories throughout the coast. Nicholson's move to revive the sardine oil industry met with immediate success and the production of better quality oil, and guano of good manurial value, by the new method induced small capitalists to install several such factories all along the coast of Malabar and South Kanara. The number of oil and guano factories increased rapidly and the peak figure was reached in the 1922–23 season when 647 factories, or approximately 3 factories per mile of the coastline were in existence. The production of oil and guano also showed record figures of 12,500 and 33,500 metric tons respectively. In the subsequent years, however, the fall in the trade of oil and guano was caused mainly by the malpractices of the



The Oil-Sardine, *Sardinella longiceps* Cuv. & Val.

Operation of the Boat-Seine, 'Mathi Kolli Valai' used in Sardine Fishery

Auctioning of the Sardine Catch

traders who were induced to do them by the high prices prevailing then, and partly also by the extreme fluctuations encountered in the fishery. The complete failure of the fishery during the forties rendered all the oil and guano factories idle and the production of these bye-products of the fishery came to an end.

Oil-sardine occurs off the coasts of Arabia, Iran, Pakistan, India, Ceylon, and Java in the Bali straits. There is no information about its relative importance and place in the commercial fisheries of these countries. In Indian waters the range of distribution extends from Bombay State to Andhra State and large shoals have been encountered only along the Kerala and Mysore States. The fishery of the oil-sardine is restricted to a narrow 8-10 mile strip of the coastal waters and this is necessitated by the nature of the craft employed in the fishery, namely, the dugout rowing canoe. The gear on the other hand has attained very high efficiency during the course of several years and consists of nets which are ideally suited for the capture of this pelagic shoaling species. The common nets used in the fishery were the boat-seines, drift nets and cast nets. More efficient types of nets were later introduced to meet the growing demand of the numerous oil and guano factories. The high prices offered by them induced the fishermen to go regularly for night fishing also with these nets.

The fluctuations in the oil-sardine fishery, both seasonal and annual, have rendered it undependable for commercial exploitation with disastrous effects on the industries which it supported during the early years of plenitude. Day wrote ' abundant in some years, they occasionally forsake their haunts for several consecutive seasons, returning again in enormous quantities '. Even though early records of the landings of this fish are not available, the data relating to the export of sardine-oil from the port of Cochin, the chief exporting centre of the West Coast, show that the fishery was poor during the years 1860–63 and exceptionally good during the years 1858–59, 1859–60 and 1863–64. From the statistics of fresh and sun-dried sardines used in coffee plantations, collected by the agents of Messrs. Arbuthnot and Co., Ltd., it is evident that the fishery was good during the years 1893–94 to 1895–96. The figures relating to the oil-sardines cured in the fish curing yards of South Kanara and Malabar between the years 1896 and 1907 show that the fishery was more or less uniformly good throughout the period except during the years 1898 to 1900 which were poor years for the fishery. No information on the oil-sardine landings for the next two decades is available; however, the figures relating to the production of the bye-products, oil and gauno, will serve to give an idea of the extreme fluctuation seen in the fishery.

The oil-sardine fishery was a failure from the years 1908–09 to 1911–12 and from 1914–15 to 1918–19. The fishery was exceptionally good during the 1922–23 and 1923–24 seasons when the total production of oil and guano along the coast reached the colossal figures of 20,000 and 57,000 metric tons respectively. The magnitude of the catches during these two seasons would become, apparent from the fact that about 2,85,000 metric tons of oil sardines had been utilised for the production of guano alone, excluding the quantities consumed in the fresh condition, used for curing or converted into beach manure. The figures serve to give an idea of the magnitude of the shoals of oil-sardines which frequented the inshore waters during those years of abundance.

The estimated landings of oil-sardine compiled by the different fish curing yards of South Kanara and Malabar and by the Central Marine Fisheries Research Station for the West Coast of India are given in Tables I and II.

TABLE I

Seasons	Landings in metric tons	Seasons	Landings in metric tons
1925–26	44,507·2	1938–39	3,413·2
1926–27	14,804·5	1939–40	7,090·2
1927–28	7,204·0	1940–41	25,268·8
1928–29	1,807·7	1941–42	4,450·2
1929–30	2,753·7	1942–43	919·5
1930–31	4,324·8	1943–44	442·5
1931–32	2,185·4	1944–45	656·7
1932–33	1,123·9	1945–46	17·7
1933–34	71,796·5	1946–47	8·8
1934–35	20,834·7	1947–48	1,191·1
1935–36	1,498·5	1948–49	290·7
1936–37	27,161·7	1949–50	3,390·0
1937–38	17,021·2		

TABLE II

Year	Landings in metric tons
1950	34,420
1951	17,240
1952	13,895
1953	51,831
1954	33,952
1955	30,447
1956	7,412
1957	1,91,469

The annual fluctuation characteristic of this fishery is seen clearly from Tables I and II. During the last 3 decades, the best catch was recorded last year when glut conditions reminescent of the former years of abundance were seen and the fish contributed about 22% of the total marine fish production of the year. The total catch exceeded 25,000 metric tons during 1925–26, 1933–34, 1936–37 and 1940–41 seasons. Even though the annual catches of oil-sardine varied considerably during these years, the fishery reached disastrously low levels after the 1941–42 season, the lowest catch of 8·8 metric tons being reached in the 1946–47 season.

The unprecedented failure of the oil-sardine fishery extending over a number of years received the attention of the Government of Madras and restrictive legislation to prevent the capture of the juveniles and spawners was introduced in 1943. The main clauses were the prohibition of: (1) the use of the highly destructive boat-seine ' Mathikolli vala ' during the sardine season from August to April, (2) the use of the gill-net ' Mathichala vala ' during the spawning period in August and September and (3) the landing of sardines below 15 cm. exceeding a total weight of 1 maund from any single boat during the fishing season. The legislation was modified and extended for two more years from 1945 to prohibit the use of these two nets throughout the season and the landing of immature sardines. The legislation

lapsed in 1947 owing to various practical difficulties encountered in enforcing the regulations.

A pioneer attempt to determine the food, spawning habits and the factors which control the migration of the oil-sardine was made by Hornell who stressed the necessity for a sound knowledge of these aspects for the proper development of the oil-sardine fishery. He also emphasised the necessity for an intensive investigation of the problems connected with the seasonal migration, food and life-history of the oil-sardine and the mackerel, the two principal commercial fishes of the west coast. As a result of his representations, the Government of Madras established in 1921 the Fisheries Biological Station at West Hill for carrying out these investigations in a systematic manner. After an year's intensive study, Hornell and Nayudu published "Some aspects of the life-history of the oil-sardine together with notes on the plankton of the Malabar coast". Their important conclusions were as follows: The local races are absent among the oil-sardines of the Malabar and South Canara coasts. Oil-sardines attain sexual maturity and almost full adult size at the age of one year, when they measure on the average 15 cm. They leave the inshore waters just prior to spawning which takes place from June to August inclusive, once only in the year. After spawning, mortality is high, particularly among the females, and of those that survive to spawn a second time, very few are met with in the fishery. Growth during the second year is extremely slow, the oldest sardines examined being approximately $2\frac{1}{2}$ years old, and this appears to be the ordinary limit of life in this species.

After a lapse of 20 years the results were published of an investigation into the causes of the fluctuations of the annual fishery of the oil-sardine, the determination of its age and the discovery of its eggs and spawning ground. The important conclusions were as follows: *Sardinella longiceps* depends mainly on pelagic organisms for its food and is, therefore, a surface feeder, occasionally resorting to bottom feeding; the inedible *Noctiluca* when predominant in the plankton might cause disturbances in the food-chain of the oil-sardine leading to local scarcity of the fish; the free eggs of the oil-sardine were isolated from the marine plankton off Quilandy.

A detailed study of the otolith of the oil-sardine in recent years led to the detection of 2 and in exceptional cases 3 rings which indicated that the average span of life of the oil-sardine is about 3 to 4 years. Studies on the length-frequencies, size and age groups lent support to the above conclusions. It is believed that the availability of food and the surface temperature and salinity influence the movements of the oil-sardines and also the

spawning and survival of the young ones. The oil-sardine fishery, shows irregular fluctuations at intervals ranging between 2 and 6 years and small-sized immature sardines contribute largely to the success of the fishery in the years of abundance. An inverse relationship is found to exist between the oil-sardine and the mackerel fisheries.

The oil-sardine fishery always commences during the S.W. Monsoon with the appearance of the spawners along the coast. The post-monsoon months show the disappearance of the spawners and the entry of the juvenile oil-sardines which form the bulk of the commercial catches. The spent oil-sardines generally appear during the closing stages of the fishery. Oil-sardines reach the average size of 10, 15 and 19 cm. at the end of the 1st, 2nd and 3rd years respectively. One-year old sardines are indeterminates, two-year old sardines are immature with developing gonads and three-year old sardines are mature adults and active spawners. The sardines spawn only once in their lifetime. Intensive study of the food and feeding habits of the oil-sardine shows that *Fragilaria oceanica* is the favourite food of the oil-sardine, especially the juveniles, and that a significant correlation exists between the occurrence of the diatom and the oil-sardine. It is probable that one of the major factors governing the fluctuations encountered in the oil-sardine fishery is the availability of *Fragilaria oceanica* in the coastal fishing grounds.

From the general picture of the oil-sardine and its fishery presented in the foregoing pages, it is obvious that sufficient attention has not been paid to the study of the biology and fishery of this economically important and valuable marine fish of Indian waters. Even though investigations were commenced some three decades ago with these objects in view, precise information relating to many of the fundamental aspects of the biology of the fish, namely, the food and feeding habits, embryonic and larval development, spawning habits, age and rate of growth, became available in recent years only. There is practically no information about the nature and extent of the fishery beyond the 10-mile limit of the present fishing zone. The oil-sardine fishery commences in August and terminates in March. From where the oil-sardines come and where they go are still largely unsolved problems. Recruitment research to determine the rate of survival of the young sardines is being given attention since the success or failure of the fishery depends mainly on the juveniles recruited every year.

THE MACKEREL

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Among the various marine food fishes which contribute largely to the commercial catches on our coasts, the Indian mackerel, *Rastrelliger canagurta*, holds the premier rank by virtue of the volume of its landings. The average annual mackerel catch for the eight-year period of 1950–57 is estimated at 62,415 metric tons, worth about a crore of rupees at the production centres. The mackerel fishery of India is even more important quantitatively than the fishery of the oil-sardine, *Sardinella longiceps*, the average landings of which are estimated at 47,583 metric tons over the same period. *Rastrelliger* spp. also contribute to fisheries of considerable magnitude in various other parts of the Indo-Pacific Area. Studies on mackerel fisheries have therefore received much attention from the scientific workers of the concerned countries and efforts are being made towards establishing collaborated research projects and to help formulation of development programmes for rational exploitation of these fisheries.

R. canagurta is very widely distributed in the Indian and the Pacific Oceans. It is known to occur along the African coast north of Durban, in the seas bordering on Arabia, Iraq, Iran, Pakistan, India, Ceylon, Burma, Thailand, Malaya, Indo-China, China, Japan, Philippines, Indonesia, New Guinea, and Northern Australia and around the Melanesian, Micronesian and Polynesian groups of islands.

There appear to be three species of mackerel in the Indo-Pacific Area, all belonging to the genus, *Rastrelliger*, *viz.*, *R. canagurta*, *R. neglectus* and *R. brachysoma*. Fisheries comprising one or the other of these species are of importance on the west coast of India, southern coasts of Thailand, west coast of Malaya, southern coast of Indo-China, in Indonesia and around certain islands of the Philippines.

The mackerel are pelagic fish occurring in shoals which are visible from a distance as patches, dark with ripples during day, and phosphorescent during night. Each shoal is composed of individuals of almost the same size suggesting that mackerel of the same age-group move together.

The food of the Indian mackerel consists of microscopic zooplanktonic and phytoplanktonic organisms. The composition of the food of the mackerel varies from season to season according to fluctuations in the occurrence of various planktonic elements. There seems to be a certain amount of selectivity in feeding, and the intensity of feeding is observed to be high when mackerel are maturing but low when they are in an advanced state of sexual maturity. Feeding intensity is also said to be poor in juveniles entering the coastal waters at the commencement of the fishing season and in the adults during the spawning season. Along the west coast of Borneo, mackerel shoals are said to follow the highest densities of plankton. The shoreward movement of the mackerel shoals at the commencement of the fishing season on the west coast of India, is probably due to the crop of plankton being richer in the inshore waters than in the offshore waters, even though, it must be admitted that our present knowledge of the plankton of Indian offshore waters is rather meagre.

There are no external indications demarcating the sexes in mackerel, but in specimens about 12 cm. in length distinct differentiation of the gonads into spermeries and ovaries is noticed. The minimum size attained at first spawning is 22·4 cm. On the west coast of India the mackerel seems to spawn from April to September as revealed by the studies on the gonadic condition of the adults. The Indian species like the European mackerel, *Scomber scombrus* L. spawns in succession over a prolonged period with only a small percentage of mature ova liberated at each time. As the time intervals between the discharge of successive batches of ripe ova and the number of batches involved in a spawning season are not known, it becomes difficult to estimate the total number of mature eggs that would have been spawned during a season. No information is available on the eggs and early larvæ of the Indian mackerel. These stages are probably pelagic. The occurrence of the very early stages of mackerel and quite small-sized mackerel recorded off Trivandrum indicates that the spawning grounds of the Indian species are not far off from the southern coasts of India. In regard to the rate of growth, the available information is too inadequate to draw any definite conclusions, but it may very tentatively be stated that the mackerel attains a length of about 10 cm. in the first year and 18 cm. or more at the end of the second year, and that individuals in commercial

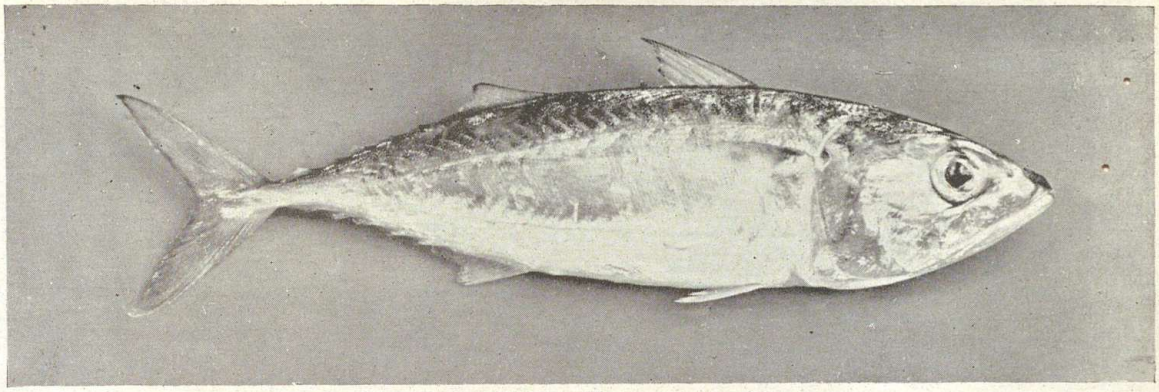
catches range mostly from 18 to 22 cm. in length, indicating that the catches are composed very largely of the second year class only. Specimens of *R. canagurta* measuring up to about 31 cm. in total length have been reported from the Indian waters. It is noteworthy that the fishery is largely composed of immature mackerel only, although mature specimens occur in small numbers towards the close of the fishing season.

The mackerel fishery of India is composed of a single species, *Rastrelliger canagurta*. A second species appears to occur around the Andamans where it does not constitute a regular fishery. The main fishery is confined to the west coast of India from Ratnagiri, south of Bombay, to Quilon in Kerala. Malvan, Karwar, Malpe, Tellicherry, Calicut, Cochin and Alleppey are the most important mackerel fishing centres. Shoals appear sporadically on the east coast of India near Mandapam, Nagapattinam, Madras, Kakinada, Visakhapatnam and some parts of Orissa. The data computed by the Central Marine Fisheries Research Station on the landings of mackerel for the eight-year period of 1950–57 are given in Tables I and II. The magnitude of the mackerel fishery is well indicated in Table I by the scale of landings as well as by the high percentage proportion of mackerel in the total landings.

TABLE I

Landings of mackerel and other marine fish in India during 1950–57

Year	Total landings in metric tons		Percentage of total landings contributed by Mackerel
	Mackerel	All Marine Fish	
1950	89,163	580,021	15·37
1951	104,900	533,916	19·65
1952	78,014	528,346	14·77
1953	70,754	581,460	12·17
1954	28,258	588,257	4·80
1955	22,795	595,722	3·83
1956	16,426	718,702	2·29
1957	89,006	875,420	10·17
Average ..	62,415	625,230	9·98



The Mackerel, *Rastrelliger canagurta* (Cuv.)

The Shore-Seine, 'Chavittu Vala' used for Mackerel and other Fishes in some parts of Malabar

Impounding of Mackerel shoals with Rampan net in the North Kanara Coast

TABLE II

Landings of mackerel during 1950–57 *shown separately for the wes t coast and the east coast*

Year	West Coast		East Coast	
	Metric tons	Percentage of total fish landings	Metric tons	Percentage of total fish landings
1950	86,736	97·27	2,427	2·73
1951	103,574	98·74	1,326	1·26
1952	77,295	96·56	719	3·44
1953	69,597	98·36	1,156	1·64
1954	27,892	98·70	367	1·30
1955	21,848	95·84	947	4·16
1956	15,023	91·46	1,403	8·54
1957	86,741	97·46	2,265	2·54
Average ..	61,089	97·87	1,326	2·12

On an average about 10% of the total catch of the marine fish consists of mackerel, but there are marked fluctuations from year to year, the catches ranging from about 2 to 20%. The causes of the fluctuations in the yield of fisheries are at present beyond our comprehension. As shown in Table II, on an average, about 98% of the mackerel landings are from the west coast and only about 2% from the east coast.

In the region of the main fishery from Ratnagiri to Cape Comorin, three zones are recognisable, depending upon the intensity of fishing, the types of craft and gear employed, and the duration of the fishery. In the zone from Ratnagiri to Mangalore the catches are very high; the duration of the fishing season is short commencing by about October–November and lasting till February–March; the types of nets used are specialized shore-seines called *Rampans* and gill-nets known locally as the *Patte Bale* ; the fishing crafts employed are the out-rigger boats called *Pandi*, *Hodi* and *Doni*. In the next zone from Mangalore to Ponnani River, the

amount of the catches is pretty high; the fishing season commences in August–September and lasts till March–April; boat-seines called *Odam vala*, *Paithu vala* and *Ayila Kolli vala* and gill-nets known as *Ayila Chala vala* are operated with dugout canoes. In the third zone extending from Ponnani River to Cape Comorin, the fishing is poor or moderate; the catches are obtained at irregular intervals during the months of August to February; generally boat-seines are used for fishing together with dugout canoes. In Table III the landings of the mackerel are shown for the period 1950–57

TABLE III

Landings of mackerel in different zones on the west coast of India during the years 1950–57

Year	Mackerel catch in metric tons in Zones I–III		
	I. Cape Comorin to Ponnani River	II. Ponnani River to Mangalore	III. Mangalore to Ratnagiri
1950	8,826	73,018	4,891
1951	4,660	62,757	36,157
1952	2,325	25,952	49,018
1953	80	15,302	54,215
1954	704	7,856	19,331
1955	1,794	4,816	15,238
1956	2,254	7,742	4,214
1957	7,786	18,624	57,858
Average ..	3,479	27,008	27,615

in the three different zones. It may be seen from the foregoing account that in the region as a whole comprising all the three zones, the fishery lasts from August to February or March. It commences early in the southern zone and late in the northern one, with a longer duration in the southern and the central zones than in the northern zone. The mackerel catches are usually poor in the beginning as also towards the close of the fishing season.

The *rampani* net of the Konkan, North Kanara and South Kanara coasts which is used in the mackerel fishery, deserves special mention. The net, capable of encircling large shoals of fish in the inshore waters, is made of hemp or cotton yarn, with 400 to 600 pieces joined end to end and operated like any other type of shore-seine. With the help of ~~six~~ five outrigger boats, *viz.*, ~~two~~ one *pandi* and four *donies*, about 80 men operate the net. When catches are good, over two million fish are landed in a single operation. In North Kanara the *rampani* is also used for impounding the mackerel, an efficient method devised to keep the fish alive up to about a week after they are caught. This helps to prevent a glut in the mackerel trade when the catches are particularly high. In impounding the mackerel, the dragging of the net is stopped when the two ends are about 500 ft. apart and the head rope is raised to a height of four or five feet by means of crutches fixed on the sandy shore. The head rope of the portion beyond the range of the breakers is fastened to boats which are anchored to keep the net in position. The mackerel from the impounded area are removed by means of small nets when required. The practice of impounding the mackerel by *rampani* net or other suitable means can be extended to other intensively fished areas, where the surplus catch of mackerel has often to be converted to manure, there being no other means for its immediate disposal.

Out of the large quantities of mackerel landed on our coasts, only a small fraction is consumed in the fresh state. The mackerel is a much-appreciated food-fish and is in good demand in the fresh condition, but owing to the inadequecy of transport and cold storage facilities, the supply of the fresh fish from the production centres to the consuming centres is very limited. It is of interest to note that since the introduction of the carrier launches in 1936 for transport of mackerel, there has been a steady increase in the fleet of the launches and at present about forty of them ply regularly between Bombay and the fishing centres on the Konkan and Kanara coasts during the mackerel season, effecting supplies to the Bombay market to the extent of over 2,000 metric tons of mackerel preserved in ice. Being a lean fish with comparatively low fat content, the mackerel is particularly suitable for curing. More than 60% of the mackerel catches are salt-cured, by dry or wet process, or pickled according to the Colombo method. The cured fish after meeting the local demand is exported mostly to Ceylon. Canning of mackerel and oil-sardines is practised on a small scale at a factory in Chaliyam near Calicut, and the product has been reported to be good, but owing to the high costs involved in the processing and packing in suitable containers, canned mackerel is not within the reach of the common man. For neat packing in small cans, the oil-sardine being

preferred to the mackerel, the canning of the latter is done in insignificantly small amounts. During World War II smoked mackerel was prepared and supplied to the troops stationed in India, but with the cessation of war, the production of smoked fish was discontinued, there being no demand for it from the local fish-eating population. Conversion of mackerel into manure for use in cocoanut, coffee and tea plantations is an uneconomic proposition although unavoidable when the catch is surplus and cannot be cured or marketed in fresh state. Large amounts of guts, gills and other parts of the viscera of mackerel, often discarded from the curing yards, are sometimes utilized in the preparation of fish meal used as cattle and poultry feed or as manure for agricultural farming.

The Marine Biological Station at West Hill, Calicut, which was opened by the erstwhile Madras Government, did pioneer work on the biology of the mackerel. Later, the various methods of curing mackerel, practised on the east coast and west coast were studied and this information is available. Subsequently, the Research Substation at Calicut and the Research Unit at Karwar, of the Central Marine Fisheries Research Station have contributed much to our knowledge of the biology and fishery of the mackerel on the west coast. Studies have been made on the early stages of mackerel by the Research Units at Madras and at Vizhingam. At the headquarters of the Central Marine Fisheries Research Station at Mandapam, racial studies on mackerel have been undertaken to ascertain the different populations entering the commercial stocks.

The research programmes of the Central Marine Fisheries Research Station envisaged under the Second Five-Year Plan aim at furnishing information on the life-history, habits, rate of growth, racial stocks, and migrations of the mackerel, besides the ecological factors controlling movements of their shoals. Such knowledge is very essential for rational exploitation of the fishery without causing any detrimental effects on the potential resources. With the expansion of the Fisheries Development Schemes sponsored by the Central Government there is every scope for increasing the total output. The introduction of improved types of craft and gear will possibly help exploration of new fishing grounds of mackerel beyond the zone of operations conducted at present. Also, with the advancement of technological knowledge and the introduction of suitable machinery for transport, storage, and processing of fish, we may hope that there will soon be a more satisfactory utilization of the mackerel catches landed on our coasts than is found at pesent.

PRAWN FISHERIES

By M. Krishna Menon, M.A., M.Sc.

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Out of an estimated total of 8,75,420 m. tons of sea fish landed along the coast of the Indian Union in 1957, about 15·5%, *i.e.*, 1,36,812 tons, were contributed by prawns and shrimps. In addition to this, considerable quantities are fished from backwaters, estuaries and freshwater about which reliable statistics are not yet available. A very large part of this catch is landed on the west coast, mainly in the Kerala and Bombay areas. The production from these two zones amounted to about 92·4% of the average annual total catch during the five-year period 1950–54. The following account of this important fishery is therefore based, for the most part, on the data collected from this coast.

Fishing Grounds.—Based on their habitat it is convenient to divide these prawns and their fisheries into three types, namely, marine, estuarine & backwater, and freshwater fisheries. The fishing grounds in the sea exploited by native fishermen with their indigenous craft and gear are mostly situated near the coast. They seldom go beyond regions ten fathoms deep and very often fish only in quite shallow waters. During the monsoon months of June to August on the Malabar coast fishermen are frequently able to catch prawns with cast-nets since shoals come so near the coast. Fishing with trawl nets from power vessels has been carried on for some time along the coast and such vessels have usually gone farther out into the sea. The rich prawn fisheries of estuaries, backwaters and saltwater lakes along the coastal areas of India, both in the east and the west, are as important as the marine prawn fisheries, if not more so, from the point of view of present production. The long chain of lakes, commonly called backwaters, extending along the southern half of the coast of Kerala and the mouths of numerous hill-streams in the Malabar area yield large quantities of prawns annually. Various species of freshwater prawns are fished from rivers, lakes and other bodies of freshwater throughout the country.

Composition of Catches.—Most of the sea prawns caught belong to a group called Penaeidea. The most important of them are as follows :

(1) *Penaeus carinatus*, (2) *P. indicus*, (3) *Metapenaeus monoceros*, (4) *M. dobsoni*, (5) *M. affinis*, (6) *M. brevicornis*, (7) *Parapenaeopsis stylifera*, (8) *P. maxillipedo*, (9) *P. sculptilis*. Among these the two species mentioned last are of significance only in some months along the Bombay coast.

Penaeus carinatus (Malayalam—*Kārachemmeen*).—This is the largest prawn of our waters, growing to about a foot in length; but it is not caught in such large numbers as some of the other species.

Penaeus indicus (Malayalam—*Vella chemmeen*, *Nāran chemmeen*).—It grows to about 8″ in length. Its fairly large size and abundance practically along the entire coastline make it probably the most important commercial species.

Metapenaeus monoceros (Malayalam—*Choodan chemmeen*).—Fully grown prawns measure about 6½″. Such prawns, however, are seldom caught from the sea by the fishermen; but they have been caught in the trawl net from deeper waters. They are common in backwaters and estuaries and contribute a significant proportion of the total catch in those months during which the salinity is not high. The catch from such localities is made up exclusively of young immature prawns.

Metapenaeus dobsoni (Malayalam—*Thelli chemmeen*).—The maximum size attained is about 4½″. It is very abundant in estuaries and backwaters and dominates the catches frequently. It is fished in enormous numbers from the backwaters of Kerala. Fairly good catches are obtained from the sea also during some months.

Metapenaeus brevicornis.—It is the commonest Penaeid of Bengal. It is caught on the Bombay coast also, but not in large numbers.

Parapenaeopsis stylifera (Malayalam—*Karikkādi chemmeen*).—It is also a comparatively small prawn, seldom growing beyond 4½″. Its characteristic reddish brown colour makes it quite easy to recognise. It is caught in very large numbers along the Kerala coast during the months December to May.

In addition to these prawns, shrimps belonging to various species of the genus *Acetes* are also caught and marketed during certain months. They are small, seldom exceeding an inch in length and occur in huge shoals. Among prawns outside the group Penaeidea, species of *Leander*, especially *L. styliferus*, contribute substantially to the catches in the Gangetic delta and the Bombay coast. The fishery of backwaters and estuaries is supported by the same species as in marine catches except for *Parapenaeopsis* sp. which do not migrate into such environments. The catches, however, are almost exclusively composed of young and immature prawns, adults being present only in

the sea. Adult males of *M. dobsoni* have been noticed in backwaters also. Most of the freshwater prawns caught belong to various species of *Palaemon*. *Palaemon carcinus* (Malayalam—*Konchu*) is the largest, growing to about a foot in length. It migrates into brackishwater to breed and because of this habit, large numbers are caught from such environments during certain months. In the Kerala backwaters there is a fairly good fishery during the months September, October and November. Because of its size and availability in good numbers for over three months it is very much in demand for freezing and eventual export.

Fishing Methods.—Boat-seine is one of the commonest types of nets used for fishing prawns along the Kerala Coast. Though there may be regional variation in minor details it consists essentially of a bag-like part and a couple of wings and is usually operated by 8 to 10 men from two canoes. It is rarely used in water over 10 fathoms in depth. Besides prawns, various species of small fish are also caught by this net. Another type of net widely used in estuaries and backwaters, creeks and shallow inlets, is a conical net with or without floats above and weights to anchor it or supported on pairs of stakes driven into the bottom. Its size varies widely; some of the largest in use along the coast of Bombay may be 500–700′ in length with a mouth of 200–300′ in circumference. It is usually set against the tide, which sweeps the prawns into them, and is hauled up at the turn of the tide. It is the most important method adopted in the backwaters of Kerala throughout the year, wherever tides are not too feeble. The Chinese nets, so conspicuous along the shore of the backwaters of Kerala, also catch considerable quantities of prawns. The cast-net, the drag-net, etc., are other types of nets in common use in various parts of the country to capture prawns.

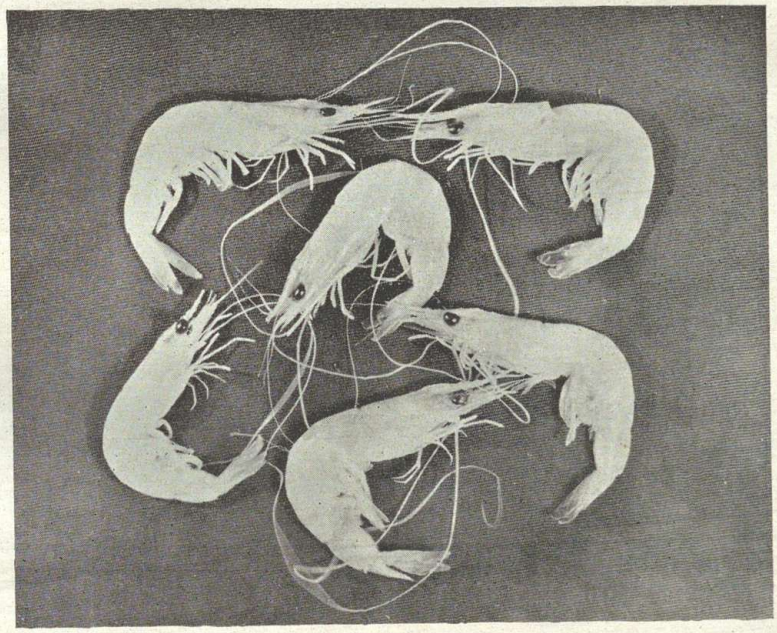
The peculiar method of trapping prawns with the aid of tidal action in paddy fields in the northern districts of the former Travancore-Cochin should also be mentioned here. About 10,000 acres of single crop paddy fields lying along the edge of backwaters and connected canals are utilised for this purpose and on a modest estimate about 4,000 tons of prawns are caught annually. The season for this fishery starts by about the middle of November and ends by the middle of April. An ingenious device made use of in the shallow stretches of the backwaters of this area is locally called '*Pachil*'. It consists of two canoes connected at both ends by short bamboo poles, and a heavy iron chain fastened by its two ends to the bows of the canoes. The chain drags along the bottom when the canoes move and the prawns which are scared jump out of the water, almost always falling into the canoes, where they are trapped.

Seasonal Variations.—Though a few prawns may be caught at various points of the coast in all months, the marine fishery is markedly seasonal. On the west coast the season generally coincides with the monsoon period, June to September in the southern half. In other months, particularly from October to April, few prawns are caught, not because they have disappeared from the fishing grounds, but because the more profitable sardine and mackerel fisheries claim the attention of all fishermen. August to October are the best months in the Bombay area, while the season in Saurashtra extends from July to September or October. The backwaters of Kerala provide an exception to this since the stake nets and Chinese nets are operated throughout the year, except when there are floods in the monsoon months. The peak of this fishery is, however, in the months of October to April.

Processing and Marketing.—Only a small portion of the catch is consumed locally. Hawkers carrying baskets of prawns and fish for door-to-door sale are a familiar sight in the villages of Kerala. Prawns are packed between layers of ice either entire or after removal of the ' head ' for despatching to inland towns. Freezing of prawns for export, mostly to America, is now being done at several centres along the coast. Prawns are graded according to size and the larger ones are frozen directly after removal of the head. Smaller ones are first boiled and shelled and then frozen.

Several methods are in vogue for drying prawns. The simplest and probably the crudest is spreading them out in the sun to dry. They are then marketed. A better method that is widely adopted is to first boil the prawns and then dry them in the sun. After they are well dried, the shells are removed by putting them in gunny bags and threshing with a stick or by beating the bag itself on a block of wood. The product has only a limited market in India; it is mostly exported to south-east Asian countries. Semi-drying is a process developed and popularised by the Madras Government Fisheries Department. In this method also prawns are boiled and then shelled. After immersion for a short time in staturated salt solution they are dried in the sun or by artificial driers. Drying however is stopped before the meat becomes hard. Boiled and shelled prawns are pickled in vinegar or weak toddy with condiments and spices mostly for home consumption. It may generally be stated that marketing is seldom attempted by the fishermen themselves except for those who are fortunate enough to own their own implements. Usually the catches pass into the hands of middlemen to whom the fishermen are obliged to sell because of prior commitments. The organization of co-operative societies is, however, gradually changing this situation.

Chinese Dip-Net used for Prawn Fishing in Cochin Backwaters



Penaeid Prawns

Biology.—No Penaeid prawn has been found to breed anywhere except in the sea. In fact, females can become mature only in the sea. The smaller species like *M. dobsoni* spawn in comparatively shallow waters up to about 12 fathoms while the larger ones like *P. indicus* liberate their eggs farther out. Several thousands of eggs are usually released by a single female. Breeding starts soon after the north-east monsoon and may continue for several months. The egg hatches out into a minute larva called nauplius, which does not resemble the parents even remotely. It sheds its skin a number of times, growing as it does so, and at the end of about 2 to 3 weeks passes into the stage known as the post-larva, which bears close resemblance to the adults. Post-larvæ of most of the Penaeids mentioned earlier migrate into estuaries and backwaters. The brackish nature of the water and the abundance of organic detritus (on which they feed) present in such environments provide extremely favourable conditions for rapid growth. Growth is not continuous as in fishes generally. Since these prawns are covered by a hard shell they could grow only when this shell is shed and the skin is soft. The length of life of most of these prawns is still unknown. *M. dobsoni*, however, seems to live for about three years and *Parapenaeopsis stylifera* for two. It may require several years' intensive study before the life-span of the other species also could be inferred.

It is this habit of the post-larvæ of migrating into brackishwater environments, that provides the basis for the rich prawn fisheries of these areas. Immense numbers of prawn fry enter these waters during several months making it possible for the fishery to continue without much interruption throughout the year. Prawns prefer a muddy bottom and they swallow the mud along with the detritus and the minute animal and vegetable organisms in it. This, however, may not furnish a satisfactory explanation for the association of prawn fisheries with mud banks, so characteristic of some parts of the Kerala coast during the monsoon period. For instance, there is a very active prawn fishery in the region of such a mud bank near Alleppey, several hundreds of tons of prawns being caught during the months May to September. It may be that since the water above these banks is placid, prawns concentrate there in order to escape from the turbulent surrounding areas.

Research.—Practically no research work on the prawn fisheries of the country had been done before the establishment of the Central Marine Fisheries Research Station in 1947. Since then much valuable data have been collected bearing on the biology of Indian prawns of commercial importance. Practically all aspects of the biology of one species, *M. dobsoni*,

have been elucidated and all aspects (except the larval development) of another species, *P. stylifera*, have been studied. The commercial catches and latterly the trawl catches have been regularly analysed with a view to collecting information on the changes in their composition from month to month. A number of papers embodying part of the data collected have already been published. The recruitment of fry to the backwaters of Cochin has been given special attention in order to follow their fluctuation from year to year and also to assess the effects, if any, of mechanised fishing in the seas outside. Experiments designed to ascertain the possibility of improving the output from the important paddy field fishery are also being conducted in a large field, approximately 20 acres in area, leased for the purpose.

Future Development.—In the course of the analysis of marine catches evidence has accumulated to show that the bulk of the catches from the sea consists of young and immature prawns. From brackishwater environments, as has already been stated, they consist almost exclusively of such prawns. Adults of larger species like *P. indicus*, *M. monoceros*, *M. affinis* are not caught in appreciable numbers at any time of the year. Biological studies have brought out the fact that older prawns pass into comparatively deeper regions of the sea. Since the sea fishery is at present confined almost exclusively to the shallow coastal waters it is not surprising that the bigger and older prawns escape being caught. Positive evidence pointing to the presence of such prawns in deeper waters has been afforded by the capture on some days of large individuals of *P. indicus* and *M. monoceros* by the trawlers of the Government of India and the Indo-Norwegian Project.

The facts mentioned in the previous paragraph point to the possibility of development of the marine fishery by extending operations far beyond the present limit. Exploratory fishing operations in waters up to about 70 to 80 fathoms have to be undertaken to discover concentrations of such prawns that could be exploited commercially. The experience of other countries, notably America, is so encouraging that efforts at exploratory fishing in Indian waters should be expected to succeed. The possibility of improving the present catches by mechanised fishing has also been demonstrated. Most types of indigenous gear seem to be inefficient when fishing close to the bottom; only trawl nets do this efficiently. Since prawns remain close to the bottom or partly buried in mud the use of trawl nets could ensure their efficient capture.

SOLE FISHERIES

By P. C. George, M.A.

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The sole fishery is one of the major fisheries of the west coast of India and it enjoys considerable local importance. The fishery is limited almost exclusively to the Kerala and South Kanara zones with an active area extending from Moolki in the north to Alleppey–Purakkad in the south. Soles are locally known as *nangu* in the northern centres and as *manthal* in the south and being a comparatively inexpensive fish, they are consumed in the fresh and cured states mostly by people of low income.

The important sole-fishing centres are Baikampady, Ullal, Kanhangad, Hosdurg, Cannanore, Tellicherry, Quilandy, Calicut, Chowgat, Ponnani, Narakkal and Alleppey–Purakkad. Although the fishery is subject to large fluctuations in the annual yield, a moderate quantity of soles is always available in the boat-seine catches, almost throughout the post-monsoon season, and at most of the centres of this coast. Like catfishes, the fish is preferred for consumption more in the cured state than in the fresh condition.

The species that contributes most to the commercial fishery is *Cynoglossus semifasciatus* Day or *vala manthal* as it is commonly known on the Malabar coast. A small but distinct fishery is contributed by the larger species, *Cynoglossus dubius*, locally known as *pada manthal*. Other species such as *C. puncticeps*, *C. lida* and *C. bilineatus* also occur in the catches, but do not constitute independent fisheries. The soles of our coasts are smaller in size as compared to species common in Europe. *Cynoglossus semifasciatus* grows to about 17 cm., but the commercial fishery is composed of specimens of the 10–13 cm. group. *C. dubius* occurring in the commercial fishery have sizes above 25 cm. and specimens as large as 45 cm., have been obtained from Quilandy and Narakkal during the post-monsoon season. Since the soles are small-sized fishes, they are always sold in bulk by weight and not by numbers as in the case of sardines or mackerel. The sole fishery season commences all along the coast soon after the south-west monsoon, by late August or early September and the active season extends up to November. Soles continue to be obtained in

moderate quantities as the chief constituent of boat-seine catches, the landings of this gear including also smaller sciaenids and miscellaneous fish.

The common types of gear used in sole-fishing operations are the shore-seines (*noona vala*), boat-seines (*paithu vala*), and cast nets (*veechu vala* or *beesu bala*) operated from canoes. The shore-seines are employed in Narakkal and nearby southern centres; cast nets operated from canoes are efficiently used in the Kanara zone. The boat-seines are in extensive use in the Malabar area and form the most popular and efficient gear for sole fishing in comparison to other gear. The boat-seines are operated from two dugout canoes each measuring about 8–10 metres in length, and employing about five to nine persons in each boat. The bag portion of the net has comparatively smaller mesh and the mesh-size increases towards the outer ends. Weights are attached to the edges to make the net sweep along the bottom during fishing for soles or prawns. The area of operation is seldom beyond the seven fathom zone and, during the active part of the season, catches are made quite close to the shore.

One of the special features of the sole fishery is that the major part of the total landings for the year is obtained within the first few weeks of commencement of the season. There is no case of warming up of the fishery as has been noticed in the case of others. Large shoals appear at certain centres quite suddenly without any previous indication and fishermen have to use all the resources at their command and employ all odd combinations of gear to net as much fish as possible. It is only during the commencing weeks of the fishery in August to September, that shoals appear at the surface or in midwater and could be fished soon after sighting of the shoreward moving shoals. During the remaining part of the year, availability of soles in a particular area could be judged only by trial fishing at different depths.

The soles are bottom feeders. They feed actively on polychætes, smaller bivalves, amphipods, cumaceans and other small and soft-bodied animals of the sea bottom. The food consumed by the soles is, within certain limits, related to the nature and amount of bottom organisms available in the different areas in the different seasons. A comparative investigation on the food and feeding habits of the soles in the different sole-fishing centres in the different seasons was undertaken with special reference to the nature of the bottom organisms and their state of colonisation. These studies indicated three distinct food-type areas, a polychæte dominant *Quilandy-type*, a bivalve dominant *Tellicherry-type* and a *mixed-type*. Although all these three food-type areas are favoured by soles, as evidenced

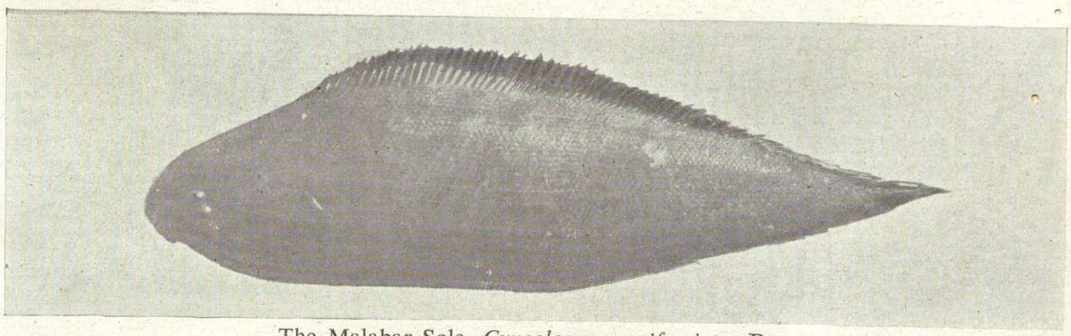
by their large-scale occurrence in these centres in the different years, the fishery is found to be at its best in the *Quilandy-type* centres which have a predominantly muddy bottom. The physical factors appear to play a greater part in producing this result than the biological factors.

The fishes that contribute to the fishery during August and September are the prespawners and fully mature specimens are obtained only during late October and November. Sole eggs start appearing in the plankton from October. The larvæ which hatch out from the eggs, grow and metamorphose into the young ones which appear in the fishery from January onwards. These very small soles, locally known as *podimanthal* if left uncaptured, would attain the commercial size and enter the fishery after the next monsoon season. But a good quantity of the very young soles are captured and removed from the inshore grounds during the hot months when boat-seines are operated for miscellaneous fishes. There is already some suspicion that owing to indiscriminate fishing of the young ones and prespawners, depletion is taking place in the sole fishery, although we do not have adequate data at the present, to support or deny this assumption.

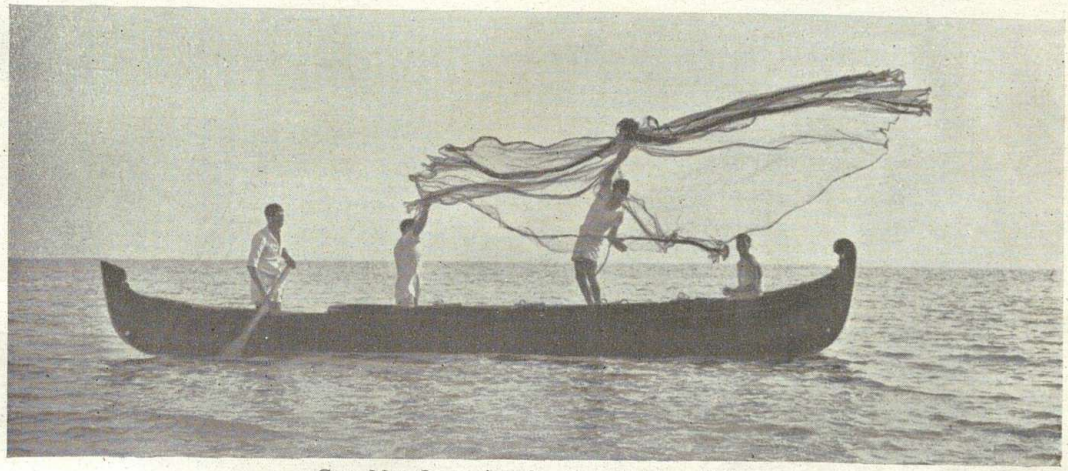
Soles disappear almost completely from the inshore waters with the onset of the south-west monsoon. They are dislodged from the inshore zone perhaps by the disturbances in the sea-bottom caused by stormy weather or by the formation and dissolution of mud banks. Disappearance of the soles and destruction of benthic organisms in the foreshore areas are noticed every year during the earliest weeks of the monsoon. As soon as the vigour of the monsoon is over soles return in large shoals. This phenomenon of reappearance of the fish in enormous numbers in midwater and in surface water is known among fisherfolk as "*manthayilakom*" and it is always accompanied by their large-scale capture. The factors contributing to this sudden and large-scale migration shorewards are not yet fully understood, owing to absence of adequate data on the behaviour of the shoals in the offshore areas during the monsoon season. The settling of the bottom-mud after agitation during the monsoon, and the rapid increase in temperature and salinity from the very low levels they had reached during the monsoon, might perhaps act as stimuli causing the return of the soles. It has always been found that the first report of shoals being sighted is obtained when the rains have stopped and sunshine prevails for a day or two. During such days veteran fishermen confidently look forward to hearing that shoals had been sighted by scouts. It seems unlikely that the food factor provides the inducement for the return of the soles at this stage, since at most places the bottom fauna have not started recolonising the area by this time, although the mud has, more or less, settled.

Soles obtained on the west coast are in great part, either cured or sun-dried and sent to inland centres. Dried soles are sold in the northern markets almost throughout the year, the price varying from seven rupees to twelve rupees a maund depending on the season. Soles are usually sun-dried on the open beach on coir matting without either gutting or salting although at certain centres they are kept lightly salted for a few hours before drying in the sun. The products are known to keep long perhaps on account of the poor fat content of the fish.

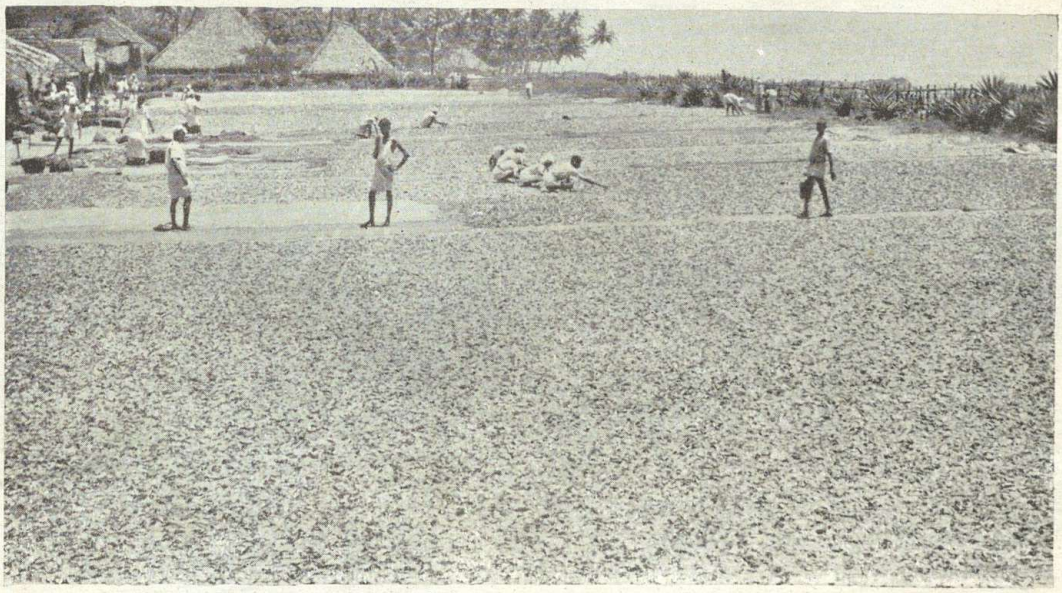
It has been found that the presence of large shoals at one centre is independent of the fishery at the adjacent centres. During the first week of September in 1956, it was estimated that about 1866 metric tons of soles were landed at Badagara near Tellicherry in Malabar, but there was little indication of an active fishery at the adjacent Calicut or Cannanore centres. Since the major part of the catches of the year is landed within the first few weeks of the commencement of the fishery, the fishing industry often finds it difficult to cope with the huge catches landed without advance indication. The uncertain weather conditions prevailing during August and September, with intermittent days of rain and sunshine, make sun-drying and curing difficult and uneconomical. Consequently, on most occasions, the large catches have to be diverted for use as manure, owing to the lack of modern and scientific methods for storing the fish or curing it.



The Malabar Sole, *Cynoglossus semifasciatus* Day



Cast Net Operation for the Malabar Sole



Extensive Dry Curing of the Malabar Sole in the Fish Curing Yard

MOLLUSCAN FISHERIES

By K. Virabhadra Rao, M.A., M.Sc., L.T.

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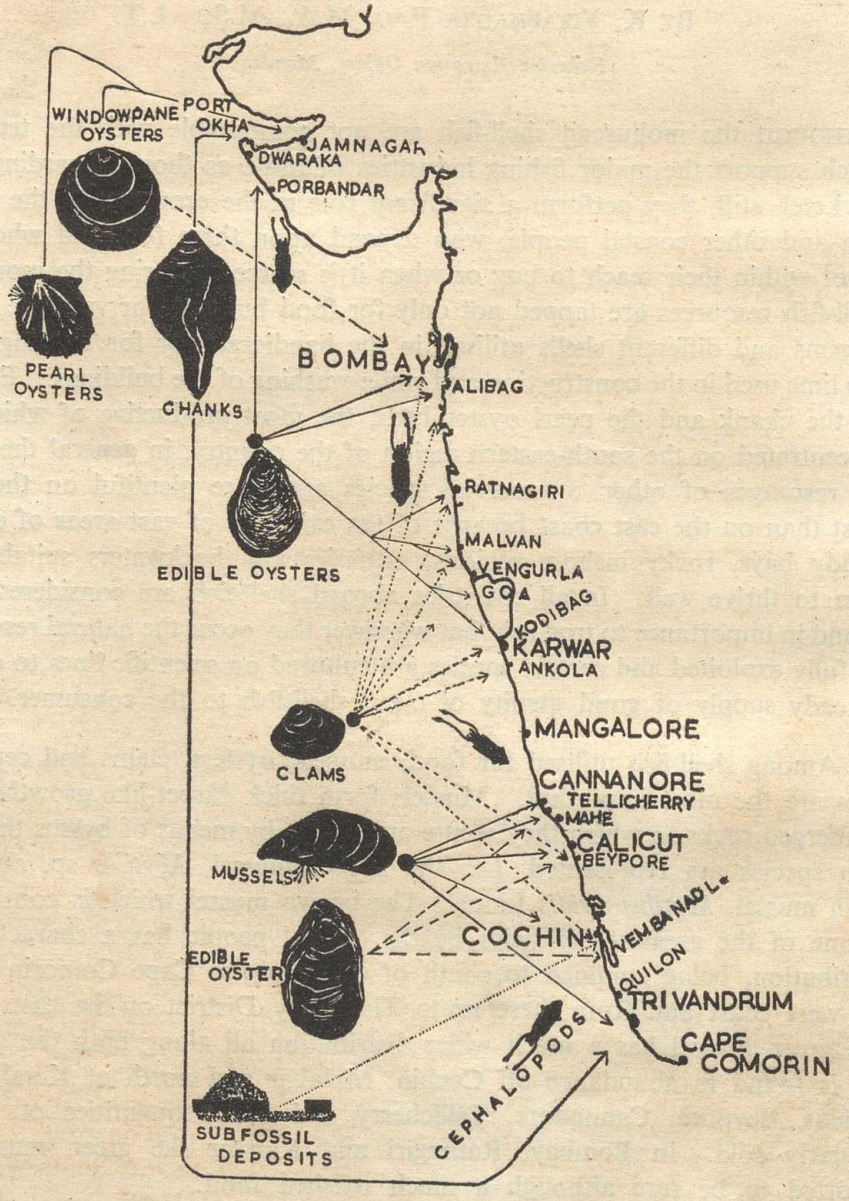
Although the molluscan shell-fish are not comparable with the true fish which support the major fishing industries of India as those of sardines and mackerel, still, they perform a significant role in the economy of the fishermen and other coastal people, who depend upon them for food when fish is not within their reach to buy or when it is scarce as during the monsoon. Shell-fish resources are tapped not only for food but also for valuable pearls as gems and different shells utilised in the handicrafts or for burning them into lime used in the construction and white-washing of the buildings. Excepting the chank and the pearl oyster beds, the most productive of which are concentrated on the south-eastern region of the country, in general the shell-fish resources of other commercial species are more plentiful on the west coast than on the east coast because of the existence of vast areas of creeks, muddy bays, rocky inshore regions, estuaries and backwaters suitable for them to thrive well. In all countries abroad shell-fish are considered only second in importance to true fish, but wherever they occur the natural resources are fully exploited and certain species are cultured on scientific lines to ensure a steady supply of good quality of clean shell-fish to the consumer.

Among shell-fish utilised for food, mussels, oysters, clams and cephalopods are the most important. Mussels form thick carpet-like growths over submerged rocks to which they secure anchorage by means of byssus threads. Two species are represented, *i.e.*, the brown mussel, *Mytilus* sp. and the green mussel, *Mytilus viridis* Linne. The brown mussel which is considered as one of the greatest delicacies by the coastal people has a characteristic distribution, being confined to south of Quilon up to Cape Comorin along the west coast and from there up to Tinnevelly District on the east coast. The green mussel has a much wider distribution all along both the coasts, but is found in abundance off Cochin, Malabar and north of Kerala. In Calicut, Beypore, Cannanore, Tellicherry and Mahe quantities of it are regularly sold. In Bombay, Ratnagiri and Karwar the green mussel is reported to be rare although a much relished food.

Demand for edible oysters in and around the Bombay City is much greater than in most other places in India, where despite the fact that the resources are plentiful their utilisation is very much limited. The species of commercial importance are *Crassostrea gryphoides* (Newton and Smith) inhabiting the muddy creeks, *Crassostrea cucullata* (Born) on the intertidal rocky coasts, *Crassostrea discoidea* (Gould) in the littoral zone of the coastal



Commercial Molluscs of the West Coast of India.

areas and *Crassostrea madrasensis* (Preston) in the estuaries and backwaters. *Crassostrea gryphoides*, and *Crassostrea discoidea* occur in Kutch creeks, Okha port, Dwaraka and Porbundar to north of Bombay, in Malad, Boisar, Satpati, Palghar, Sanjim Kalve, Navapur and Mahim around Bombay and in Alibag, Ratnagiri, Jaytapur, Malwan, Vengurla, Goa and Karwar to south of Bombay. The rock oyster, *Cr. cucullata*, is found all along the coasts while the backwater oyster, *Cr. madrasensis*, is confined to the southern regions on the west coast but widely distributed in all the estuaries and backwaters of the east coast.

Of all the molluscan shell-fish clams which occur in great abundance are the best utilised for human food, they being considered nutritious and delicious. The common backwater clams, *Meretrix casta* (Chem.) and *Katelysia opima* (Gmelin), the bay clam, *Meretrix meretrix* (Linne) and the black clam, *Vellorita cyprinoides* (Grey) are the principal species supporting clam fisheries on the west coast. *M. casta*, although widely distributed is particularly abundant in the south-western coastal backwaters and estuaries. *M. meretrix* occurs in large beds along Bombay, Alibag, Ratnagiri, Jaytapur, Karwar, Kodibag, Ankola, Moorbad, Wadvoni, Mirgan, Harwada, Mudgian and Sanikatta. In the southern regions it is comparatively rare, its place having been taken up by *M. casta*. The black clam *Vellorita cyprinoides* has a peculiar distribution, the living ones at present being confined only to west coast backwaters and estuaries although its dead shells occur in sub-fossil deposits on the east coast as well. Other bivalve shell-fish used for food are *Arca granosa* Linne, *Cardium* sp., *Paphia malabarica* (Chem.) and *Sanguinolaria diphos* (Gmelin). Among some of the gastropods gathered here and there occasionally for food purposes are *Thais* spp., *Umbonium vestiarium* (Linne) and *Natica* sp.

Nowhere on the west coast do the edible cephalopods, *viz.*, cuttlefish, squids and octopi constitute a regular fishery, they being obtained only incidentally in nets all through the year in the normal fishing operations. *Sepia rouxii* Ferussac et d'Orbigny, *Sepia aculeata* F. et d'Orb., *Sepia rostrata* and *Sepiella inermis* (F. et d'Orb.) among the cuttlefish, *Sepioteuthis arctipinnis* Gould, *Loligo indica* Pfeffer, *L. hardwickii* and *L. affinis* among squids and *Octopus rugosus* (Bosc.), *O. octopodia*, *O. favonia*, *O. incertus*, *O. herdmanii* and *O. hongkongensis* Hoyle among the octopi are some of the common species. When the squids and cuttlefish occur in large quantities, they are sun-dried for export. Cephalopods are commonly used in hook and line fishing as bait. It may be of interest to note that on the southern coasts of Palk Bay and the Gulf of Mannar there is a seasonal fishery for squids

lasting from February to June, the chief commercial species being *Sepioteuthis arctipinnis* Gould.

The chank and the pearl fisheries are the most important of the molluscan fisheries of India. The chank beds of *Xancus pyrum* (Lamarck) occur on the west coast in the Gulf of Kutch near Port Okha and in the Arabian Sea off Trivandrum. On the east coast the most productive beds are chiefly in the Gulf of Mannar near Tuticorin and Kilakarai, and in the Palk Bay near Devipatnam and Rameswaram. Chanks are also found in fair numbers from Point Calimere to the Madras City. The chank beds along the east coast are far more extensive and productive than those on the west coast. However, chank shells fished from the Gulf of Kutch are of good quality and they fetch a very high price. Unlike on the east coast where divers are employed for the collection of shells from the beds in waters up to ten fathoms of depth, those in the Gulf of Kutch are exposed at low water spring tides and the chanks are hand-picked by the fishers. The beds are often leased by the Government for a few thousand rupees annually. The chank beds off Trivandrum coast are the poorest and the revenue is collected by levy of export duty on the chanks fished. Annually many lakhs of chanks are required by the shell bangle manufacturers who receive the raw product from the wholesale suppliers in Bengal. Chanks with the sinistral twist of the spire are extremely rare and considered very valuable, owing to the belief that such shells bring fortune to the possessor. Often such chanks are mounted in gold and silver and dedicated to the temples.

As in the case of the chank beds, the pearl oyster beds on the west coast are much limited in their extent and also less productive than those on the east coast. The latter extending from Cape Comorin to Kilakarai with the most productive central zone off Tuticorin coast are world famous from time immemorial for the excellent quality of the oriental pearls which the oysters yield. The species of commercial importance is *Pinctata vulgaris*, along with which *P. chemnitzi*, *P. margaretifera*, *P. anomioides* and *P. atropurpurea* also are known to occur from the Indian waters. On the west coast of India from the Gulf of Kutch pearl oysters are fished in some several thousands annually from the reefs to the north of Halar District in Saurashtra and those near Jamnagar. On the east coast during productive years the beds yield several millions of oysters worth two to three lakhs of rupees. Like the chanks the oysters are collected by hand when the reefs in the Gulf are exposed at low tides.

Small seed pearls of inferior quality used in medicine are procured from windowpane oyster, occurring in the bottom of bays and harbours, in Balapur area and the Rann Bay in the Gulf of Kutch. Fair numbers

are found along the Bombay coast, but further south they being so sparse are of little value. The seed pearls can be procured not only from the living oysters, but also from the dead ones. The Gulf of Kutch fisheries of the windowpane oyster about 1914 have fetched very high rentals, but in recent years they have deteriorated and the prices offered for the seed pearls have also fallen considerably. The shell of the windowpane oyster being thin, flat, translucent, and iridescent is often used in the Far East in glazing the doors and windows.

Molluscan shells for lime are gathered from the estuaries and backwaters in considerable quantities. During monsoon when large amounts of dead shell are drifted ashore by the currents, they are collected and made use of for the purpose. The bulk of the shells comes from the sub-fossil deposits which occur in thick layers beneath the surface soil and consist of a variety of bivalve and gastropod species. On the west coast, the sub-fossil deposits of *Meretrix*, *Arca* and *Vellorita* are extensive in the Vembanad Lake in Kerala.

The chank and the pearl oyster beds are under the ownership, control and supervision of the State Governments, who conduct their fisheries in a well organised manner, but shell-fish resources in respect of other utilisable species in general are largely neglected. Proper legislative measures to prevent depletion are lacking. Many of the clam and oyster beds as those near Ratnagiri and Karwar which were once productive have in recent years undergone much denudation. Repopulation of the depleted beds with the seed clams or spat oysters from other productive beds would go a long way in re-establishing the beds. Culture of shell-fish is not practised in India, but it is worthwhile trying as the results are expected to be fruitful. Clams for which there is good demand can be cultured in tidal flats employing simple and inexpensive methods. Though the demand for oysters is from the cultured few, by adopting simple methods of collection of spat when they set in the natural habitats, preparation of suitable beds for the young oysters to grow to marketable size and periodical examination of the growing oysters to prevent their destruction from enemies and pests, there could be built up a small industry to meet the existing demand. Except in the case of pearl oysters and chanks no estimates are available regarding the total production of the various species of shell-fish. Intensive surveys of the exploitable resources, accurate estimation of the annual production, detailed biological investigations on species of commercial value and strict measures of state control over the natural beds of the molluscan shell-fish are essential for the proper upkeep and management of their fisheries.

OFFSHORE FISHERIES

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The utilization of the fishery wealth available in the seas around India was confined until recently to the inshore region extending less than ten miles from the shore, the offshore region being left mostly untouched. This was partly because of the want of mechanization of the craft and gear, and partly because of the want of sufficient knowledge of the availability of good catches in the offshore grounds. While various exploratory surveys conducted before Independence such as those of the "Golden Crown" (1908–11) in the Bay of Bengal, the "William Carrick" (1921–22) off the Bombay and Kathiawar coasts and the "Lady Goschen" (1927–30) off the east and west coasts of southern India had given indications of the existence of considerable fishery resources in the Indian offshore waters, these surveys were all of a relatively short duration and because of this and other factors they did not succeed in inducing the fishing industry to take to any regular exploitation of those waters. The intensive exploratory survey and development work carried out during the past ten years has broken new ground and while much work is still to be done, it now appears that offshore fishing has come to stay. Not only has the existence of certain productive offshore fishing grounds been verified but private enterprise has also taken over the exploitation of some of these grounds by the use of trawlers or other types of large fishing vessels. A gradually increasing number of small vessels and country craft have also been mechanized during recent years, particularly in the Bombay State and these frequently fish in the near-offshore grounds with very good results.

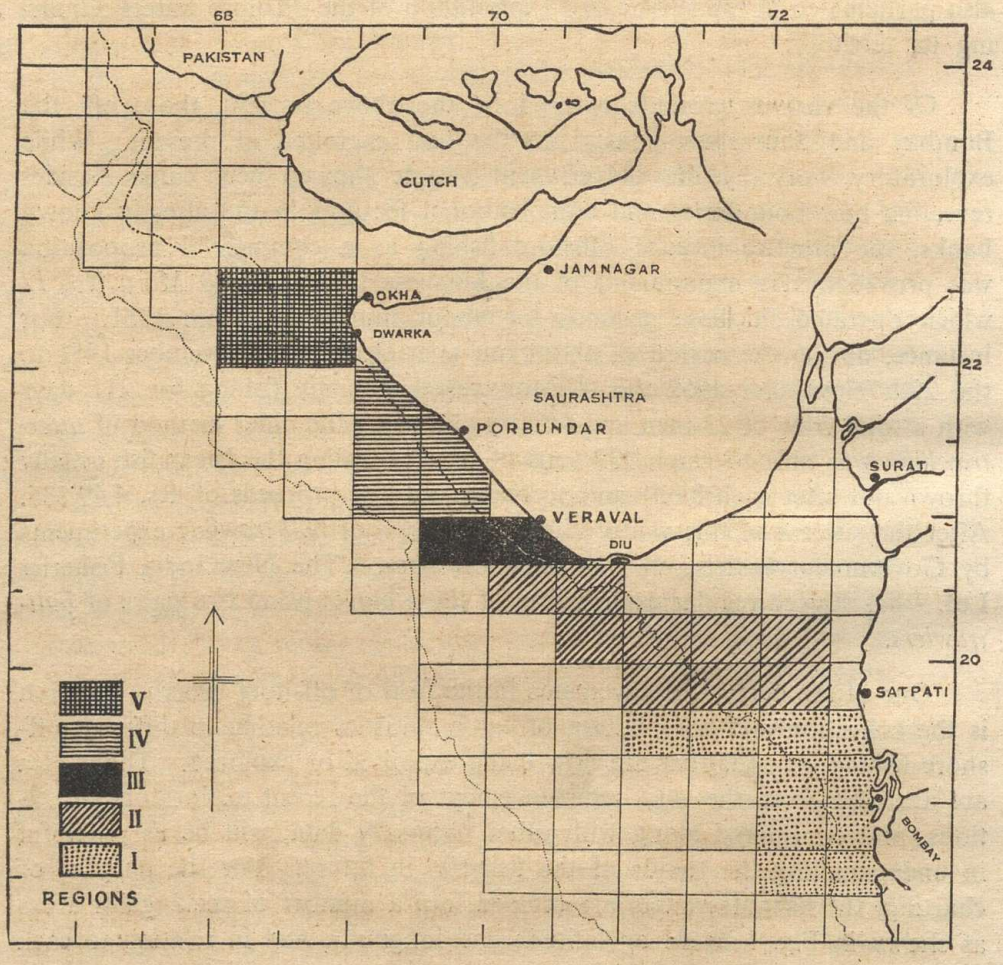
One of the main factors contributing to this development in the field of offshore fisheries has been the sponsoring of sustained exploratory surveys by Governmental agencies with the help of foreign experts and equipment wherever necessary. The Government of India opened the Deep Sea Fishing Station in 1946 and initiated offshore fishing experiments off the Bombay and Saurashtra coasts in January 1948. After experimenting with certain types of craft and gear in the different grounds, it has been possible to chart a considerable portion of the offshore waters of this region and also

to prove that the Japanese method of fishing known as *bull-trawling* is much more profitable than the older method of *otter-trawling* for catching the fishes of these grounds. The exploratory vessels have been gradually increased in number and the survey has been extended since 1957 to the southern part of the Arabian Sea also. The Government of West Bengal launched an exploratory programme in 1950 with two trawlers to study the fishable grounds in the northern part of the Bay of Bengal and have been continuing the work with five trawlers at present. The Travancore Government sponsored some deep sea fishing experiments off the south-west coast of India in 1949–50 and this confirmed the belief held before, that fairly good fisheries exist in the offshore waters west of Travancore and also in the waters adjoining the well-known Wadge Bank which has been profitably exploited by Ceylon for a long time. The former Saurashtra Government also participated in the survey and exploitation of the offshore waters adjoining its territory.

Of the various grounds covered by the above surveys, those off the Bombay and Saurashtra coasts are the best exploited at present. While exploratory work by the Government vessels showed new banks besides revealing new boundaries and compositional features in the already known banks, the practicability of offshore fishing as a commercial proposition was proved by the experiments of the Japanese trawler *Taiyo Maru No. 17* which operated in these grounds for about four years from 1951. For instance, during the period of about one year from 28th November 1951 to the 25th November 1952 this 277-ton vessel, actually fishing for 211 days with a total crew of 23 men and officers and using the older method of *otter-trawling*, was able to catch 939 tons of fish (excluding the cheap fish usually thrown out after each haul) and to realise net sale proceeds of Rs. 4,49,385. After the success of this venture and the success of *bull-trawling* experiments by Government vessels, an Indo-Japanese firm, " The New India Fisheries Ltd. " has started regular exploitation of these banks using two pairs of *bull-trawlers*.

One of the current achievements in the field of offshore fisheries research is the collection and compilation of catch statistics relating to different offshore fishing grounds that are now being exploited or explored. These data are available from the very commencement of the recent exploratory operations, and considered along with other necessary data, will be very helpful in understanding the trends of the fisheries in future. For the purpose of charting, the fishable waters are divided into a number of rectangular areas as shown in Fig. 1 based on latitude and longitude, and in relation to each

one of these areas the catch details are calculated. But while these individual areas are important in the primary charting and assessment of catch trends, it is each fishing bank or region as a whole that should be considered for understanding the broader trends and general behaviour of the fisheries. Such banks or regions are distinguished from one another on the basis of the compositional features of the fisheries and peculiarities of the grounds. Five regions are recognised off the Bombay and Saurashtra coasts: (1) the Bombay region extending southward to 18° 20′ N. lat. and towards the north and north-east upto 19° 40′ N.–71° E.; (2) the Cambay region, extending from south-west to north-east from 72° 30′ E.–19° 40′ N. to 70° E.–20° 40′ N.; (3) the Veraval region, a narrow strip of about 20 miles width extending seaward from the coast upto 69° 30′ E.; (4) the Porbundar region, extending north-eastwards from the previous region up to 22° N.–69° E.;



Exploratory offshore fishing regions of the Bombay and Sourashtra Coasts.

(5) the Cutch gulf or the Dwaraka region bounded by the latitudes 22° N. and 22° 40' N. and the longitudes 68° E. and 69° E.

The most important commercial fishes of these grounds are *dara* (*Polydactylus indicus*), *ghol* (*Pseudosciaena diacanthus*), *koth* (*Otolithoides brunneus*), *wam* (*Muraenesox talabonoides*) and *karkara* (*Pomadasys hasta*). Considerable quantities of *dhoma* (small sciaenids dominated by *Otolithus* spp.), catfishes and rays are caught in certain grounds but are sometimes rejected by the commercial vessels in favour of more profitable kinds of fishes. Among other fishes of value that occur in the trawl catches of these grounds may be mentioned the sharks and skates, *rawas* (*Eleutheronema tetradactylum*), *surmai* (*Scomberomorus* spp.), *pomfrets* (*Pampus argenteus*, *P. chinensis* and *Parastromateus niger*), *tamb* (*Lutjanus* spp.), *chand* (*Drepane punctata*), *kati* (*Pellona* spp.), *datali* (*Chirocentrus dorab*), *bombil* (*Harpodon nehereus*), *Synagris* sp., *Psettodes erumei*, ribbonfish, prawns & lobsters and cuttlefish.

Table I shows the total quantities of all fish caught by the Bombay-based trawlers from the different offshore fishing grounds during the years 1949–50 to 1954–55 and Table II shows the quantities of seven selected categories of fishes caught by these trawlers in the Dwaraka region during the same years. A general decrease in the catches is noticed in these tables for the year 1954–55. This is mainly due to reduced fishing effort by the trawlers operating in the area and the total withdrawal of one of them.

TABLE I*

Total takings (in lb.) of all fish from the different offshore trawling grounds during the years 1949–50 *to* 1954–55

Regions	1949–50	1950–51	1951–52	1952–53	1953–54	1954–55
Bombay ..	1,21,481	33,655	2,05,313	1,43,069	1,57,545	121
Cambay ..	2,61,576	3,85,346	4,34,327	6,65,301	4,00,447	48,775
Veraval ..	6,105	3,608	3,91,342	1,74,767	82,559	56,497
Porbundar ..	196	..	3,04,426	1,88,347	2,55,836	2,09,920
Dwaraka ..	..	..	12,69,878	12,50,392	20,31,773	1,53,417

* The figures given in Tables I to IV have been taken from the data compiled by the Sub-Bombay-Station of the Central Marine Fisheries Research Station; 1 lb. = 0·454 kg.

A good indicator of the abundance and availability of the fishes in the trawling grounds is the catch per unit effort. Tables III and IV show the

TABLE II

Takings (in lb.) of seven principal categories of fishes from the Dwaraka trawling grounds during the years 1951–52 *to* 1954–55

Year	*Dara*	*Ghol*	*Koth*	*Wam*	*Karkara*	Catfish	Elasmo-branchs
1951–52 ..	2,06,819	1,40,237	48,800	32,391	2,09,055	80,819	1,81,112
1952–53 ..	3,61,335	1,03,310	3,04,760	27,507	1,30,617	1,53,588	74,087
1953–54 ..	4,60,208	1,78,856	4,39,263	71,498	2,53,247	1,55,527	1,66,140
1954–55 ..	56,112	6,938	31,754	2,961	10,459	11,782	8,920

catch rates of all fish in the different regions and the catch rates of five selected categories of fishes in the Dwaraka region respectively, during the years 1953–54 and 1954–55, when the 135-ton cutters *Ashok* and *Pratap* carried out *bull-trawling* experiments. The high catch rates of some of the regions will be easily noticed in these tables.

TABLE III

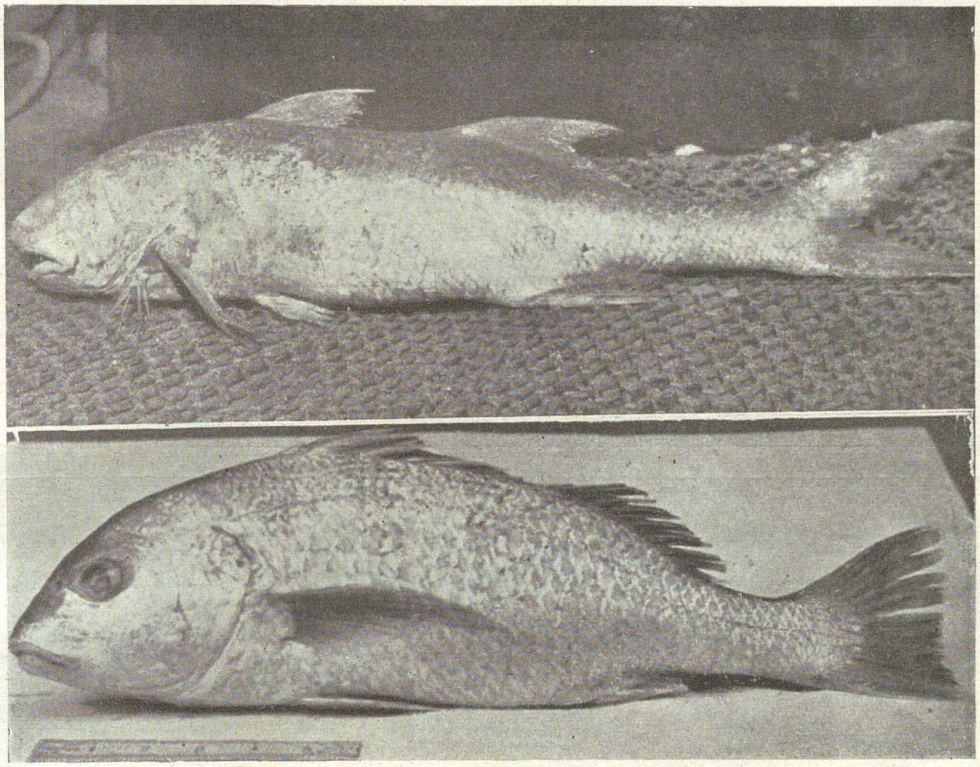
Catch of all fish (in lb.) per trawling hour, by the cutters Ashok *and* Pratap *from the different regions*

Regions	Years	Dec.	Jan.	Feb.	March	April	May
Bombay ..	1953–54	836·8*	309·4	1,137·1*	695·4	..	535·6
	1954–55	..	80·7*	..	..	..	..
Cambay ..	1953–54	655·8*	225·1	..	311·4*	..	320·1
	1954–55	..	1,359·2	545·7*	312·5*	2,478·8*	1,120·6*
Veraval ..	1953–54	785·3*	663·8	..	1,213·0*	..	568·2
	1954–55	..	1,388·4	..	1,423·3	1,280·2	2,246·7*
Porbundar ..	1953–54	..	1,651·1*	..	896·6*	1,009·2	605·4
	1954–55	..	742·0	1,776·0	1,561·6	1,084·8	..
Dwaraka ..	1953–54	958·8	1,335·1	1,332·4	1,695·5	1,241·8	1,526·5
	1954–55	..	1,327·1	3,059·2	1,314·4	914·3*	..

* Less than 10 trawling hours.

The Dwaraka or the Cutch gulf region has so far proved to be the richest of the five trawling grounds, yielding both the best landings and the highest average catch rates per unit of effort. This ground is also the best for the trawl fisheries of *dara* and *koth* which are characteristic of this region.

SOME IMPORTANT FISHES OF THE BOMBAY AND SAURASHTRA OFFSHORE GROUNDS



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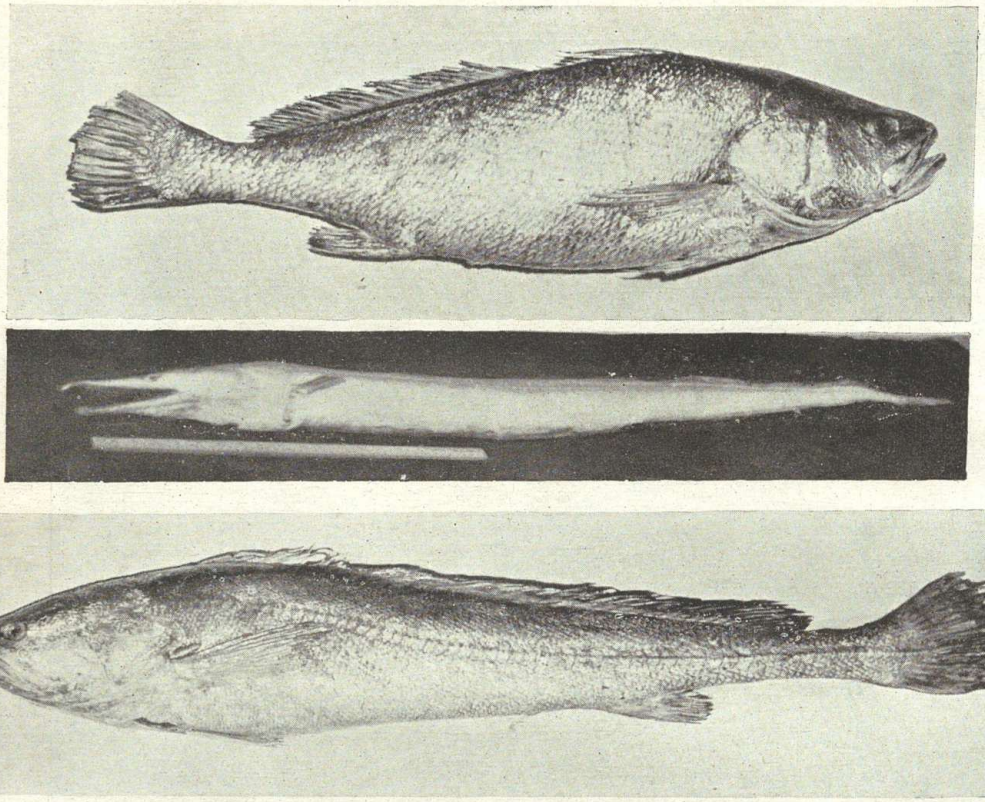
1. Dara (*Polydactylus indicus*). 2. Karkara (*Pomadasys hasta*).

SOME IMPORTANT FISHES OF THE BOMBAY AN SAURASHTRA OFFSHORE GROUNDS



3. Ghol (*Pseudosciæna diacanthus*). 4. Wam (*Muræsox talabonoides*).
5. Koth (*Otolithoides brunneus*).

TABLE IV

Catch of Dara, Ghol, Koth, Wam *and* Karkara *per trawling hour by* Ashok *and* Pratap *in the Dwaraka region*

Fish	Year	Dec.	Jan.	Feb.	March	April	May
Dara	1953–54	398·3	706·8	755·1	214·2	243·6	67·4
	1954–55	..	338·1	1,371·1	233·4	455·9*	..
Ghol ..	1953–54	56·8	44·3	51·3	201·0	208·6	143·5
	1954–55	..	57·8	93·9	158·5	48·9*	..
Koth ..	1953–54	126·5	124·3	85·8	35·0	34·4	1·4
	1954–55	..	108·2	822·0	288·5	65·7	..
Wam ..	1953–54	16·4	16·6	18·1	95·4	128·7	59·5
	1954–55	..	20·6	46·5	51·3	53·1*	..
Karkara ..	1954–55	..	194·8	94·5	86·6	30·6	..

* Less than 10 trawling hours.

The *Wam* fishery has been best in the Cambay and Veraval regions. *Ghol* occurs in some quantities in all the regions. *Karkara* is mainly caught in the Porbundar and Dwaraka regions. Catfishes, sharks and rays form a good proportion of the catches in the Bombay and Cambay regions.

The bulk of the yield of all these grounds has been seen to be in the neighbourhood of the 20 fathom line; *dara* and *koth* show greater abundance on the landward side of this line while *ghol*, *wam* and *karkara* occur more on the seaward side. It has also been noticed that the trawler catches tend to be better during day time than during night time and also better during the neap-tide period than during the spring-tide period. A study of the catch rate trends along with the temperature distribution charts has indicated the possibility of there being certain optimum temperatures limiting the abundance of the different fishes even within the limited ranges found in our waters. The hydrological studies made at Bombay have also indicated the possibility of seasonal upwelling in the coastal waters between 20° N. and 21° N. latitude and to a less extent up to 22° N. latitude during the period December to February. These mixing phenomena must be of great importance in determining the fertility of these waters.

The *dara* and *koth* fisheries of the Dwaraka region are mainly constituted by juveniles and immature adults. Biological work on these and other species of importance has been receiving attention at the Bombay Substation of the Central Marine Fisheries Research Station.

In the Kerala offshore waters, experiments were conducted in 1949–50 with the vessels *Chandrika* and *Ashok Kumari* (Dory-fishing or mother-ship operations), *Sagarakumari* and *Kanyakumari* (mainly *otter-trawling*). The trawling ground was between longitudes 77° E. and 77° 45′ E. and latitudes 7° 40′ N. and 8° 15′ N. in what has been described as the northward extension of the Wadge Bank. The mother-ship operations consisted of towing a number of the smaller boats to the offshore fishing grounds and allowing them to fish by the use of hooks and lines. This was carried out in two grounds, namely, in the north in an area lying between longitudes 76° E. and 76° 30′ E. and latitudes 8° 30′ N. and 9° 15′ N., and in the south between latitudes 7° 45′ N. and 8° N. and longitudes 76° 45′ E. and 77° 45′ E. (excluding the Wadge Bank proper). While both these operations did not appear attractive commercially, they did indicate the existence of good fisheries of species such as *Epinephelus* spp., *Lutjanus malabaricus*, *L. argentimaculatus*, *Carcharinus limbatus* and *Pristis cuspidatus*. Almost all the species obtained by line fishing were obtained from the trawling grounds also, there being many additional species. Of these some of the first class fishes were *Lethrinus nebulosus*, *L. reticulatus*, *L. ornatus*, *Parupeneus trifasciatus*, *Epinephelus areolatus*, *Lutjanus johni* and *Scomberomorus commersonii*. The quantitative results of the trawling operations have not been published.

During 1957, the Government vessels *Ashok*, *Pratap* and *Durga* started exploratory work off the Kerala coast in co-ordination with the schooners of the Indo-Norwegian foundation, with Cochin as base. The highest monthly catch rate by *Ashok* and *Pratap* (*bull-trawling*) during 1957–58 was obtained in December (1215 kg. per hour), exploring mainly between Alleppey and Quilon. In one voyage during this month the catch rate was reported to be as high as 1429 kg. per hour. The work of the *Durga* and the Norwegian vessels appears to have indicated so far that the best period for trawling for prawns in the near-grounds up to 20 fathoms is May-June and December-January. In December, prawns formed 54·7% of the catches of *Durga*. The catches of all the offshore fishing vessels working at Cochin are being analysed regularly and efforts are being made for charting the different offshore grounds of this region in detail.

The analysis of the data of the Bengal trawlers, *Kalyani I* to *V* has also been taken up recently at Calcutta. The regions at present explored include the following grounds: (1) the Black Pagoda region, (2) the Sand Head region, (3) the Tiger Point, (4) the False Bay Point, (5) off the Devi River mouth, (6) off the Prachi River mouth and (7) off the Baitarani River mouth. *Kurtus indicus* was abundant in several of these grounds, the other important

fishes including pomfrets, sciaenids, perches, ribbonfish, elasmobranchs, eels and prawns. The best grounds during the first half of 1957–58 were those of the Devi and Prachi River mouths yielding 1231 and 1092 lb. respectively per hour of fishing.

Both exploratory and research programmes on offshore fisheries are expected to be substantially expanded and intensified in the future. The existing offshore fisheries such as those of sharks, seer and the flying-fish require to be investigated for further development. The tunas deserve particular attention on account of their value in foreign markets. While their economic importance is yet to be realised in our country, as many as five species of the tuna group seem to be present in our seas and some of them have long been known to occur in the currently exploited areas yielding on an average about 3,500 tons of fish per year. They are caught off the Ratnagiri coast, off the Kerala coast, around the Laccadive Islands, off Tuticorin, and roundabout the Andaman Islands. Reports of tuna shoals are occasionally heard from masters of fishing and other vessels as sighted at various regions in the Indian waters. It seems very likely that exploratory work in this direction may lead to fruitful results.

Several grounds which were located in the past have to be looked for again. On the east coast for instance, the *Lady Goschen* was reported to have found some offshore fishing grounds not known before and it was claimed that these grounds were superior at that time in quality and value to those of the west coast offshore fisheries; they even seem to have attracted the attention of Japanese fishing interests from the distance of thousands of miles. Unfortunately the work that was so promising could not be continued owing to unsurmountable technical and administrative difficulties, and further exploration of the east coast grounds is still to be made. It is expected that this gap will be covered when the projected offshore fishing stations at Tuticorin and Visakhapatnam are opened.

On the west coast, the exploratory survey needs to be extended to cover the Kanara and Ratnagiri coasts and the regions around the Laccadive Islands. It is also necessary that offshore exploration and research should include programmes on the mackerel and the oil-sardine which form our most important marine fisheries at present. Such studies should help in understanding the fluctuations in the occurrence of these fishes in the inshore waters if not in finding new fishable stocks of them in the offshore waters. It is expected that the proposed increase in the offshore fishing activities will provide opportunities for the implementation of such programmes also.

FISHERY SURVEY AND STATISTICS

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The development of fisheries will help the country in meeting the deficiency in the much needed protein in our diet. The role of reliable and accurate statistics in framing plans or formulating policies for such development need not be overemphasised.

It is however necessary to know the various items of statistics that need be collected. The term, fisheries statistics, is a very comprehensive one and is somewhat different from the term agricultural statistics. Agricultural statistics can generally be divided into three groups, *viz.*, (*a*) statistics on potentialities for exploitation, (*b*) statistics of production, and (*c*) statistics on distribution. These statistics will generally describe the agricultural economy completely. Similar statistics on fisheries will likewise describe the economic side of the fishing industry which is engaged in commercial fishing. But there is still another aspect *viz.*, statistics to determine the magnitude and structure of the various fish populations which yield fish catches. Such statistics may be termed biological statistics and have to be clearly distinguished from the economic statistics of the fishery. The distinction will become clear if we take the analogy of the mine. While statistics of potentialities, production and distribution determine the status of the industry, data on the geological structure of the mine lead to an assessment of the total available resource. Similarly data on the biological characteristics of fish populations determine the optimum catch that could be derived from the fish populations without adversely affecting them.

Fishery statistics can, therefore be classified into two groups. The first group contains statistics on items which will describe the economic pattern of the fishing industry and will help in formulating plans for further economic expansion of the industry. Detailed information on the various items of statistics of the later group, *i.e.*, the biological statistics, will throw light on the relation between catch and fish populations and will therefore help in formulating plans for scientific and efficient management of fisheries. As has already been stated, the requirement of data on the economic side

of the fishing industry may be classified into the following broad divisions: (i) Potentialities for exploitation, (ii) Production and (iii) Utilization.

The statistics on potentialities for exploitation will include data on the following: the total available water-area for fishing, the extent of area exploited, the number of persons engaged in fishing and other allied activities, the number of equipments such as boats and nets available for fishing. A study of the personnel engaged in fishing in relation to the equipment they possess and the catches obtained by them will reveal the nature of the industry and will suggest methods for its development. As any development plan for the industry also envisages simultaneous improvement in the living conditions of fishermen, collection of data on socio-economic condition of fishermen will probably come under this head.

The statistics of production mainly relates to the total landings. But data on cured, dried and processed fish together with other by-products like shark-liver oil, fish meal, etc., will come under this head. The study of the production figures in relation to regional demands will suggest ways in which the production has got to be regulated.

The statistics of utilization, demand and supply will show how the production is being utilized. Statistics of cured, dried and processed food will show how much fish is being consumed fresh. Market data and prices in different regions will indicate the position of demand and supply. Statistics of capital investment at different stages of the industry will point to the structural pattern of the industry.

Before stating the requirements of data necessary under the head biological statistics, it will be relevant to put in a few words the nature of the problem for which these statistics will be required. Mere development of the means of production will not improve production if the fish is not there or if the inherent qualities of the fish populations are adversely affected by fishing. If P_1 and P_2 denote the total populations of a fish in the beginning and end of a year, the change in population is given by

$$P_2 - P_1 = (G + R - M) - C \qquad (1)$$

where G is the growth, R is the recruitment and M and C are mortality and catch respectively. If there is no catch, the change of population will be denoted by $(G + R - M)$, which may be termed the rate of natural increase. This rate of natural increase is obviously a function of the population and may be denoted by $F(P)$. If $C < F(P)$, the population will increase. But the increase in population will increase the degree of competition between fishes and will thus reduce the natural rate of increase, thereby bringing the

population back to the original level. If $C > F(P)$, the population will decrease temporarily but this will afford better opportunities to the individuals to grow, increase the survival rate of the new arrivals and reduce mortality, thus increasing the natural rate of increase and bringing up the population to the original level. Thus it is clear that the catch can be greater than $F(P)$. But if it is very much greater than $F(P)$ the population can never recover back to its original position. Thus the maximum catch which will not change the population will be termed as the optimum catch. Any catch more than this optimum catch will affect the population and therefore the future catch. Any catch lower than the optimum catch will be both economic and biological wastage. Thus an efficient and scientific management of fishery means determination of the level of this optimum catch and the stable population. Such determination is very complex. For, the fish populations are not only affected by commercial fishing but also by various environmental factors. All such environmental factors along with commercial fishing affect the natural rate of increase and therefore the fish populations. Correct determination of populations therefore will require comprehensive biological and hydrological data which will estimate the environmental factors. But to start with, we may treat the environmental factors as random variables and try to understand the relationship between the amount of fishing, the quantity and quality of catch and the quantity and quality of fish populations and the rate of natural increase of population.

We know that the commercial catch is proportional to the amount of fishing (E) and to the population, *i.e.*, $C = KEP$, where K is a constant and KE measures the instantaneous rate of mortality. From above, the catch per unit effort U is given by

$$U = CE = KP \qquad (2)$$

If we get an estimate of K, and know U from observations, we get an estimate of the population during the year. Therefore if we know catch, from equation (1), we get an estimate of $F(P)$, the rate of natural increase. If we plot the estimates of U and $F(P)$ for several years, the resulting curve will have a mode. This mode represents the optimum catch.

Thus the essential data required for assessment of fish populations are: (i) commercial catch and its composition by species, (ii) amount of fishing effort for the catch of each species, and (iii) an estimate of the mortality rate of the populations, along with data on other biological and environmental factors for a fuller assessment of the fish population.

In conformity with the general aim, the interest of the Central Marine Fisheries Research Station was mainly directed towards the collection of

the second group of statistics, though some economic statistics such as village-wise statistics of boats and nets were also collected in course of the preparatory survey conducted for designing the main survey. When the Central Marine Fisheries Research Station started functioning in 1947, it was found that excepting for some rough estimates of catch as given in *Agricultural Report of Marketing of Fish*, no reliable statistics on an all-India basis were available for any of the items of statistics listed above. It was, however, imperative, in consonance with the objectives of the Institute to have accurate estimates of catch, effort, natural rate of increase, etc., from year to year to assess the condition of various fish populations.

It was therefore contemplated to devise a sampling technique which would give a fairly accurate estimate of the catch and the effort, from which estimates of natural rate of increase could be obtained. Accordingly in 1948, a preparatory survey was carried out on complete enumeration basis, in which village-wise data were collected on the number of fishermen, the number of fishing units of different types, the fishing seasons, the type of fish caught and general information on disposal of catches. A resurvey was again undertaken in 1955–56 to make the inventory of fishing villages up-to-date.

On the basis of information collected in the preparatory survey, the entire coast-line of India was divided into twelve zones, making each zone as homogeneous as possible from the point of fishering practices and fisheries. To start with, three representative fishing centres (villages) were selected in each zone. But from 1955–56, the number of centres was increased to six on the west coast zones, which are responsible for landing more than 75% of the total catch. In order to increase the accuracy of the estimates, the coast-line of India were redivided into twenty homogeneous zones from 1957. The number of fishing villages studied was also increased, so that about 10% of the total number of villages was covered.

Three selected fishing villages are put in charge of a field investigator who visits each village once in each fortnight, the duration of stay at a village during each visit being three days. During each day's stay at village, a certain fixed percentage (varying from 10 to 20% from zone to zone) of fishing units landing their catch are examined on the basis of systematic selection, and data on total catch, catch of different species of fish, man-power engaged, duration of fishing, etc., are collected. The numbers of different types of fishing units landing their catches are also recorded. The fishing unit mentioned above is a boat-net combination. It is taken as the ultimate sampling unit, as the quantity and quality of catch depend mainly on the type of gear used.

The data are analysed separately for each zone every month. For the first four years from 1950, only estimates of catch were obtained along with its composition. From 1954, estimates of effort and catch per unit-effort are also being obtained. It is hoped that ten to fifteen years' data on the above items would enable us to determine the status of the fish populations. A summary of the data collected during the eight years (1950–57) are given in Tables I and II.

TABLE I

Showing annual catch in metric tons, total effort in thousand man-hours and catch (in kilogramme) per man-hour

Year	Total Catch (metric tons)	Total Effort (1000man-hours)	Catch (kg.) (per man-hour)
1950	580,021	..	..
1951	533,916	..	..
1952	528,346	..	..
1953	581,460	..	..
1954	588,257	317,272	1·85
1955	595,722	331,033	1·80
1956	718,702	334,887	2·14
1957	875,420	318,147	2·74

It will be seen that the minimum essential statistics on the *biological* side are now being collected regularly and on a planned basis. On the other hand, excepting for the catch statistics which are being collected in connection with the biological assessment of fish populations and some village-wise statistics of fishing population and fishing units which were collected during the two preparatory surveys, statistics on the *economic* side of the fishing industry have yet to be collected on an all-India basis, although some States have been collecting such statistics at the State-level. It is necessary that the area of collection of comprehensive economic statistics relating to fishing industry be extended to cover the whole of India. While an understanding of the relationship between catch and fish population will lead to better management of fisheries, economic statistics on various items of fishing

TABLE II

Showing the composition of the average annual catch for 1950–57

	Fish	Average catch in Metric tons	Per cent.
1.	Elasmobranchs	22,781	3·64
2.	Eels	2,755	0·44
3.	Catfishes	20,281	3·24
4.	*Chirocentrus*	4,515	0·72
5.	(*a*) Oil-sardine	47,583	7·61
	(*b*) Other sardines	42,391	6·78
	(*c*) *Hilsa*	1,050	0·17
	(*d*) *Anchoviella* and *Thrissocles*	32,076	5·13
	(*e*) Other clupeids	23,448	3·75
6.	Bombay-duck	60,011	9·60
7.	Flying-fish	1,844	0·29
8.	Perches	9,168	1·47
9.	Red mullet	2,691	0·43
10.	Polynemids	5,097	0·82
11.	Sciaenids	42,357	6·78
12.	Ribbonfish	31,519	5·04
13.	Carangids	17,327	2·77
14.	Silver-bellies	12,758	2·04
15.	*Lactarius*	5,458	0·87
16.	Pomfret	12,722	2·03
17.	Mackerel	62,414	9·98
18.	Seer fish	7,285	1·17
19.	Tunnies	2,460	0·39
20.	Sphyraena	1,286	0·21
21.	*Mugil*	237	0·04
22.	*Bregmaceros*	5,024	0·80
23.	Sole	7,938	1·27
24.	Prawns and Crustaceans	109,572	17·53
25.	Miscellaneous	31,182	4·99
	TOTAL ..	625,230	100·00

industries will be needed for framing an efficient plan for further economic expansion of the industry.

ECONOMIC SEAWEEDS

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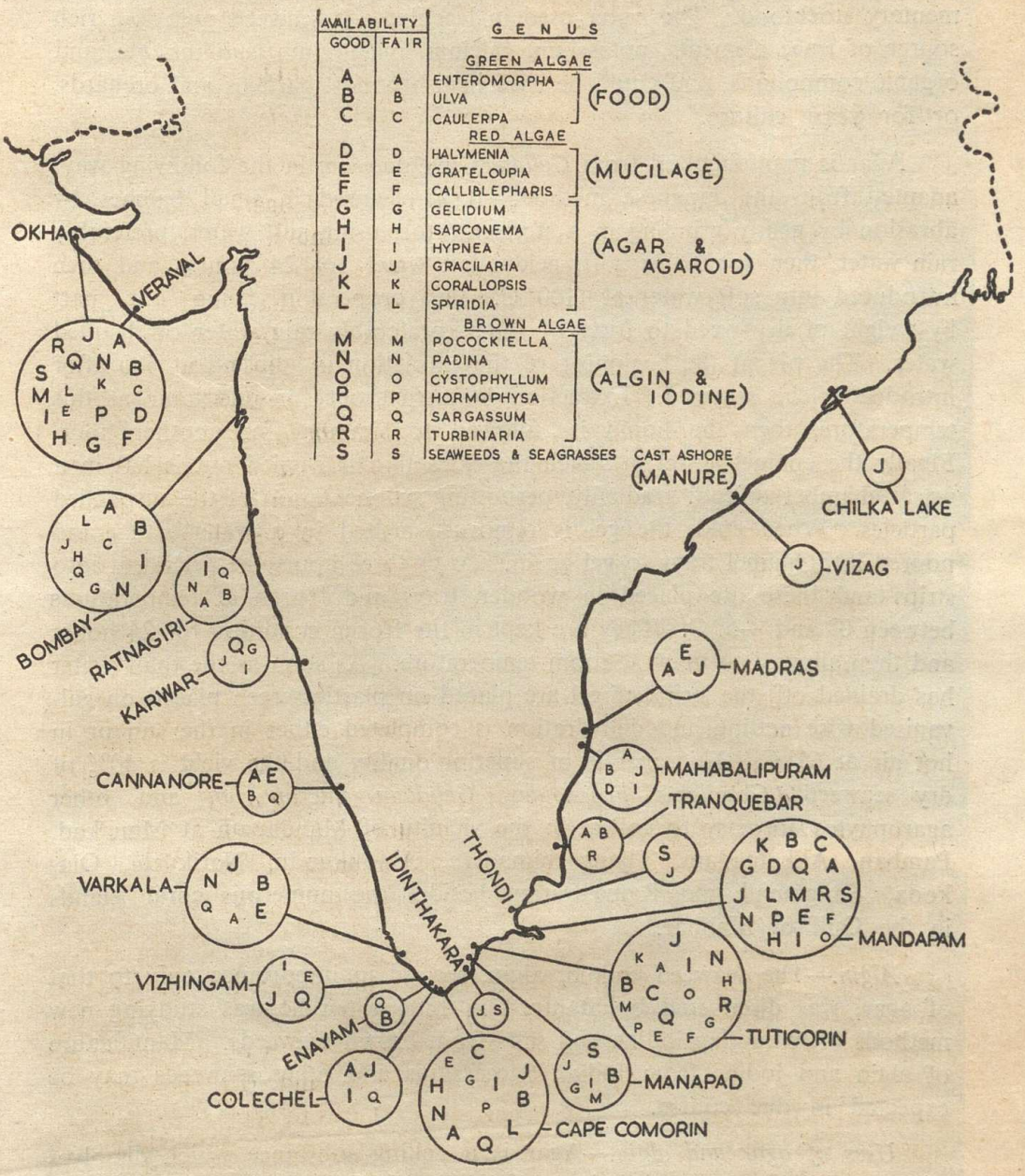
Seaweeds are important economically since they yield agar, alginates and mucilages. They are invaluable as stockfood and manure. Some seaweeds have medicinal properties. Lastly certain seaweeds are edible and nutritious. The most abundant Indian seaweeds are those that yield agar and algin. The former comprise red algæ of the genera *Gelidium* (Fig. 1), *Sarconema*, *Gracilaria* (Figs. 2 and 3) and *Corallopsis*. The latter comprise brown algæ of the genera *Hormophysa*, *Turbinaria*, *Cystophyllum*, *Sargassum*, *Dictyota*, *Padina*, *Pocockiella*, *Colpomenia*, *Hydroclathrus* and *Rosenvingia*. *Gelidium* and some Gracilarias on the one hand, and *Sargassum* on the other are the most valuable economically, being abundant on our coasts and giving high yields of their respective products (map). The rocky stretches of coast throughout India, specially in the States of Bombay, Mysore, Kerala and Madras are rich in *Sargassum* and some forms of *Gracilaria*. Hornell as far back as 1918 ascertained that 100 tons of fresh *Sargassum* are washed ashore annually on the Kathiawar coast. Considerable amounts of *Sargassum* are available at Karwar where, however, it is being used as manure. The coral Islands—the Laccadives and the Islands in the Gulf of Mannar—and the coral reefs in the Bombay State at Veraval and Porbandar have a wealth of *Gelidium* and of a number of forms of *Gracilaria*. Kerala, particularly the District of Trivandrum, has a wealth of *Gracilaria* besides *Sargassum*, and agar and algin were first extracted in India at the University of Travancore.

Agar manufacture.—Gracilaria crassa, *Gelidium micropterum* and *Gracilaria lichenoides* (Figs. 4 and 5) would serve for the production of bacteriological agar since their gels are sufficiently firm and the setting temperature is 34°, 40°, 43° C. respectively for the appropriate strength of agar solution. Manufacture of agar from *Gracilaria lichenoides* and *Gracilaria crassa* (*kanji-pasigal*), without the aid of machinery, promises to spread as a cottage industry. The method was worked out at the Central Marine Fisheries Research Station, Mandapam and consists in the seaweeds being collected,

washed thoroughly, bleached-dried in the sun, cleaned in a stone mortar in a few changes of water, soaked, ground into pulp, leached in soft water, and introduced as dried pulp into boiling water for extraction. The supernatant clear sol is removed after it gels. Drying of the gel is done on plastic



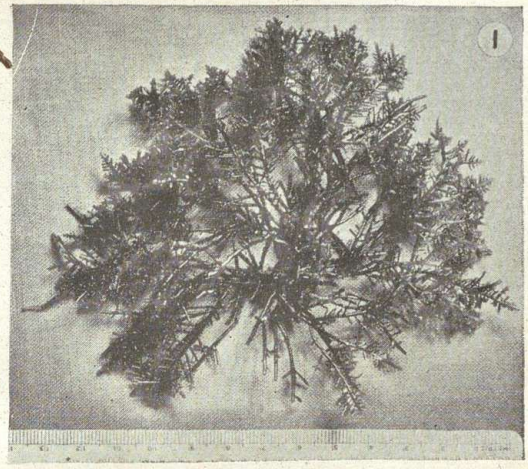
Map showing the distribution of the Economic Seaweeds of India.

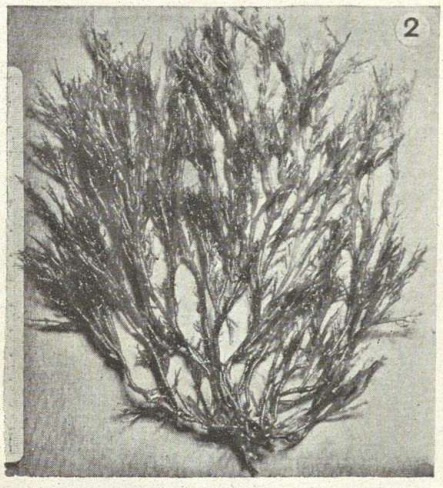
net (Fig. 6). The resulting agar as analysed compares favourably with any imported product, and 45% to 50% of the clean, dry seaweed is the yield. The residue (which is high in mineral and trace element content) obtained after the removal of agar, when dried and pulverized, is a useful supplementary stockfood. The water used in leaching the seaweed pulp is a rich source of trace elements, potassium, calcium, magnesium, sulphur, etc. and organic compounds, and could be used in fish ponds, gardens and orchards, or for yeast culture.

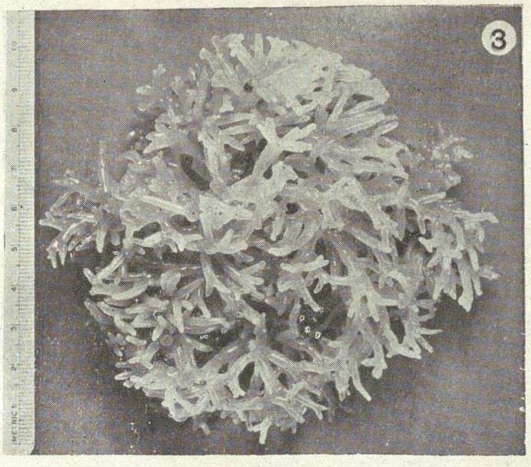
Agar is manufactured from *Gelidium micropterum* in the following way, adapted from the Japanese method. It is cleansed in small batches by abrasion by gently grinding in a stone mortor, using soft water, preferably rain water, then soaked in soft, acidulated water for 24 hours, and then introduced into soft water at 100° C. the proportion being one part by weight of dry weed to forty of water, preferably rain water or distilled water. The pH at the beginning of the extraction is adjusted at 6·0 after introducing the seaweed. Extraction is carried out for one hour at this temperature, then the liquid is allowed to simmer for another hour. Finally the enamel vessel in which the extraction is carried out is left in a warm chamber to cool gradually, permitting sedimentation of the suspended particles. When cold, the gel is removed, melted in a water-bath, and poured into enamel trays to gel again. After three hours the gel is cut into strips and these are placed in wooden trays and frozen at temperatures between 0° and −5° C. They are kept in the frozen condition for 24 hours and then allowed to thaw at room temperature. As soon as the thaw water has drained off, the strips of gel are placed on plastic screen placed on galvanised wire netting and dehydration is completed either in the sun or in hot air at 65° C. This agar is of superior quality and the yield is 40% of dry seaweed. *Gracilaria lichenoides*, *Gelidium micropterum* and other agarophytes are easy to collect in the vicinity of Mandapam at Manakad, Pamban, Akkamadam, Thangachimadam, Aryankundu, Narikuzhi, Olakoda, Sangumall and Rameswaram besides the numerous coral islands in the Gulf of Mannar.

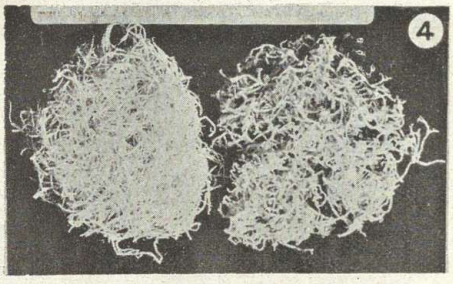
Algin.—The seaweed colloid, algin, second in importance only to that of agar, was discovered by Stanford in 1884 when he was studying new methods of extracting iodine and salts from brown seaweeds. Manufacture of algin and iodine from Indian Sargassums and other seaweeds may be expected in due course.

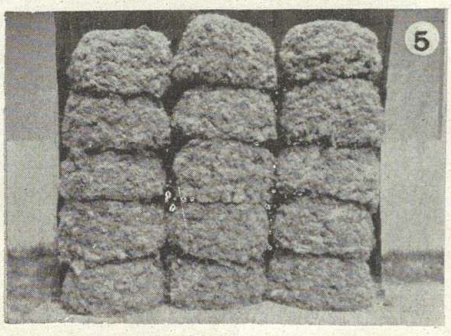
Uses of agar and algin.—Agar is a gelling substance which dissolves when cooked for some time in water; the solution sets to a jelly without

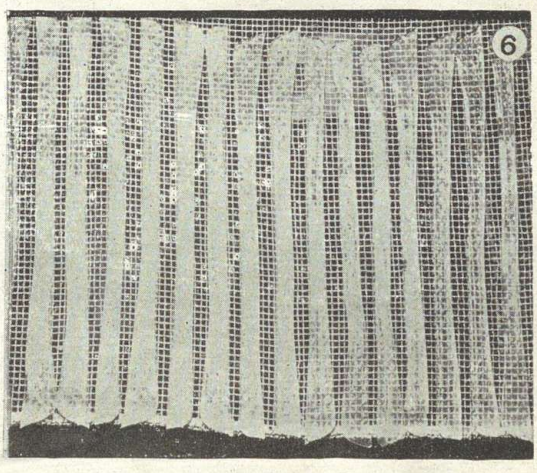


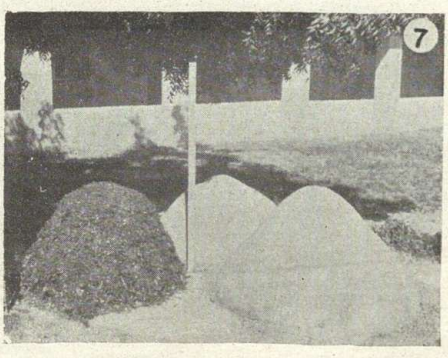












1. *Gelidium micropterum*—living plant. 2. *Gracilaria lichenoides*—living plant. 3. *Gracilaria crassa*—Portion of living plant. 4. *G. lichenoides and G. crassa*—dried and bleached. 5. *Gelidium*—stored in bundles of 10 lb. 6. *Gracilaria* gel strips on plastic netting. 7. Seaweed compost mounds.

the aid of ice when it becomes somewhat cooler than the atmosphere in the tropics. Agar gel remains firm for a considerable range of temperature above that at which agar solution sets; hence even if the warmth of the air increases it does not melt, and it is necessary to heat it to rather near the boiling point of water to make it melt. The lag in temperature between melting of agar gel and setting of agar solution is a very useful property. Thus, agar gel serves as the ideal " soil " on which bacteria, moulds and other minute organisms may be conveniently grown in rooms maintained at the required warmth. More recently, seaweed meals have been experimentally tried as culture media for micro-organisms, but they do not have all the advantages of agar for bacteriological work. Some idea of the range in the uses of agar may be gathered when we mention leather, paper, photographic films, tungsten wire, dental impression material, prosthetic appliances, laxatives, surgical dressings, confection sweets, jams and vegetable pastes, canned fish, bread and cakes, ice-cream, vinegar, cosmetics, toothpastes, hectograph duplicator rolls and marine storage batteries.

Alginic acid is a gelatinous substance which practically does not dissolve in water, either cold or boiling, and goes into solution only when treated with alkali. The water-soluble alginates can be made into insoluble salts by treatment with alkali earth or heavy metals. The common industrial alginates are those of Sodium, Ammonium, Calcium, Aluminium and Copper. Sodium alginate, to which the name algin is usually applied, is used in the manufacture of cheese, milk-powder, custard-powders, cakes, jam, jelly-sweets, aerated waters and in fruit-drinks. In stabilizing ice-cream it is employed more commonly than agar. It is used in milk puddings where the calcium of milk forms gelatinous calcium alginate. Sodium alginate is soluble in water, but can be made into creamy or jelly consistency by controlled addition of calcium citrate. The use of sodium alginate is common in pharmaceutical and cosmetic preparations. At the Central Marine Fisheries Research Station, Mandapam, copper alginate is being developed as preservative and waterproof coating for fishing tackle.

Unlike agar, agaroids are rather soluble in cold water and their solutions set into gels at lower temperatures than do the solutions of agar. Thus agaroids are chiefly useful as stabilizing media in suspensions and emulsions. Indian red algæ such as *Hypnea* and *Spyridia* yield agaroids which could be used for sizing textiles and paper; other uses will no doubt be developed when chemical and nutritional researches on them are carried out. By chemical treatment agar could be produced from agaroids. Cementing material for card-board manufacture is prepared from the mucilages of the

red seaweeds *Grateloupia*, *Halymenia* and *Calliblepharis*. At Tellicherry (Kerala) fishermen use the mucilage of *Grateloupia* for protecting their nets, the latter being dipped in the mucilage and dried.

Seaweeds as food.—The seaweeds of our coasts include not a few edible algæ of which the green algæ *Enteromorpha*, *Ulva*, *Codium* and *Caulerpa*, the brown algæ *Hydroclathrus*, *Padina*, *Turbinaria* and *Sargassum* and the red algæ *Porphyra*, *Grateloupia*, *Gracilaria*, *Rhodymenia*, *Acanthophora* and *Laurencia* may be cited.* Gelatinizing substances are found in *Enteromorpha*, *Ulva* and *Chætomorpha*; hence these are useful in making jams and candies which derive nutritive value from them. In Indonesia, Australia, and elsewhere, dry, sunbleached seaweeds are utilized directly in domestic cookery for dessert jellies. The Gracilarias are plentiful on the coasts of Kerala, Ramnad, Tinnevelly, Cape Comorin, etc. and the preparation of the bleached, dry seaweeds as well as the production of household agar could be organised on cottage industry lines. These would be handy for making not only jellies (*vide* Table I) but also Indian desserts such as *halva* and *payasam*. In the district of Ramnad the use of a number of Gracilarias as food is known and they are called ' kanji pasigal,' *i.e.*, porridge seaweeds. Porridge meal is prepared from sun-bleached, dry *Gracilaria lichenoides* which is thoroughly washed in a grinding stone, soaked, then ground fine and dried on organdy cloth in the sun. Two teaspoonful of this meal cooked in a cup of water makes a porridge that has most of the minerals and trace elements we need, but is low in calories. Seaweeds have been used medicinally in the East since ancient times and to a less extent in the West. Outstanding examples are the use of seaweeds to combat goitre, and the *Digenea* seaweed-vermifuge used in China.

Seaweeds as food for farm animals.—The emphasis on seaweed as food for farm animals is on the minerals, trace elements and vitamins; hence seaweeds serve to supplement the usual rations. Seaweed meals are a new feature in stock raising in many countries. It is estimated that the annual demand in the United Kingdom for blended seaweeds is five thousand tons. Spectacular improvement in the health of flocks and herds has been observed, and pigs and poultry have responded well to a seaweed supplement to the daily rations.

Seaweed compost.—Seaweed compost could be prepared in mounds as follows. Partially dried seaweeds are sprinkled with freshwater, drained

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* *Chlorella*, a unicellular freshwater alga, has been shown to have a high protein content and to be suitable for use as food by human beings.

TABLE I

Food Stuff	Quantity of agar used	Method of addition
Ice-cream ..	$\frac{1}{8}$ teaspoonful ($\frac{1}{4}$ g.) per cup of ice-cream mix	Dissolved in boiling water and added to warm ice-cream mix. (Prevents it from melting soon)
Tomato sauce ..	$\frac{1}{2}$ teaspoonful (1 g.) per lb. of tomato sauce	Dissolved in boiling water and added to the sauce towards the end. Boiling after adding agar should be avoided.
Jams, Jelly, Marmalade	One level teaspoonful (2 g. per lb. of these)	Dissolved in boiling water and added to the sauce towards the end. Boiling after adding agar should be avoided.
Blancmange (without corn flour)	$1\frac{1}{2}$ level teaspoonful (3 g.) per cup of milk with sugar	Dissolve agar in a small amount of water in a double boiler and pour into warm milk not *vice versa.*
Lime jelly ..	$1\frac{1}{2}$ level teaspoonful (3 g.) per cup of water with sugar and lime-juice	Dissolve agar in the water in a double boiler, add sugar and and strain; keep aside and then when somewhat cool add lime-juice and pour into mould.

and if need be chopped up. They are piled up on the compost floor (Fig. 7) in layers 6″ thick, interlaid with dry, powdered cow-dung, 1·5″ thick. The diameter of the mound could be 6′ and the height 4′. The cow-dung supplies additional bacteria and fungi (micro-organisms) that break down the organic matter into simpler compounds valuable as plant nutrients. It also prevents escape of ammonia which is then fixed by bacteria into nitrites and nitrates. A thick layer of moist clay is spread over the mound and it is smeared with cow-dung, so as to seal the mound completely to provide increase in temperature required for the growth of micro-organisms and also to prevent volatile compounds escaping. The mounds are watered lightly once a day in order to maintain sufficient moisture within. The temperature rises gradually, indicating microbial activity, to about 43° C. during

the period of about 2 weeks. It then drops slowly to 34° C. about 1° C. above than of the air outside, by the end of two months, and the compost is then stable and ready for use. Composting may also be done in pits lined with brick and mortar and sealed with a layer of clay on top. A roof is essential to keep out rain as otherwise the compost will rot.

In a field trial with *bhendi* the plants that received *Hypnea* seaweed-compost showed on the average 73% increase in yield over those that received cow-dung and wood-ash; and the fruits were first collected in the former two weeks earlier, fruiting reaching its peak a month earlier than in the other set of plants. Large yields were got from sweet potato, tapioca, various beans and gourds, greens, lime, papaya, and drum-stick, and remarkable results were got with crotons and zinnias.

In the districts of Ramnad, Tinnevelly and Cape Comorin, it is estimated that about 5,000 tons of fresh seaweeds and sea-grasses are cast up on the shores annually, yet, unaccountably they are not conventionally used as manure. At the rate of 10 tons per acre, the above amount would be sufficient to enrich 500 acres. The seaweeds available on the shores and backwaters of Kerala are also of great significance as manure. Seaweeds enrich the soil by forming humus which is able to absorb and firmly hold large quantities of water, and thus seaweed manure conserves water for crops.

Potash is present in large amounts in seaweeds, but there are only moderate amounts of nitrogen and phosphorus. They are best used as supplement to farm-yard manure or other fertilizers which are rich in nitrogen and phosphorus. Seaweeds as a whole are especially good sources of the trace elements copper, magnesium, zinc, boron, molybdenum, iodine, manganese and iron. To mention particular seaweeds: *Hypnea* is rich in manganese, *Padina* in iron and manganese, Enteromorpha in magnesium.

MARINE FISH FARMING

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The growing need in recent years to augment our supply of fish protein has been largely responsible for focussing our attention towards means of utilizing every possible ecological niche for fish culture as part of a programme on greater exploitation of our natural resources. Rearing fish in confined areas has certain definite advantages over fishing in open waters of the sea because of the control that can be exercised on a restricted body of water and the relative ease with which fish can be obtained more or less throughout the year irrespective of natural interferences by the weather. Marine fish farming may be considered as an extension of the principles of freshwater fish culture which has been practiced in India and elsewhere over centuries. Much of our knowledge in saltwater fish farming is still in an empirical state and more scientific techniques will have to be adopted in order to put the industry on a sound basis.

A brief mention about the different systems of saltwater fish culture as practiced elsewhere will be helpful before discussing the status of the industry in our own country. In Europe, since the Romans started culturing fish in freshwater as early as in the 1st century B.C., the principles were successfully adapted for saltwater fish culture and soon the practice spread along the coast of Italy and France. Renowned at present as the 'Valli culture' of the Adriatic lagoons along the north-east coast of Italy or the marine fish farms of Arcachon in France, these bring valuable crop of fish, particularly eels and mullets, which are highly esteemed in those regions.

Among the Eastern countries, saltwater fish culture is being widely carried out in Indonesia and the Philippines and to some extent in Japan and Formosa. One can appreciate the importance of this industry in the economy of these countries when it is understood that an annual yield of about 33 million pounds of fish (16·5 million kg.) are obtained from an area of nearly 200,000 acres (80,000 hectares) of ponds providing means of livelihood for the 250,000 people of the Islands of Java and Madura in Indonesia alone while in the Philippines about 173,000 acres (70,000 ha.) of fish ponds

are reported to produce approximately 89 million pounds (24·5 million kg.) of fish per year valued at nearly 40 million pesos or about 33 million rupees. From the extent of development of these ponds, it would appear that fish farming is part of the traditional culture of the people of these countries. The saltwater ponds of Indonesia known as 'Tambaks' are famous throughout the East and one of the popular beliefs that the Tambak industry came to be established under the influence of the Hindu rule of the Islands might be of incidental interest to us in India. The sizes of the present-day Tambaks vary widely up to many hectares, the water-supply is mainly brackish, tide controlled and regulated by means of sluice gates. The principal crop of fish in these ponds is the milkfish (*Chanos chanos*) but other species of salt-tolerant fish and prawns are also cultured.

Compared to the developments made in these regions mentioned above, it may be admitted that even the idea of marine fish farming in our country is of relatively recent origin. The immense scope for an organised system of marine fish farming in our country was originally conceived by James Hornell who, in 1911, suggested the development of coastal saline swamps, backwaters, estuaries, deltaic marshes and even salt-pan channels for purposes of cultivating saltwater fish. Since then the Madras Government started a marine fish farm near Tuticorin by converting some of the lagoons in that area and stocking it with mullets (*Mugil* spp.) and whiting (*Sillago* sp.). But after a brief trial period the venture was discontinued owing to certain unforeseen circumstances. Again, several years hence, the Madras Fisheries Department revived the idea by starting an experimental marine fish farm in Krusadai Island in 1944 by transforming a marshy swamp in the island into suitable ponds. The results of milkfish culture as conducted in these farms compared favourably well with those obtained in other countries and the experiment in general was encouraging.

The farms in Narakkal (Cochin, Kerala State) mark a definite achievement in saltwater fish culture on a large-scale. Originally about 13 acres of swampy area adjacent to the beach were converted into fish farms during 1940–42. Brackishwater supply was effected by means of canals and the farms were stocked with mullets and milkfish. The success in this experiment led to the further development of marshy area around this original site and at present the State-owned farms at Narakkal and vicinity cover an area of nearly 125 acres fetching a substantial revenue to the Fisheries Department. There is also an equally productive farm at Ayiramthengu adjoining the backwaters of the Kayamkulam Lake in Kerala and the ponds extending over 20 acres are utilized for culturing the pearl-spot (*Etroplus suratensis*), mullets and the milkfish.

The flourishing prawn industry of the Malabar coast deserves special mention in this connection as the backwaters in these regions constitute one of the most highly productive types of saline waters. At the close of the rice harvest by about October, almost every rice field is utilized for prawns and miscellaneous fish culture. Brackishwater let into these fields carries with it millions of prawn fry which are allowed to grow there for a period of about six months before they are caught. Experiments conducted by the Prawn Research Section of the Central Marine Fisheries Research Station have revealed that these fields, under proper management, can give a much higher annual yield (ranging from 900 to 1,300 kg. per hectare) of fish and prawns.

Besides the Government sponsored experimental ponds reference may be made to the saltwater 'Bheris' of Bengal and several tidal inlets, saltwater lakes and saline lagoons spread along the coast of Orissa, Andhra and Madras States. Some of the saline lagoons on the south-east coast of India, get periodically inundated during the monsoons and establish temporary connections with the sea allowing large numbers of fish fry to enter these areas. As such, an unorganised fishing of some magnitude exists which is of importance in the economy of the people of the neighbouring villages. These lagoons, which constitute a distinct type of ecological environment not wholly comparable to the other types of culturable waters and consequently presenting certain special problems, still seem to show scope for development into more productive areas. Recently, the Central Marine Fisheries Research Station has undertaken the construction of an experimental marine fish farm in the low-lying areas near Mandapam as a beginning towards the development of these regions and also to gather more scientific data relating to the various aspects of saltwater fish culture.

While several swampy or marshy areas exist along the coastal tracts, it may be pointed out that all of them need not necessarily be ideal for marine fish farming on commercial lines, as natural waters are known to vary widely in their productivity. Depending on the source of water and the physiography of such areas they may be classified variously. In the construction of fish farms an important consideration lies in the choice of the site which has to be determined in conjunction with factors such as the type of soil, availability of good water-supply, proximity to fry sources, facilities for transport and many more similar considerations. Both the physical and chemical characteristics of the soil are significant and as a general rule the farm must be underlain with clayey type of soil which is almost impervious to water.

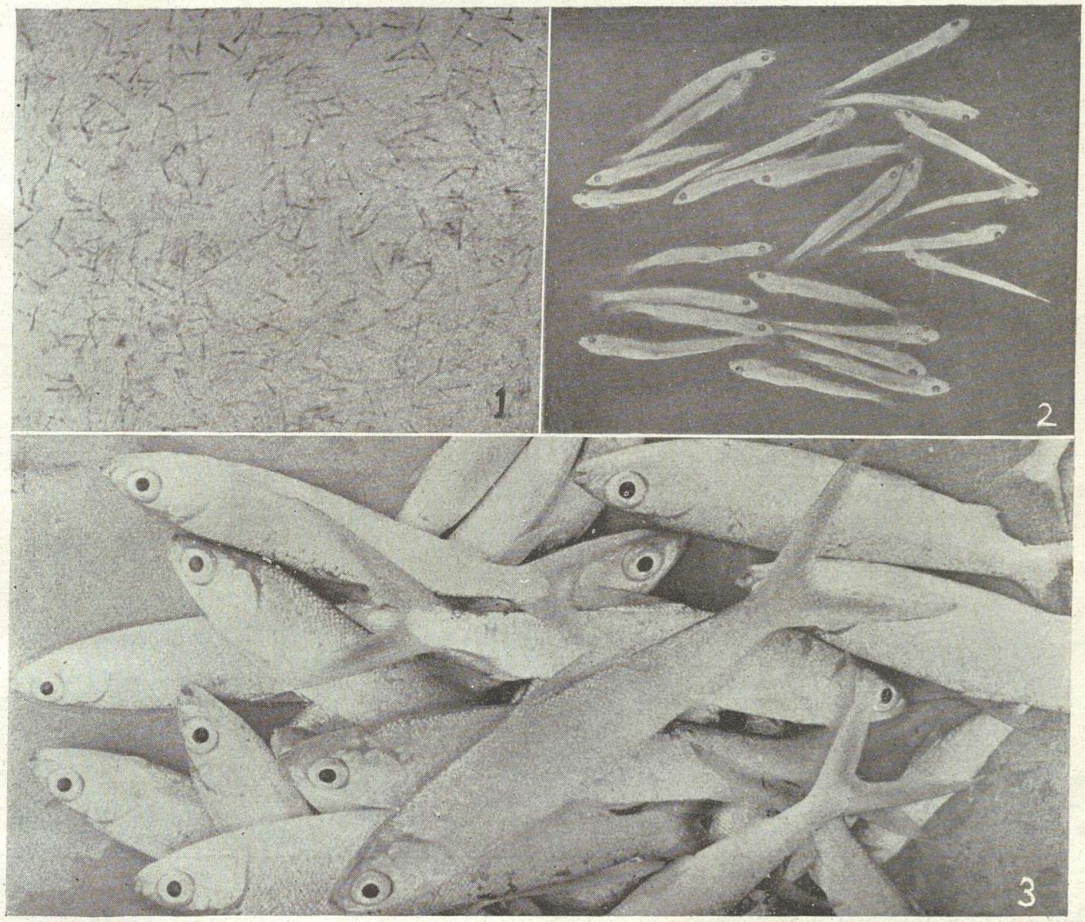
Actual construction of the ponds to adjust to the tidal factor usually involves excavation of earth and this earth can be utilized for the construction

of bunds and embankments. A good binding clay is essential for the stability of these embankments; additional protection by turfing or growing of suitable plants is very necessary. This can substantially reduce the cost of maintenance of farms. In many of the Eastern countries the farmers make use of the embankments for growing cash crops as an additional source of income. In an ideally planned farm two or three separate types of ponds should be set apart for fish of different stages, as for example, small shallow-water compartments or nurseries for the care of the fry and progressively larger tanks for rearing the fingerlings and the growing fish. Intercommunications with sluices will in such cases be helpful in transfering the fish from pond to pond with least injury to them and this can be achieved by manipulation of the sluices during water flow and based on the habits of the fish.

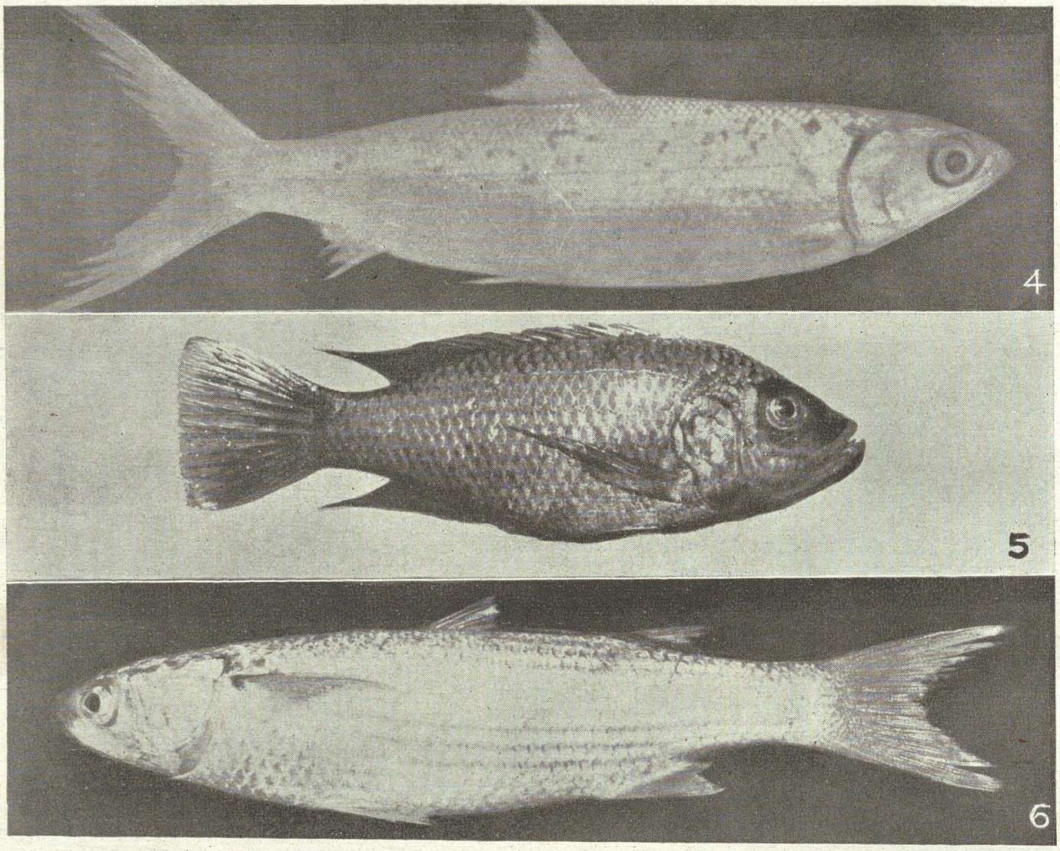
In marine fish culture it is more or less implied that the major source of water-supply is from the sea. Although properly designed marine fish farms can be wholly dependent upon seawater for their supply, this factor itself might sometimes lead to limitations on effective operation and satisfactory management. Proximity to freshwater streams or canals is desirable as providing an additional source of water especially in regions where the tidal amplitude is insufficient during part of the year and in summer months when the salinity in ponds shows a tendency to go up. Some of the well-known characteristics of the pond water such as temperature, pH, dissolved oxygen and availability of nutrients are important here as they are for freshwater fish culture for the proper growth of fish food organisms. The farmer may be cautioned of the possibility of some of these factors, especially the salinity and temperature, attaining lethal levels for certain species of fish during particular periods of the year and a periodic check becomes essential. This will also help to make up certain vital deficiencies that might occur due to natural causes.

In respect of fish stocks an essential consideration lies in the choice of suitable species that are able to adapt themselves to a fairly wide range in salinity and temperature because of the possible fluctuations in these factors in the tropics. Species which attain marketable size during the course of one season usually satisfy the primary objectives of the average fish farmer as he can get his ponds ready for restocking during the subsequent fry season after the harvest. But in commercial practice with species that are able to grow to an economic size by rearing them beyond one year, larger ponds become necessary and the farmer is faced with additional problems in their management. Judicious combinations of more than one species of fish often give better yield than monoculture. The principle involved here

SOME FISHES FOR OUR SALTWATER PONDS



1. A swarm of the fry of the Milkfish (*Chanos*) 15–20 mm. long at the time of their appearance along the coast. 2. A few from the above enlarged. 3. The Milkfish, at the end of one growing season in the marine fish pond at Mandapam Camp.



4. An adult Milkfish. 5. *Tilapia*, an exotic species. 6. A Mullet (*Mugil*). Several species are useful for saltwater fish culture.

is the fuller utilization of available food. But the farmer has to bear in mind that production cannot be increased by mere overstocking. The addition of too large a number results in small stunted individuals while a very low level of stocking is uneconomical as all the food in the pond may not be properly utilized. The question of maintaining a proper condition of the fish and obtaining a sustained yield is, perhaps, the most difficult in many cases. Even in ponds with fairly stable physico-chemical conditions many fish farmers experience a gradual fall in yield year after year unless other measures are employed to provide a steady supply of food for the growing fish. Proper encouragement for the growth of aquatic microflora which play an important part in the food chain in the pond becomes essential and for this chemical fertilizers such as superphosphates and nitrates have been found helpful. The growing fish can well be maintained on supplemental feeds such as oil-cakes, cotton-seed meal, rice bran and similar material which will also serve to increase the fertility of the water. Indescriminate use of fertilizers may sometimes result in the overgrowth of undesirable algæ and weeds which can be a menace in fish ponds. Timely control and eradication of these by physical means seems more desirable than use of chemicals. Considerable practical experience rests behind all these methods in successful fish culture.

One great handicap to our fish farmer is his dependence upon natural sources for the collection of fry for stocking purposes as many of our cultivable fish do not breed in confined waters. The difficulties involved in their collection and transport are great. However, in recent years a very useful line of research has met with success in hastening the spawning or inducing spawning in fish in captivity by the administration of hormones. Very significant results have been achieved in our country too, of late, in making carps breed in ponds by this technique and this would indicate possibilities for its application to other freshwater fish and, perhaps, marine species as well.

We have in our country several useful varieties of fish which are admirably suited for culture in different types of saline waters. The milkfish (*Chanos chanos*) and the mullets (*Mugil* spp.) rank foremost among these as they satisfy most of the requirements for saltwater fish culture. Both these are widely distributed in the Indo-Pacific region. The fry and fingerlings of *Chanos* show some preference for certain types of ecological environments characteristic of shallow sheltered tidal creeks and mud flats, and large numbers of them are usually collected from April to July in several centres in peninsular India. Mullet fingerlings can also be obtained from similar

surroundings and although available more or less throughout the year, they are particularly abundant during the post-monsoon seasons. Both are non-carnivorous marine species while the pearl-spot (*Etroplus suratensis*) is more an estuarine form and is also largely used for culture in brackish-waters. Similarly, the prawns of the *Penæus* and *Metapenæus* groups are invaluable for culture in saltwater ponds either by themselves or in combination with fishes when these can fetch a proportionately significant yield as compared to the main species under cultivation. In contrast to these non-carnivores mention must be made of the many less important fishes, particularly the Bhekti (*Lates calcarifer*) which thrive well in saline environments where there is a natural abundance of forage fishes. The mouthbreeding fish *Tilapia mossambica*, originally a native of the freshwaters of Africa and recently introduced into our country from the East, has shown some promise for culture in a variety of environments including saline waters some of which are not quite conducive for the growth of better indigenous species. Special methods for the management of the different species will have to be adopted as their feeding habits and adaptability to environmental conditions vary considerably.

A brief reference to the future scope for marine fish farming in India seems appropriate in this context. Our cultivable saline waters including the tidal estuaries, backwaters and swamps scattered along the coast cover nearly 1·3 million acres (about 0·5 million hectares) and a theoretical estimate of annual yield from these waters amounts to 640 million pounds (approximately 30,000 metric tons) of fish. As pointed out earlier, all these places may not be ideally suited for conversion into productive areas. However, a satisfactory yield seems possible in our country too with increased knowledge and adoption of better techniques. Small farms can hardly serve as the whole source of income for the individual farmer or be self-sufficient, but they are invaluable as an auxiliary source of profits. On the other hand, farms on commercial lines, extending for about 20 hectares or more, have greater significance to the community and the local population, whose economy will be served by providing work for the people, by meeting the local fish requirements and by yielding a relatively easy income from the immediate neighbourhood almost throughout the year. The cost of such a project need not be very high. Placing some of the unused saline coastal swamps at the disposal of interested public and, possibly, some kind of initial financial assistance from the respective State Governments might however serve as an impetus and encouragement for establishment of commercial fish farms and promotion of this useful industry.

FISH PRESERVATION

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Compared with other food materials fish is highly perishable. At the temperatures prevailing in India fish can remain in fresh condition up to eight hours at the most after being taken out of the water. Most fishing in India is carried out within a distance of about seven miles from land; the boats remain at sea for a few hours and return to port on the same day. No preservation methods are employed on board the boats to ensure that the catch remains in good condition when brought ashore. Fishing is carried out in mid-waters further away from land by mechanised craft at Bombay and a few other centers. These vessels remain at sea for some days and the catch is iced on board for preservation. The proportion of iced fish thus landed, to the total sea fish landings is however small at present. In view of the increasing emphasis on the exploitation of both the inland and marine fisheries of our country, and the gradual increase in the purchasing power of the common man resulting from progress in industrialisation, the use of modern methods of fish preservation and processing as well as improvement in the quality of the product obtained by indigenous methods of preservation are necessary. Progress in fish preservation is essential for the proper utilisation of the fish landings and raising the nutritional status of the dietary of our people by increasing the consumption of fish.

Before discussing the problems of fish preservation with special reference to Indian conditions it is necessary to explain briefly the biochemical and other changes which constitute fish spoilage, and the principles underlying the various methods of preservation. The external surfaces of the freshly caught fish and the gut, if full of food, carry large numbers of bacteria which attack the flesh after the death of the fish. The various enzymes produced by the rapidly multiplying bacteria convert the flesh-proteins into simple components, the amino acids, and finally into ammonia and carbon dioxide. The sea fish also contain trimethylamineoxide which is reduced through bacterial action to *trimethylamine*, a basic compound having the sharp, characteristic odour of spoiled sea fish. This reduction occurs

during the early stages of the spoilage and the estimation of the trimethylamine provides a very useful test for assessing the freshness of fish. Hydrogen sulphide, indole, etc., are produced in the later stages of fish spoilage; these substances produce the odour characteristic of putrefaction. Other changes which are not due to bacterial action also occur during spoilage. The enzymes of the tissues and viscera of fish continue to function after the death of the fish. This process, termed autolysis, results in the flesh becoming soft and more susceptible to bacterial invasion. The fat of the fish undergoes oxidation causing rancidity. A third type of spoilage occurs when fish are frozen and kept in storage. The proteins of the fish muscle undergo changes in their physical structure; these changes called 'denaturation' cause the flesh to become tough and fibrous, reducing its flavour.

The autolytic and oxidative changes proceed very slowly compared with the changes brought about through bacterial activity. Lowering the temperature reduces the rate of reproduction of the bacteria. Initially the bacteria multiply very slowly; this period is called the 'lag phase'. At ordinary air temperature, *i.e.*, 27° to 31° C., the lag phase lasts for a few hours only; at the temperature of melting ice, 0° C., the lag lasts for a few days. When the temperature is lowered still further below 0° C. some bacteria are slowly destroyed but many remain alive in a dormant condition. This phase lasts for several months.

Autolytic changes are reduced to the minimum at low temperatures; oxidative changes continue to take place. Denaturation of the proteins is maximum when the rate of freezing is slow as might happen if the freezing temperature is not sufficiently lowered; hence quick-freezing or 'deep-freezing' in which the fish are frozen within about six hours by employing temperatures as low as — 40° C., is carried out.

As seen from the above discussion the period of storage of fish in ice can extend only over a few days. The incorporation of chemical preservatives such as sodium nitrite, or antibiotic such as chlorotetracycline (popularly known as aureomycin) in small concentrations extends the preservation period by about one week.

Frozen storage at about — 20° C. can preserve the fish in excellent condition for several months. During the long period of storage dessication, *i.e.*, loss of moisture, is minimised by glazing the frozen fish with a film of water at intervals during the storage. Modern methods of wrapping the fish in moisture-proof material have yielded good results. A recent development in this line is the freezing of fish in alginate jelly; this is particularly

useful in the case of fatty fishes. This prevents the contact with oxygen thus minimising rancidity development, besides retaining moisture. Denaturation of the protein is also minimised under these conditions. Alginic acid is a carbohydrate substance extracted from certain seaweeds and is commonly used in food preparations, *e.g.*, as stabiliser for ice-cream.

Bacteria are susceptible to increases in temperatures. Moist heat is particularly lethal to bacteria and the application of temperatures of about 121° C. and a steam pressure of about 15 lb. per square inch for short durations suffices to destroy all forms of bacterial life. Even the resistant forms, spores, produced by certain types of bacteria, are destroyed under these conditions. The canned product obtained by the application of these methods is essentially sterile. Thermophilic sporeforming types might occasionally survive the canning process.

Common salt (sodium chloride) acts as a preservative in two ways: it helps to draw the water away from the flesh by osmosis and it also directly kills many of the bacteria. Loss of moisture is detrimental to bacterial life. There are however a special group of bacteria which not only can tolerate high concentrations of salt but depend on high salt concentrations for optimum growth. These bacteria produce a red pigment which causes the discolouration often present on the surface of dried salt fish. The elimination of these bacteria presents a problem in the fish curing industry. These bacteria have their origin in the curing salt.

In smoking fish the preservative action is due to two factors: the preliminary brining which is always done removes large numbers of bacteria and subsequently the phenolic constituents of the smoke kill most of the remaining bacteria. Some dehydration also occurs during the smoking process. Dehydration of fish by mechanical means is also carried out as a method of preservation. The dehydrated fish flesh is reconstituted by soaking in water before cooking.

Present Status of Fish Preservation in India.—Nearly one-half of the total marine fish landed in India is marketed after curing by one or other of the several indigenous methods. Sea fishing is mostly in the inshore waters and the small size of the boats and the inshore fishing conditions do not lend themselves to easy adaptation of preservative methods on board. The supply of really fresh marine fish is therefore limited in proportion to the total sea fish landings. Preservation methods which yield a fermented or semi-fermented product such as the *nam-pla*, or *patis* popular in the south-east Asian countries are not used in India. Smoked fish is

not liked by the people and very little smoking is carried out for preserving fish.

In large cities such as Bombay and Calcutta cold storage facilities and ice are available. Fish is often packed in ice and kept overnight in the cold storages for marketing the next day. Ice is becoming available more and more in fishing centres and considerable quantities of fish are transported in ice by rail and by motor trucks into the interior. Fish are thus sent inland up to distances of three hundred miles. Insulated vans are not usually available at most places, but the fish are packed in ice in baskets or boxes for transportation. Large quantities of fish are transported from the Chilka Lake area to Calcutta as well as from west coast places such as Calicut to Madras City or to Bangalore. Carrier motor launches also transport iced fish from Karwar in the south and from various fishing centres in the north to the City of Bombay where there is a very large demand for fresh fish.

There are a number of fish freezing plants on the west coast at Bombay, Mangalore, Calicut, Cochin, Trivandrum, etc. These plants, with the exception of the plant at Bombay, are engaged exclusively in freezing prawns, lobsters and frog-legs for export. At Bombay choice varieties such as pomfrets, Jew fishes (*Sciaenids*), *Dara* (*Polynemus* spp.) are frozen when the catches are abundant and stored for several months. The frozen fish are taken out, thawed and marketed according to the demand during the rest of the year. The frozen fish is consumed in Bombay city and practically no frozen fish is sent into the interior.

There are a few fish canning factories, but these work for a few months only and often are engaged in canning other products during the rest of the year. Present canned fish production is almost negligible. The demand for canned fish as a variety is mainly met by imported products.

Freshwater fish are mainly consumed in the fresh condition, and are often transported alive. Large quantities of freshwater fish are brought in ice from distant places to consumer centres such as Calcutta. In some areas curing is done to a limited extent.

After this brief review of the existing status of fish preservation it is possible to appraise the present trends and outlook for the future of fish marketing and the role that fish preservation has to play in the developing Indian fishing industry.

While the consumption of fresh fish is bound to increase due to increasing transport facilities, increasing availability of ice, etc., the importance of the fish curing industry is not likely to diminish. Being cheap the cured

product will be necessary for supplying the needs of the poorer classes. The emphasis therefore has to be on an improvement in the quality of the cured fish so that the product is acceptable to a wider sector of the public.

During the years subsequent to World War II the most important development in the marketing of fish has been the production on a large-scale of deep-frozen fish in several countries. The deep-freezing process makes it possible to keep fish in a condition almost the same as absolutely fresh fish over a period of several months, without any change occurring in its flavour or consistency unlike as in other preservation methods. The usefulness of the freezing method in evening out the fluctuations in the supply of fish due to the seasonal abundance in the catch is obvious. This long-term preservation method can be of great use in maintaining an adequate supply throughout the year and thus help in maintaining more balanced prices. However transport and distribution facilities are of prime importance in the development of a frozen fish trade. The frozen product must reach the kitchen in the frozen state. For making this possible the maintenance of a cold chain at all stages from the freezing plant to the retailer's counter is a prerequisite.

The technical maintenance of such a cold chain is difficult in a relatively undeveloped country like ours. It may even appear useless to attempt an expansion until adequate transport and even retail cold storage facilities are developed in the first place. A general application of the freezing method to fish preservation in India will depend on the industrial progress of the country and an increase in the standard of living. The frozen product is essentially suited to the taste of consumers who are anxious to simplify their daily routine and save time as demanded by an industrialised economy.

However, while any large-scale expansion may not be feasible immediately the need for providing for the development of the frozen fish industry is real even now. With the increased exploitation of offshore fisheries and mechanised fishing operations envisaged in the near future resulting in the availability of excellent raw material (fish catches brought in ice storage) in great abundance the freezing of fish is inevitable as a routine method for preservation. It is conceivable that frozen fish fillets and processed products such as ready to eat fish-sticks which are popular in the U.S.A. and other countries would be in demand in our urban areas in particular.

Not only for the production of fish for direct consumption but also for the development of other processing industries such as the fish canning industry, freezing is a very valuable aid.

While the development of an export trade in frozen fish is not conceivable in the near future there are immense possibilities of increasing the export of frozen prawns, lobsters, etc., immediately. The freezing plants now engaged in processing prawns have no adequate supplies of the raw material. The supply of prawns, etc., could be increased through planned exploitation of the fishing grounds. The prawns have to be iced immediately upon being taken and transported to the freezing plants. The quality of the raw material is of the utmost importance in maintaining the high quality of the frozen product and thus stabilise the demand from overseas countries.

The relatively short season when suitable fish is available for canning is one of the difficulties in the development of canning on a large-scale. But with increased exploitation of the fishing grounds in middle and even distant waters and availability of cold storage and freezing facilities this problem could be solved to some extent. There is an immediate need to produce canned fish for meeting the demand from our Defence Services. An industry on a modest scale could be supported at present on the demands from the Services. Fish such as mackerel and sardines which are abundantly available on the west coast have been canned by some local firms and the product is good and wholesome.

While evaluating the possibilities of the development of fish processing industries such as canned fish, fish freezing, frozen fillets, etc., it is pertinent to visualise the other beneficial results of these developments. The fish residues from the processing plants, such as the heads, entrails, fins and scales provide considerable quantities of raw material for the production of fish meal, poultry feeds, fish manure, pearl essence, enzymes for use as leather bates, etc. The existence of processing industries provide centralised supplies of the raw materials.

Researches carried out in recent years have revealed the possibilities of the employment of antibiotics in fish preservation. Chlorotetracycline, a product of the mould *Str. aureofasciens*, was found effective in concentrations as low as one part per million. Trials made in Canada and some other countries showed that when incorporated in ice it enhanced the preservation period by about one week. Other methods of using this antibiotic include dipping the fish in solutions containing fifty parts per million of the antibiotic which reduces the bacterial load on the surfaces of the fish and helps to keep the fish fresh for a few hours longer even at ordinary air temperatures. Tests have shown that the antibiotic is destroyed to the extent of over 50% during normal cooking processes and there is no hazard to health in the concentrations in which it is likely to be injested in food. In Canada and

in the U.S.A. the use of chlorotetracycline in seven parts per million concentration in uncooked poultry and fish has been permitted. Experiments carried out at the Central Marine Fisheries Research Station have shown that several varieties of fish remain fresh for longer periods in ice treated with five parts per million of aureomycin compared with fish kept in ordinary ice. In fact in our tropical conditions the problem of preserving fish is difficult and the aid of chemicals and antibiotics may prove very advantageous. There are certain drawbacks in the use of medicinally important antibiotics in food preservation industries. The development of pathogenic strains resistant to the antibiotic, and sensitisation of persons handling the antibiotic are to be anticipated. This necessitates a search for new antibiotics for use in fish preservation.

Quality control measures are essential in all methods of fish processing, at all the stages of the 'cold chain', and at different stages in the canning and curing procedures. Suitable objective tests chemical, bacteriological or physical are needed for facilitating the establishment of quality standards. So far no test which is satisfactory from all aspects or which can be generally applied has been perfected. Research from the basic as well as technological aspects is necessary before any of the known tests could be put into use particularly from the enforcement standpoint. These and other problems are expected to be dealt with in detail at the Central Fisheries Technological Research Station of the Government of India which is to be established soon to carry out investigations on fish processing as well as on fishing gear and craft.

FISH CURING AND FISHERY BY-PRODUCTS

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As in the case of many of the maritime countries of the world Fish Curing is one of the oldest industries in India. As much as 21% of the total production is marketed in the form of dried fish and 19%, comprising mainly sardine, mackerel, catfish, seer-fish, pomfret, shark, sole, etc., in the form of salted fish.

Fish Curing generally comprises all methods of preservation except refrigeration and canning, and includes (i) drying, smoking, salting and pickling of fish, (ii) various combinations of the above and (iii) methods in which vinegar is used or fermentation is adopted. In India, however, drying and salting are the most common methods used in the curing of fish. The present position of the fish curing and by-product industries in the country could be seen from the export-import figures for 1953–54 furnished in the table. Dried fish is exported to Ceylon, Singapore, Burma and other countries. Wet salted fish is mostly exported to Ceylon. Fish maws and shark fins are mainly exported to Hongkong, Singapore and U.K. Fish manure, mainly 'guano', is being largely exported to West Germany. Fish oils and other marine animal oils are imported from foreign countries for use in the leather industry. The same is the case with canned, fresh-chilled and frozen fish.

The Fish Curing industry has been flourishing through ages and has not been affected to any great extent by modern techniques of fish preservation and processing. The fact that more and more emphasis is laid on the supply of fresh fish to consumers by resorting to freezing and cold storage, however, cannot be overlooked. In spite of this modern trend the Fish Curing industry is not likely to suffer. The reasons for such a conclusion are as follows: Fish Curing does not require much of equipment and capital

Import-export figures of fishery products during 1953–54*

Fishery Product	Exports		Imports	
	Quantity in metric tons	Value in Indian rupees (thousands)	Quantity in Metric tons	Value in Indian rupees (thousands)
Fish: dried, salted and smoked	28,257	43,035	3,237	1,612
Fish, dried (not salted) ..	18,111	28,375	1,991	670
Fish, dry salted	8,801	12,966	498	336
Fish, wet salted	1,036	507	556	339
Beche de mer	3	20	..	..
Fish maws and shark fins ..	309	1,187	32	48
Fish meals—fish manure ..	2,593	998	..	..
Fish oils	..	..	185	325
Canned fish	..	..	179	468
Chilled and frozen fish ..	..	..	13,213	14,098
Miscellaneous—				
Cowries	8	17	327	145
Tortoise shells ..	25	90	2	64
Other shells	112	243	8	13

* *Year Book of Fishery Statistics, F.A.O., Vol.* 6, 1955–56.

unlike in the case of freezing and canning and individuals with minimum capital could undertake drying, salting or smoking of fish using home-made equipments. Areas which are not adaptable to freezing or canning plants could be made use of for curing work. There is no organised by-product industry in India. The main reason for this may be the absence of fish canning factories which usually provide the raw materials for many of the by-products.

The chief methods of curing practised in the country, particularly in the west coast, are (i) drying, (ii) salting, both dry and wet salting, (iii) pit curing and (iv) 'Colombo method' of curing. Smoking is also being adopted in some parts of Orissa and Madras States. But somehow this process has not found favour with the fish-eating population of the country.

All the methods mentioned above are, in principle, intended to keep fish from spoilage caused mainly by bacteria, moulds, yeasts, etc., and that caused by chemical or physical agencies.

Direct Drying.—Natural air-drying or drying by mechanical dryers are the only processes which can strictly be called drying processes in fish curing industry. In India drying processes are mainly restricted to open sun-drying. The usual method is to rinse the fish in seawater soon after landing and spread them on coir or cadjan mattings in the open air. In certain areas no rinsing is done and at times fishes are spread even on the open sandy beach. Fishes like Bombay-duck, marine eels, etc., are dried by hanging them on bamboo or wooden rods or ropes stretched horizontally between vertical poles. This method is found to be very effective since all the sides of the fish get dehydrated uniformly. Further, in this method there is no possibility of extraneous matter like dirt or sand getting into the dry product. The process is similar to the one adopted in Norway for making stockfish.

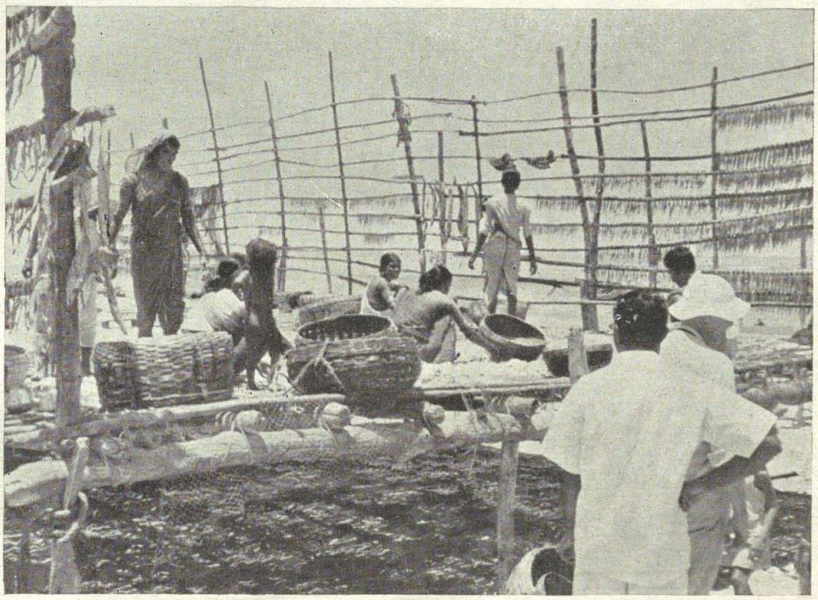
A casual survey of the cured products prepared in the various fish curing centres in the country would show that no strict standards are followed by the curers. The same type of fish, collected from the same place during different periods, vary widely in moisture content and chemical qualities. A good percentage of insolubles, mostly sand, would also be present in the samples. The extent of variation in some of the main chemical characteristics of sun-dried fish is given in the table on a later page.

In many parts of Kerala especially in the southern region and in some places in Bombay State appreciable quantities of shrimps are also sun-dried and used, during certain seasons of the year.

Salting.—Salting is another equally important process by which fish is cured in India. Regular fish salting work is going on in the numerous Government as well as private fish curing yards distributed all along the west coast of the country. The preservative action of salt is due to the restriction of microbiological activity following desiccation of the tissues. Salt enters the body of the fish, removes sufficient liquid to form a brine to cover them, at the same time makes the body fluids saturated with salt. This latter phenomenon helps in coagulating the proteins in the body fluids which in turn get deposited on the skin and cell-walls. Other functions served by salt are, the direct action of NaCl on the putrefactive micro-organisms, the removal of oxygen and the sensitization of micro-organisms to carbon dioxide.

The success of salting process has been found to depend, to a large extent, on the following factors:—

Dry Curing of Ribbon-fish in Malabar



Sun-drying of Bombay-Duck (*Harpodon*) at Versova, Bombay

(i) *Composition of Salt.*—It has been shown by actual trials that fish salted with pure salt are limp, soft and have straw or cream colour, and that the presence of calcium and magnesium causes whitening and stiffening of the flesh and imparts acrid flavour to the product.

(ii) *Temperature.*—It is practical knowledge that temperature influences the penetration of salt during salting processes. The higher the temperature the greater will be the rate of penetration of salt into the body of the fish.

(iii) *Condition of Fish Used for Salting.*—Small fishes like sardines are salted without gutting and removing the entrails. Under such conditions salt penetration will be very slow, and will often be insufficient during the normal period of salting. Big fishes are gutted, washed well in seawater and deep longitudinal scores are made before applying salt. This facilitiates easy penetration of salt uniformly throughout the fish.

(iv) *Method of Salting.*—The technique of salting varies considerably, dry salting, wet salting, brine salting and various combinations of these. The products differ in the texture of their flesh and flavour and also in their chemical quality.

(v) *Fat Content of Fish.*—It is generally accepted that the more the fat content the less will be the rate of penetration of salt. Further, in fatty fishes rancidity soon develops when the salted fish is kept in contact with air.

In India, both dry salting and wet salting are practised. In certain areas in the south and south-east coasts a process called " pit curing " is also carried out. This process is similar in principle to wet curing with the exception that the fish treated with definite proportions of salt are buried in pits lined with cudjan mattings over the sides and top, covered over with sand which is trampled down to give pressure. After two to three days in the pit, the fish are removed and marketed without any further treatment.

In dry salting the proportion of salt to be added to fish has been fixed by the various State Governments. But these standards are not strictly followed by fish curers with the result that salted fish is far from uniform. The range of variation in some of the essential chemical constituents of dry salted fish, given in table below, is sufficient proof of the above statement. The situation thus requires some serious thinking by both Government agencies and fish curers for the improvement of the quality of our salted fish products.

Wet salting process is next in order of importance and is practised in places like Ratnagiri, Malpe, Calicut, etc., in the west coast. In the " Ratnagiri process " of wet curing the fish are stacked on cement floors with half of the calculated quantity of salt applied evenly. The next day fish are restacked with

Method of Curing	Moisture %	T.V.N. mg./100 g.	Salt Content %
Sun-drying	13·8–42·5	48·5–287·0	0·6–15·2
Dry salting ..	20·0–51·0	25·0–467·6	7·1–21·5
Wet salting	33·0–50·9	67·0–313·0	10·0–17·6
Pit curing	35·5–45·5	126·0–666·0	15·8–18·6

the top layer moved to the bottom and half of the remaining salt applied. On the third day it is again restacked and the remaining salt added. The self liquor is allowed to flow off. The product is marketed without drying.

In Alleppey the process is almost similar except that the entire quantity of salt is applied to well cleaned and gutted fish (mostly sardines and mackerels) and then arranged in close-woven bamboo baskets. The fish is marketed without drying.

An ingeneous method of salting called "*mona*" cure is done in the N. Kanara district of Mysore State. The entrails of fishes like mackerel, *Otolithus*, *Lactarius*, etc., are pulled out through the mouth and after thoroughly washing, the abdominal cavity is filled with salt. The rest of the procedure is the same as in dry cure.

As in the case of fish, different processes are adopted in the curing of prawns also in the west coast of India. The method is to sundry the prawns. Smoking is also practised on a cottage industry scale in the Circars.

'Prawn pulp' is prepared on a large scale in the west coast. Prawns are boiled in seawater and sundried on coir mattings or bamboo trays. The hard-dried, product is packed in jute bags and beaten with clubs to separate shells from meat. The product is generally exported to Malaya and Burma.

The method of "semi-drying" prawns, initiated by the Madras Fisheries Department has been adopted now on a commercial scale at Tanur and places nearby. The method consists of "blanching" cleaned prawns in 4 to 6% brine in tinned copper vessels for 2 to 3 minutes, removing the shells by hand, followed by brining at 25° Be and drying. The product has good natural appearance and the meat is soft; and as such it is bound to have consumer appeal.

The only method of pickling practised in India is the 'Colombo method' popular in Malabar and S. Kanara districts. The material produced in these places is intended mainly for export to Ceylon. A substance called *gorukapuli* (the fleshy covering of the seeds of *Garcinia cambogea*) is used as an adjunct to salt in this process. Usually mackerel, rainbow sardine and oil-sardine are used in this type of curing. The gutted fish is salted with the correct ratio of salt and then a small quantity of *gorukapuli* is thrust into the abdominal cavity of the fish. The fishes are arranged in large wooden barrels with intermittent layers of salt and *gorukapuli*. The possibility of using ordinary tamarind in place of *gorukapuli* has been engaging the attention of the Central Marine Fisheries Research Station, and the results achieved so far are encouraging. It is expected that sardines and mackerel pickled with salt and ordinary tamarind would be acceptable to fish-eating people in the country as they are quite familiar with tamarind in other ways.

One of the causes for the diversity in quality of cured fish, as could be seen from the table, might be the uncertainty in the quality of the salt used. A lot of experimental work has to be carried out to determine the optimum level of sodium chloride desirable and the maximum impurities allowable in fish curing salts. Work on these aspects has already been initiated at the Central Marine Fisheries Research Station.

Fish Meal and Oil.—The preparation of fish meal and body-oil from fishes has been in vogue in India from very early times. Certain fishes like the oil-sardine are used for the extraction of body-oil during periods of abundance. The methods are primitive. On the other hand the liver-oil industry, especially the shark-liver oil industry, has shown considerable progress and there are three modern factories, one at Calicut, one at Trivandrum and the third at Bombay.

All oil-bearing species of fish other than those explored for liver-oil can be utilized for the production of body-oil. Usually body-oil extraction and fish meal preparation are undertaken together. The industry is common in the west coast in places like Malabar and S. Kanara where large shoals of oil-sardine appear between August and February. The method adopted in these places is the one developed by the Madras Fisheries Department and consists in cooking the fish in open pans and pressing out the oil from the cooked material. The residue is dried in the sun and forms "guano" which is used as manure. The oil is separated from the water and filtered.

In modern techniques of fish meal manufacture both the dry and wet reduction processes are employed. In the dry reduction process the material

is crushed to small pieces and cooked in a chamber externally heated by steam, while it is kept stirred. The dried residue forms the meal. In the wet process steam is passed directly into the mass at high pressure and cooked fish pulp is passed into a press to remove water and oil. In this process, oil is collected as a by-product. The fish meal plant operating at Calicut employs the dry reduction process and treats lean fish for the production of meal. There is great scope for the introduction of modern techniques in our country for the manufacture of fish meal and fish oil on a cottage industry basis. Both these products find numerous industrial uses and could play an important role in the development of our national economy.

Good fish meal can be utilized as an animal or poultry feed. They contain almost all the essential amino acids in fair proportions as well as most of the vitamins of the B group. Fish meals also supply a liberal quantity of calcium, available phosphorus and trace minerals. Besides, fish meals are known to contain A.P.F. which helps optimum growth in animals fed on it. Efforts are now being made to utilize fish proteins to combat protein malnutrition in human beings. Various methods of preparation of edible fish flour are known in the advanced countries. In India, work is in progress at the Central Marine Fisheries Research Station in developing a fermentation process for the preparation of quality fish flour for edible purposes from elasmobranch fishes. Considering the peculiar position of India as a predominantly rice-eating nation this aspect of the fish meal industry is bound to have increasing importance in the coming years.

Shark fin makes excellent soup and the skin of sharks could be processed into high quality leather.

A variety of useful products could be made out of fish scales, skins and bones. Fish scales when carbonized give animal charcoal which finds use in clarifying, decolourising and otherwise purifying liquids and solutions. The scales of fishes contain an iridescent substance called " guanine " which is used in the manufacture of ' pearl essence ', used in making artificial pearls.

Isinglass prepared from air-bladder of fishes is used in the clarification of wine and also as an adhesive in the preparation of court plaster, special cements, etc. Enzymes extracted from fish-guts are used in leather industry.

In conclusion it has to be mentioned that there is vast scope for the development of fish curing and fishery by-product industries in India. Much of the fish wealth of the country is not fully utilized, as fishermen lack facilities and technical knowledge. It is for the detailed investigation of these and related problems that a Central Fisheries Technological Research Station is being established by the Government of India.

FISH OILS

By U. Sundar Kini, M.A.

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While the medicinally important shark liver oil has received considerable attention very little work has been done in India on the production and utilisation of fish body oils. Therefore in this paper the potentialities for the development of fish body oil, are considered briefly at the outset followed by consideration of the liver oil industry.

Sardines and other clupeids account for about 20% of our marine fish landings which approach 1 million tons per annum. The potential capacity of oil production from these and other fatty fishes, is considerable. The methods currently employed in the manufacture of fish oils are crude and inefficient yielding an oil poor in quality. However, using improved methods of cooking the fish, pressing, filtration to remove the protein debris, and centrifugation for separating the oil it is possible to obtain a product which could be used industrially for various purposes.

Fish oils find application in leather dressing, in the manufacture of insecticidal soap, as quenching medium for tempering steel, for smearing the outer surfaces of boats for preservation, etc. There is a substantial demand from our leather industry for suitable fish oils which is not met by the indigenous supply. The *iodine* and *acid* values as well as the colour of the oil are important in considering the suitability of the oil for this purpose. Ray liver oil which contains very little vitamin A, alone is being used commercially in leather dressing. Recent work carried out abroad has shown however that liver oils have no special advantage over the body oils in treating skins in the tanning process. Improvements in the technique of production of the fish body oils and an evaluation of the chemical and physical constants of body oils of different fishes, in different seasons and from different environs are necessary in order to offer a suitable quality of oil to the leather industry. Analyses of fish oils obtained from different sources and by varying techniques are being carried out at the Central Marine Fisheries Research Station with the view of standardising the quality.

Besides these uses of the fish body oils new fields for their use are worth exploitation. The fish oils have a rather unusual chemical structure in that long chain fatty acids (mainly C_{20} and C_{22}) having a number of double bonds up to 6, are present. Such long chain poly-unsaturated fatty acids are found in other animal and vegetable oils only to very limited extent unlike in the fish oils. The high degree of unsaturation of the fish oils render them less stable than other oils and hence reduce their market value in comparison with the other oils. But due to this unusual property their use in other fields is potentially very important. Some of the fatty acids and their derivatives can be used in various ways as indicated below: Poly-unsaturated fatty alcohols prepared from fish oils are important as starting material for preparation of several derivatives such as Alkyl halides, Silicones, and Quaternary ammonium salts. Considerable research work from the basic aspects is necessary for developing processes for utilisation of the body oils.

Importance of liver oils.—" The average Indian diet is deficient in vegetables and fruits which supply some of the vitamins. Milk and eggs contain relatively large amounts of two other vitamins A and D and the fact that only small section of the population can afford their use in adequate amounts results in deficiency of these Vitamins A and D in the diet of large sections of the people" so reported the Bhore Committee appointed to review the health of the nation in 1946. A recent medical inspection of the students of a premier college in Madras City, the majority of whom came from the well-to-do section of society, showed that nearly 25% showed definite signs of Vitamin A deficiency. Further, there is ample evidence that Vitamins A and D are the two vitamins commonly in short supply in these days of food shortage. Before World War II, we depended for supply of these two vitamins A and D on cod-liver oil imported mainly from Norway and later on from England. During the early stages of vitamin research cod-liver oil was thought to be a very rich source of Vitamins A and D. Cod-liver oil on an average contains about 1000 international units of Vitamin A per gram; never exceeds 3000 generally. Halibut liver oil, on the other hand, contains on an average 50,000 international units per gram and sometimes tops 300,000 units. Indian shark-liver oil averages about 10,000 to 15,000 and at times reaches 200,000. Today, therefore, cod-liver oil is considered, comparatively, a poor source of Vitamins A and D.

Development of the industry.—It was the World War II that promoted the establishment and the quick development of shark-liver oil industry. The dearth of cod-liver oil, consequent on the Nazi conquest of Norway, created a huge demand for alternative sources of Vitamins A and D and

all over the world shark-liver oil was soon produced, first as a substitute for and later to replace cod-liver oil. In India, the Government of Madras was the pioneer in the industry followed by Bombay, Sind, Baroda and Travancore. Bengal and Orissa have since organized production of the oil. The Government of Madras set up the Government Oil Factory at Kozhikode (Calicut) in 1940 for the refining and marketing of shark-liver oil. The factory is now fully equipped with the most modern extraction and testing equipment. On reorganization of States in 1956 the factory has became a Kerala Government concern.

Sharks and shark-fishing.—Vitamins A and D are concentrated in the oil of the liver of sharks. The liver alone, therefore, is separated and treated for oil. There are about 57 species of sharks which frequent our coasts but only livers of 20 of them are of commercial importance. Sharks are of various sizes and some of them grow up to 40 feet. Shark fishing in this country is still primitive and a risky avocation. They are caught by hook and lines and the fishermen sometimes have to brave twenty miles out into the sea to catch them.

Extraction of liver oil.—The livers vary in size also, largely depending on the size of the shark. A single liver may be anywhere from a few pounds to 400 lb. in weight. The oil and vitamin content also vary from shark to shark and season to season. There are various methods of extraction of oil. Vast progress has been made in the extraction methods since early days. The simplest method, of course, is to chop them up and cook them in water. The oil which oozes out may then be collected. In this the maximum yield of oil and vitamins is not obtained. The alkali digestion method is much favoured in commercial establishments where efficiency of extraction is of great importance. In this the livers are pulped in a disintegrator. This mass is then digested in stainless steel vessels under careful temperature and alkaline conditions by open steam. When completely digested the mass is sent through a centrifuge to separate the debris, water and oil. The liver debris can be dried and made into a poultry feed. Oils prepared thus have only a faint fishy odour and taste and can be blended without elaborate refining. Here, however, the protein portion of the liver is completely destroyed and lost. To save this, the livers are sometimes solvent extracted and the liver debris used as animal feed. But this is a costly method. There are other digestion methods also but details of these are closely guarded secrets of individual factories.

Estimation of Vitamin A in shark-liver oil.—There are three methods—biological, colorimetric or chemical and physical—available for the

estimation of Vitamin A potency of fish-liver oils. The last two offer advantages of speed and reproducibility while the biological method is fundamentally more accurate and reliable.

Biological method.—In broad outline, the biological method consists in feeding young albino rats carefully bred for the purpose from the age of five weeks, when they weigh about 60 grams, on an artificial diet balanced in all respects except for the absence of Vitamin A. Fed on such a synthetic diet the rats cease to grow after a month. Known quantities of the substance to be tested are then given and the response in growth is then taken as a rough measure of the amount of Vitamin A contained in the supplement administered. The procedure is repeated with cod-liver oil of known potency or of B carotene and the potency of the unknown ascertained. This is a complicated procedure and involves considerable amount of time and money.

Colorimetric method.—Oils containing Vitamin A when dissolved in chloroform and mixed with a chloroformic solution of antimony trichloride give a blue evanescent colour. The intensity of the colour is a measure of Vitamin A potency. This method was previously used in the Government Oil Factory but now the Vitamin A potency is determined spectrophotometrically according to internationally accepted methods.

Physical or spectrophotometric method.—This physical method is based on the fact that Vitamin A is characterized by selective absorption in the ultra-violet region of the spectrum. When any substance containing vitamin A is dissolved in a suitable solvent and kept in the path of ultra-violet rays, Vitamin A absorbs a portion of the rays in a certain region, depending on the concentration of Vitamin A in that substance. If the intensity of absorption is measured then the Vitamin A potency can be estimated. For this purpose a spectrophotometer is used. Ultra-violet light from a constant source is passed through the solution of the substance or its unsaponifiable portion dissolved in ethyl alcohol or cyclohexane and another beam through the pure solvent used. Photographs are taken of the spectra at various intensities and from these the quantity of light absorbed by, and hence concentration of, Vitamin A contained in the substance calculated. A recent improvement is the photoelectric spectrophotometer which dispenses with the taking of photographs. The beams of light passing through the solvent and solution fall on a photoelectric cell and difference in the electric current generated in the cells can be easily read off on a galvanometer and hence the Vitamin A potency can be calculated. The Government Oil Factory is equipped with the Beckman Photoelectric Spectrophotometer,

Hence the standardization of the products of the factory is comparable with those of the most modern pharmaceutical firms anywhere in the world.

Vitamin D.—The Vitamin D unit adopted by the International Conference is the biological activity of a milligram of the International standard solution of irradiated ergosterol which has been found to be equivalent to that of 0·025 microgram of crystalline Vitamin D. There is unfortunately no sure chemical method of estimation of Vitamin D; it has to be assayed biologically. There are two or three methods of carrying out the biological assay but they need not be detailed here.

Blending of shark-liver oil.—As stated above the Vitamin A potency of shark-liver oil varies vastly and hence the standardization of the oil is absolutely necessary. During early days of the World War II, a substitute having the same specifications as imported cod-liver oil was required. As shark-liver oil generally contained more Vitamin A than cod-liver oil, it was found necessary to blend shark-liver oil with a vegetable oil which did not contain Vitamin A and market the blend having cod-liver oil potency. This is sound in principle and practice too. In addition, pure high potency shark-liver oil is also marketed after refining and standardization.

Clinical data for shark-liver oil.—Although the shark-liver oil marketed by Government Oil Factory and other factories owned by other States Governments was superior to imported cod-liver oil, the early expansion of the market was hampered because of the stigma attached to " shark " and the reputation which cod-liver oil had gathered during the past decades. But the value and efficacy of standardized shark-liver oil like Seagold brand shark-liver oil and Adamin soon became evident to the medical profession. Recently Adamin High Potency Shark-Liver Oil was tried clinically in the important hospitals in the city of Madras with encouraging results. The clinical data convincingly proves that standardized shark-liver oils like Adamin are comparable in quality and in biological potency, to any foreign oil of similar standard.

A vital industry.—The importance of Vitamins A and D in nutrition should need no emphasis. Ample supplies of these are required throughout life. A great deal of sickness and diseased condition is traceable to the deficiency of Vitamin A. In our country Vitamin A deficiency is widespread and hence the importance of the shark-liver oil industry cannot be overestimated. Good nutrition is the key not only to the physical and mental well-being of the individual but also to the progress of the nation. Putting more life into the years and more years into life is nowhere so urgent as in India today.

FISH MARKETING

By P. I. Chacko, M.A., Ph.D., F.Z.S.

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Fish marketing technique includes the practices of actual handling of the fish, preservation and storage, processing, transport, manufacture of by-products and delivery to the consumer. These practices are not so simple especially owing to the highly perishable nature of the commodity and the unfavourable conditions of the environment and climate in our country.

Production and utilisation.—The present annual production of fish in India has exceeded one million tons due to the efforts of the Government of India and the various States' Governments in implementing comprehensive programmes for the development of the fishing industry based on surveys and expansion of fishing areas, initiation and co-ordination of biological and technological researches, conservation and judicious exploitation, introduction of small mechanised boats and larger power vessels, supply of fishery requisites to fishermen, organisation of fish trade and improvement in the socio-economic condition of the fishermen. The present *per capita* consumption of fish in the country is estimated to be about 3·9 lbs.

Present state of marketing.—The fish trade in India is not very well organised. There are a number of limiting factors inherent in the general social and economic environment which are acute owing to the special nature and location of the fishing operations and the highly unstable character of the commodity. The fishing centres are scattered along the coastline or diffused over inland areas, and are therefore not easily accessible. Facilities for handling, storing and processing and means of communication and transport are either very limited or absent. The primary producer continues to be poor, ignorant and indebted. His earnings are low, as immediately on landing he has to sell cheap or lose his catch. He is dependent on the fish merchants for financial assistance to support him during the slack seasons, and also for the disposal of his catches. As the catch is the only security for loans advanced, the merchant is able to determine the fisherman's earnings, irrespective of the volume of his catch. The merchant exercises control over such distribution facilities as exist and extracts the maximum profit

from his limited turnover. There is much wastage of effort in the arrangements for the collection and disposal of supplies. Fishermen are not yet associated together in effective co-operative effort. The public's demand for fish is also restrained by low levels of purchasing power and is based on undue preferences for certain species and varieties which derive from unfamiliarity, ignorance and prejudice. The fish markets are congested and unhygienic and do not attract sufficient customers.

Need for improvements.—There is urgent need for removing the obstacles to expansion and to introduce a competitive element into fish marketing. Co-ordinated measures for improvements in production and distribution from the fisherman to the consumer are necessary. The important among these to be considered on the marketing side are: (*a*) arrangements for assembling catches from all fishing centres; (*b*) provision of facilities for processing (especially salting and drying) and storage of supplies for which there is no adequate local demand; (*c*) provision and better use of communication and transport facilities, especially to bring areas of shortage within reach of existing supplies; (*d*) promotion of domestic and export markets through trade and consumer education; (*e*) improvement of practices in handling, packing and processing; and (*f*) researches on preservation and processing under conditions prevailing in the country; and (*g*) regulation and close supervision of marketing practices. These measures may be implemented by individual enterprises, especially under the stimulus of special incentives such as credit facilities or subsidies. But at the initial stages of development, Government have to help the fishermen. Since recently, the State Governments are assisting the fishermen to play their due share for increasing fish-production and distribution through the co-operative movement which is gaining popularity among them. Through these co-operatives the fishermen are given loans and subsidies towards credit facilities for the elimination of their dependence on money-lenders and middlemen, purchase of domestic as well as production requirements, construction of curing sheds, godowns and markets and for transporting and marketing their produce. There is now particular interest throughout the country in using Government sponsored co-operative schemes to give the fishermen an interest in marketing and an opportunity to bring about improvement as well as to introduce more efficient and competitive methods into the fish trade. But these activities have to be intensified for obtaining quicker results.

Marketing of fish catches of the west coast.—The west coast of India is rich in pelagic and mid-water fisheries, and accounts for seventy per cent.

of the total landings in the country. The marketing problem along this belt is acute, especially for want of roads to landing centres and of adequate storage and transport facilities. The few ice-plants and cold-storages along the coast are wholly inadequate for the proper preservation and storage of the catches. A large portion of the latter is therefore salted and dried, facilities for which also are not sufficient and satisfactory. The most urgent necessity for improving fresh fish trade in this sector is the availability of plenty of cheap ice at all important landing centres, inexpensive insulated transport containers, and insulated road and rail wagons. Early steps have to be taken to provide these immediate requirements. Apart from fishermen co-operatives, fish sales unions have to be organised for attending to the selling of catches and helping to finance the co-operatives.

The fishing industry in India has a good future for expansion provided proper attention is paid not only to increasing production but also to all aspects of marketing.

FISHERMEN CO-OPERATIVES

By V. John, B.A., F.Z.S.

Deputy Director of Fisheries, Kerala

Co-operation is more essential in the fishing industry than in any other, since the people engaged in this industry are largely poor and depend for their finances on middlemen who very often exploit them. As a result of this, the workers actually engaged in the industry do not thrive, as much as might be expected. Further, the profits obtained from fishing are uncertain, since one good season is often followed by one or more bad seasons. The fishing season lasts for only about nine months in the year on the Kerala coast, there being no fishing carried on during the monsoon months. The profits made during the season would certainly be sufficient if prudently utilized to carry the fisherman and his family over the non-fishing months. But through force of habit, the fishermen usually spend away all their earnings during the fishing season itself and borrow money from the middlemen for their expenses of the slack season. Though the middlemen advance money, they appropriate a big proportion of the next seasons catches in realization of the amount advanced. The result is that in the course of a few years many of the working fishermen have to surrender the ownership of their boats and nets to the creditors. Thus, out of about 1,00,000 fishermen in the Kerala State who regularly go out to sea for fishing, only a very small percentage own the boats and nets which they use and enjoy fully the fruits of their labours. This is a very sad state of affairs.

From what has been stated above, it will be seen that the prime needs of the fishermen are, firstly, the elimination of middlemen by the creation of an agency catering to their credit needs and marketing their produce to good advantage, and secondly, the encouragement of the habit of saving.

With these main objects in view, Sir Frederick Nicholson, the founder of the earliest Fishery Department in India, namely the Madras Fisheries Department, strove for the starting of Fishermen Co-operative Societies. The earliest Societies to be started were in Malabar. There were great difficulties in the beginning, both in organizing the Societies and in getting them to work successfully. As the fishermen are out in the sea most of the day and often till late at night, the officers of the department are unable to

get in touch with them to organize co-operative work among them, nor are they able to maintain effective supervision. Most of the working fishermen are very ignorant, and unable to perceive the advantages of Co-operative Societies. It was only after the Fish Curing Yard staff and Fishery School teachers who happened to live in the fishing villages were made *ex-officio* Secretaries and Presidents of these Co-operative Societies that they showed any marked improvement in their working. The number of Fishermen Co-operative Societies in the Kerala State at present is well over 100. In the Malabar area alone (the districts of Cannanore, Kozhikode, Palghat, Trichur and Ernakulam) there are 89 Fishermen Co-operative Societies with a membership of 10,000, a paid-up share-capital of Rs. 3,10,000 and outstanding loans of Rs. 7 lakhs . The Societies encourage the members to save what they can, by distributing hundi boxes to them in which to deposit their savings, these being remitted to the societies at the close of the month. Savings deposits in the Fishermen Co-operative Societies of Malabar area alone totalled Rs. 11,000 during last year. Thrift collections are also made by way of cess levied on the salt sales to the members from Fish Curing Yards, the total amount collected during the same year being Rs. 6,500. The Fishermen Co-operative Societies have also an aggregate investment of Rs. 32,000 in the shares of other Co-operatives. The proper working of the societies and their orderly progress depend mainly on the interest and sincerity of the Board of Directors. There are a few societies in the Malabar and Travancore-Cohcin areas which have made commendable progress. Kaipamangalam Society in Trichur District and Kasargode Society in Cannanore District are good examples. The Kaipamangalam Fishermen Society has an office and godown of its own, and advances loans on jewels, and conducts chit-funds, besides carrying on other usual activities. Repayment of loans is prompt, less than 1% of the loans being overdues. The Kasargode Fishermen Society has been advancing loans to sea-going fishermen for purchase of boats and nets, with the result that half the number of boats in that area are now owned by the members of the Society themselves. This Society has also undertaken the marketing of fish. The Society advances money on fish besides helping the members to sell the fish jointly and obtain better prices. Some of the Societies make bulk purchases of articles required by the members, such as yarn, nets, coir-mats and even food-stuffs and cloth which they distribute to the members on advantageous terms. Apart from credit facilities, the members of the Societies make good savings through joint purchase of their requirements.

As the borrowing is restricted to a maximum of Rs. 1000, and the period of ordinary loans is not more than three years, most of the fishermen

were unable to utilise the loans for the purchase of boats and nets. To get over these difficulties the Kerala Government have provided a substantial amount in the Second Five-Year Plan, to be used for issue of long term loans repayable in ten years. These loans are issued to the members either for the purchase of boats and nets or for the clearing of debts incurred on boats and nets. This scheme is bound to be of very great benefit to fishermen.

Till 1950, the lease of fishing rights in inland tracts of water was by public auction the lease being granted to the highest bidder. The working fisher folk were not much benefited by this practice the right of fishing being obtained in auction by men with capital to invest. In order to see that the profits go to those actually engaged in fishing, Fishermen Societies are now given the right of obtaining the lease at rates not exceeding the average of the previous five years' rentals. Several societies have earned considerable profits as a result of this arrangement. In the grant of licenses for stakenet fishing also, members of Fishermen Societies are given preferential treatment. Members of Vengalam, Velur, Elathur, Madai, Chettuvayi, Engandiyoor, Deevarajana, Engandiyoor South, Kaivarthajana and Kadapuram are given such licences for inland fishing in Baliapattam, Taliparamba, Korapuzha and Chettuvayi rivers.

For co-ordinating and expanding the work of the Fishermen Co-operative Societies, a Federation of these societies has recently been instituted in Malabar. Its objects are, to arrange for the proper marketing of the fish caught by the members of the affiliated Societies, to construct or take on lease Ice Factories, Cold Storages, etc., to purchase or take on hire improved types of fishing boats, gear, etc., and generally to assist and guide the affiliated fishermen Societies in the conduct of their business. Out of the 89 Societies in the Malabar area, 46 have become members of this Federation.

The Kerala Government have a scheme to bring all the working fishermen into the co-operative fold, to bring about ownership of all the fishing boats and nets by Co-operative Societies and to ensure that collection, processing and marketing of the produce are done on co-operative lines. There is good reason to hope that when this scheme begins to operate, the lot of the fisherman would be greatly improved.

The ultimate aim of the co-operatives extends beyond the promotion of the fishing industry and envisages the welfare of the fishermen community as a whole and tries to make them a useful section of our society.

DEEP SEA FISHING

By K. Chidambaram, M.A., F.Z.S.

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Fishing in the seas bordering India is at present largely confined to a coastal belt of about 7–10 miles in width. Though fishing is carried on to a small extent in distant parts of the sea, bulk of the marine fish landings are from inshore waters. The indigenous crafts and gear employed by Indian fishermen, though well suited for fishing in these areas, do not meet the needs of fishing in distant and deeper waters. It was, no doubt, realised that though production of fish could be increased to some extent by developing inland fishing, large proportion of increased landings should come only from the seas.

Deep sea fishing, fishing in offshore and distant parts of the high seas for surface, midwater and bottom forms, is to be carried on along two main lines:—

(i) by increasing the range and duration of the existing operations by installing engines in fishing boats, suitable for mechanisation; and

(ii) by undertaking exploratory fishing with the object of introducing new methods.

Since 1902, occasional attempts have been made at offshore and deep sea fishing in Indian seas for conducting surveys and commercial fishing by large-sized trawlers. These resultsed in the location of some important fishing grounds off the coasts of India and Ceylon, but did not prove commercially successful because of the high cost of maintenance of the vessels, lack of adequate knowledge of the fishing grounds, lack of trained personnel, lack of information on the suitability of different types of vessels for Indian conditions, lack of harbour facilities, etc.

Since the end of last war, considerable emphasis has been laid on the development of deep sea fishing to augment the fish supplies of the country. The Government of India established a Pilot Deep Sea Fishing Station at Bombay in 1946 with the object of charting fishing grounds, determining fishing seasons and fishing intensities, assessing suitability of different kinds of fishing craft, gear and methods under Indian conditions, carrying out

experiments on methods of preservation of fish, training of Indian personnel in powered fishing methods, and in general, for undertaking work that would lead to the development of commercial offshore fishing in India.

Exploratory offshore fishing was conducted from 1948 onwards with trawlers for bottom fishing and with Reekie boats for midwater and surface fishing. So far more than 17,000 sq. miles of sea have been surveyed and charted off the coasts of Bombay and Saurashtra. The exploratory surveys have indicated the richness of fishing grounds in certain regions and also the seasons of abundance of important food fishes in those grounds. In 1953, the two other trawlers belonging to the Government of India were converted for 'bull trawling' operations. Very encouraging results have been achieved by this type of fishing, as a result of which an Indo-Japanese concern has commenced commercial fishing with two pairs of bull trawlers and have proved successful.

On the east coast, the Government of India had not so far undertaken any comprehensive survey on deep sea fishing. The Government of Madras made a preliminary survey on deep sea fishing between 1927 and 1930 with one trawler. The West Bengal Government established a Deep Sea Fishing Station at Calcutta and surveys of the fishing grounds at the head of the Bay of Bengal were being conducted since 1950 by two other trawlers. Three bull trawlers were procured for that State under the T.C.M. programme.

Under the Second Five-Year Plan, it has been proposed to expand the activities of the Deep Sea Fishing Station, Bombay, and establish offshore fishing Stations at Cochin on the west coast and Tuticorin and Visakhapatnam on the east coast. All the power fishing vessels procured under T.C.M. programme are being pooled for operation from the four centres.

The Offshore Fishing Station at Cochin was established in February 1957 by moving the two cutters, *Ashok* and *Pratap* and the shrimp trawler, *Durga*. Recently this fleet has been strengthened. The programme of exploratory and experimental fishing at Cochin has been closely co-ordinated with the work of the fishing schooners of the Indo-Norwegian Project.

The offshore fishing unit at Tuticorin has begun to function in June 1958 under the Government of India. The fleet will be strengthened by transferring some of the power fishing vessels from the west coast.

The development of deep sea fishing does not end with increasing fish production; it raises several other vital problems requiring simultaneous attention. Safe anchorage for mechanised boats and large vessels, ice and

cold storage facilities, transport from landing centres to centres of consumption, organisation of marketing, training of personnel, etc., are some of the most important factors to be considered in developing deep sea fishing. Facilities are provided for the training of personnel on board the offshore fishing vessels of the Government of India, Government of West Bengal, and of the Indo-Norwegian Project. The Central Fisheries Technological Research Station, recently established, is undertaking investigations relating to the improvement of fishing gear. Ice and cold storage plants exist now in some of the important fish-landing centres. Two harbour specialists have completed the survey in the States of Bombay, Mysore, Kerala and Madras for recommending suitable centres to develop small-scale fishing harbours. Facilities provided under the foreign aid programmes are being taken advantage of to train fishermen for shore management, distribution and marketing of fish.

The importance of survey and exploration of fishing grounds, provision of facilities for handling and storage, quick turn around of the vessels, training of local personnel, marketing facilities, etc., has been clearly indicated during the trawling operations of the vessels in different periods since the war. The Indo-Japanese fishing company, New India Fisheries, Ltd., has successfully demonstrated during the last two years the potentiality of the fishing grounds off the Bombay coasts. Certain proposals for the establishment of fishing companies by Indian enterprise in collaboration with foreign interests are also under consideration by the Government of India. The integrated programmes of development on hand for offshore and deep sea fishing, offshore fishery research and investigations on fishing gear, fish processing and handling would lead to increasing the range of fishing operations to the distant and deeper waters off the Indian coasts and contribute towards increasing the fish production of our country.

FISHERIES EXTENSION SERVICE IN INDIA

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The principles of extension have been practised for many years in countries with a highly developed commercial fishing industry. In this country however, it is a pioneer venture, with few guide lines to go upon. Fisheries Extension Programme is being organised here, for the first time, with due consideration of the administrative and technical requirements of different States and regions. 'Fisheries' being a State subject, the State Fisheries Departments are responsible for all aspects of fisheries development work, including fisheries extension in connection with inland and onshore fisheries. As a 'concurrent' responsibility of the Central Government, however, the Central Fisheries Research Stations have been undertaking a major part of fisheries research and investigations.

In view of the somewhat inadequate personnel available for fisheries work in the States and also in view of the fact that increasing tempo of fisheries development work brings up numerous problems for investigation by the Central Research Stations, it was decided to set up a Central Fisheries Extension Organisation for carrying the results of experiments and research to the acid test of practical use in the field. This Organisation is expected to help the State Fisheries Departments in demonstrating improved techniques, developed by research, in connection with fish farming, improvement and reclamation of culturable waters, fishing gear, fishing methods and fish processing and for promoting fish marketing and co-operation. It is also to render advice to fish farmers, fishermen and fish trade in order to increase production and promote better utilisation of fishery resources.

In addition to numerous enquiries for information on improved fishery techniques, requests were received from several States, deficit in fish seed resources, for the supply of fry and spawn of suitable species for fish culture. The first Fisheries Extension Unit, established at Calcutta in 1953, has arranged to supply an increasingly large number of selected fishseed to various States and also some neighbouring countries. Beginning with

about 90 lakhs in 1953, this Unit supplied over 220 lakhs of fry and spawn in 1958, thus making a very material contribution to the development of pond fisheries in different parts of the country. It also developed techniques for transport of fishseed in specially designed plastic bags. Practical training and demonstrations in connection with improved methods of fish culture and control of weeds have also been given to fish culturists of West Bengal and fishery trainees from other States.

In view of the fact that conditions and fishery problems vary to a very marked degree in different parts of the country, seven more Fisheries Extension Units have been recently established (1956–58) on a regional basis at Allahabad, Bhopal, Bangalore, Delhi, Gauhati, Hyderabad and Mandapam. A Unit for Patna has been sanctioned and more Units will be set up shortly in suitable areas. Each Unit has a sanctioned staff of three technical hands, but it has not been possible as yet to fill all the posts. In-service training has been given to these officers, particularly on pond-cultural practices, techniques of induced spawning of Carps and manipulation of audio-visual publicity apparatus. T.C.M. provided the services of a Fisheries Extension Expert in 1957, besides some equipment in the form of jeeps and audio-visual vans.

As a co-operative programme at the level of the people concerned, Fisheries Extension work is, in essence and approach, akin to teaching the adults their professional work. Being essentially educational in nature, field training and demonstrations, talks and seminars and also written and visual publicity are the various methods which have to be employed in order to obtain tangible results. All the Fisheries Extension Units have taken up these activities in their respective areas. In addition to attending to the individual problems of fish farmers, fishermen and fish curers, the Fisheries Extension Units have been training 'village level workers' in improved methods of fish farming, giving talks and demonstrations on fishery subjects, participating in several exhibitions, showing fishery films and preparing and distributing publicity pamphlets in regional languages. So far, pamphlets and papers on "Fisheries Extension and Co-operation", "Development of Fisheries in U.P.", "Fish Seed Sources of Boori Narbada", "Fish Curing Methods" and "Fishery Training" have been prepared or published by different Units.

Extension Service being a two-way traffic, Fisheries Extension Units not only collect and disseminate results of investigations by research institutions or other agencies, but also collect field data on fisheries and fishermen of their respective regions and information regarding problems faced

by the fish farmers or fishermen for necessary investigation. One of the principal problems in most States is the paucity of fishseed of Major Carps or other culturable varieties of fish. The Extension Units have been assisting the State Fisheries Departments in the survey and exploration of spawning grounds and fishseed collection centres and in demonstrating improved techniques of collection and distribution of fishseed. Particularly valuable results have been obtained by the Extension Units of Calcutta, Allahabad, Bhopal, Hyderabad and Gauhati in this connection. In order to further augment the supply of fishseed, the technique for "induced spawning' of Major Carps, under controlled conditions, has been successfully adopted this year by the Fisheries Extension Units of Gauhati, Allahabad and Hyderabad, adding several lakhs of fry for stocking purposes and saving considerable amount of cost on collection and transport from the natural breeding grounds. In particular, extension on deep-water fishing has been carried out by the Units at Hyderabad and Allahabad, on eradication of weeds by the Units at Calcutta and Allahabad, and on fish curing techniques, utilisation of seaweeds and improved nets by the Extension Unit at Mandapam. The Extension Units of Allahabad, Bhopal, Hyderabad and Mandapam have been particularly active in popularising co-operation movement through pamphlets, talks and personal contacts with fishermen in their respective regions. Although most of the Extension Units have only recently started their activities and are still lacking their full complement of staff and equipment, appreciative references were made about their work and assistance to the States' Fisheries Departments at the Conference of State Ministers of Fisheries held in July, 1958, at Mysore.

THE INDO-NORWEGIAN PROJECT

By G. M. Gerhardsen*

The sea is a source of food which is often neglected. It is found in many countries that the waters adjacent to the coast abound in fish and yet, only a fringe of it is used.

In India we find that many people don't know how large the country really is for they don't realize fully that the sea also, with its riches, belongs to it. Yet, there is reason to believe that in the present food situation in India, food returns from investment in fisheries development will compare favourably with investment in agriculture. But before the additional food supplies yielded by fisheries can be classified as substantial, a considerable effort in scientific research, training and experimentation must be made, for fisheries development is not an easy thing anywhere. When attempts are made to step away from ancient methods to modern techniques, so that the lot of the people may be improved, problems are bound to creep up.

This is the setting of the Indo-Norwegian Project, started in 1953 on the basis of a tripartite agreement between the United Nations, the Government of India and the Government of Norway. It is said, *inter alia*, that the Government of Norway will " assist the Government of India in carrying out a programme of development Projects to contribute to the furtherance of the economic and social welfare of the people of India ....."

While the Project is designed and operated in the spirit of the United Nations it varies from the United Nations Technical Assistance—and supplements it—by making a considerable amount of capital equipment available to the experts. Also, the administration is unique in its attempts to blend Indian and Norwegian administrative experience. It is hoped that a pattern will emerge which can be useful now that the idea of Project administration is gaining momentum in international co-operation.

The original Project area of some 10 square miles includes villages Puthenthura, Neendakara and Sakthikulangara in the Quilon District, on both sides of the inlet to the Ashtamudi Lake. Fishing is the main source

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of livelihood. The people are poor but cheerful, intelligent and extremely co-operative. They take easily to mechanization.

When a wider area of the sea is to be exploited, mechanization is essential. The fishermen can go further and exploit the sea out to the edge of the continental shelf, some 50 miles from the coast, while local non-mechanized boat seldom go more than 5 to 10 miles away.

Where harbours are available such development is fairly easy, but in the Project area shelter can only be found by crossing the surf on the shallow sand-bar at the entrance to the Ashtamudi Lake. So the boats must be tailored to these conditions. The possibility of building a harbour in this area has been examined by the Project, but prospects of getting one within reasonable cost limits are not very bright.

First a small 22 feet boat was introduced and more than 60 were built in the Project. Young fishermen took them over on easy terms after 6 months training in the Project. With the boats they have been doing reasonably well and considerably better than the owners of small canoes. And yet it is found that results vary so much from one boat to another that it would be too early to draw firm conclusions.

It would also be a strange coincidence if the first boat we tried was a perfect one. The experiments must continue and a new type, developed in the Project, is now being built. With this boat which is known as the INP type the fishermen will be able to pass the threshold, as it were, not only to mechanized propulsion (which relieves them from rowing) but also new methods of fishing. Thus the second step toward successful mechanization has been made. The experimental programme with boats also includes trials with "Surf boats" which can be put on to the beach and launched from it. Some weeks ago an All-India seminar on such problems was held in the Project.

In the experimental fishing which is conducted by the Indian and Norwegian fishermen employed by the Project encouraging results with new gear and with modified local tackle have been achieved. Some of these will no doubt be assimilated here and become part of the new Indian fishing industry.

Boat yard and Workshop, situated inside the southern side of Neendakara Bridge by the Ashtamudi Lake, was inagurated in July 1954, designed to build and maintain mechanized fishing boats and also to serve as part of the fishery education and gear development centre. About 70 people are employed, inclusive of two Norwegian advisers: one boat building and one mechanic.

The timber for the wooden boats is brought to the yard by backwater and sawed up by sawmen. The planks are brought into the adjacent

carpentry building containing circular saw, band saw, planing machine, right angle cutting machine and tool grinders. Here the parts for the wooden hulls are made ready for erection in the boat-building shed alongside. In this shed, eight 22 feet, or six 25 feet boats can be built simultaneously on either side of the centrally placed slipway leading into the Ashtamudi Lake.

Two boilers for steaming planks to be bent and for net preservation are fuelled by shavings and scrap wood.

Larger boats up to 40 feet length are built at the eastern waterfront corner of the yard under a temporary leaf-roof.

The mechanical workshop building accommodates the main switch board, a Diesel driven stand-by generating set (all machines are independently electrically driven), air compressor, battery charging equipment, smithy, hydraulic press, cylinder grinder, tool grinders, two drilling machines, lathe, shaping machine, a two ton overhead travelling crane and the usual work benches with vices, hand tools, etc., as well as engine and spare part store.

Repairing of boats is carried out on the slipway and at the western part of the yard, underneath the net drying and storage shed, where different types of fishing gear are mounted and repaired.

A quay covers the waterfront practically to the slipway.

So far, the following boats have been built:

63—22 feet and smaller boats,

2— larger boats (M-5 and M-6),

4—25 feet boats are completed up to April 1958.

Refrigeration Plant.—The Refrigeration Plant consists of an ice producing unit (capacity 25 tons in 24 hours), ice storage for 100 tons of ice, cold storage for 100 tons of fresh fish (which can then keep for 2 or 3 days), deep freezing unit of 6 tons capacity and storage for 100 tons of deep frozen fish. The temperature in the latter room is minus 20° to minus 30° C.

To operate this plant a small co-operative society of fishermen will be formed. The point here is that unless marketing problems are attended to simultaneous to expansions in fishing, prices will go down and the effect will be felt by all. Excess quantities must be transported to the inland area where demand is good. For this insulated vans are being provided. But the fish must also be brought to the customers at the right time and the cold rooms of the plant and the ice which it produces will, by halting if not arresting the bacterial growth, make it possible to retain the fish for some time and thus regulate marketing.

The bye-laws of the Sales Organization are designed to suit existing legislation in Kerala but at the same time incorporate experience gained by Norwegian fishermen over the last 30 years or so in co-operative marketing efforts. The aim will be, therefore, to give the association a fairly autonomous status and reduce external influence to a minimum.

The Health Centre.—The object of the work at the Health Centre, with its Preventive and Curative sections, is to improve health and sanitary conditions among the fishermen in the area.

There are two Preventive Clinics where children and pregnant women are counselled regularly and treated when necessary. Medicines, vitamin preparations and milk powder are given in great quantities free of charge. The 7 beds in the Maternity Ward are always occupied. Whenever possible the people are given health education, especially through home visiting by the midwives and the Public Health Nurses. One midwife is advising on family planning. The children at the primary schools of the area are regularly examined. Vaccinations against small-pox and tuberculosis are performed.

The Sanitary Inspectors report on sanitary conditions in the villages and are in charge of the building of latrines, which are offered at a nominal price. So far, more than 1,200 latrines have been constructed in the villages.

The water-supply situation is not satisfactory. Some improvements have been made but only when the comprehensive water-supply scheme has been completed will there be water in abundance.

While much stress is laid on the prevention of diseases in the area, the sick people must get treatment and the need for medical help is considerable. Therefore, a Curative Clinic was started at the beginning of January 1957 and the number of patients has been very high. Medicines are given free. There is also a Tuberculosis Clinic with an X-Ray Unit. The tuberculosis patients are treated as out-patients with modern medicines.

Pipe Factory.—The Pipe Factory produces prestressed reinforced concrete pipes by the so-called Premo methods.

A concrete core pipe is first moulded. It has pre-tensioned longitudinal reinforcement. The core pipe is made in a centrifuge. When cured, the helical reinforcement is spun on under tension, adding transversal compressive tension to the pipe. The pipe is filled with water under sufficient pressure to reduce the pre-compression in the core pipe to zero, both longitudinally and transversely. The pipe is now given the outer layer of concrete, and

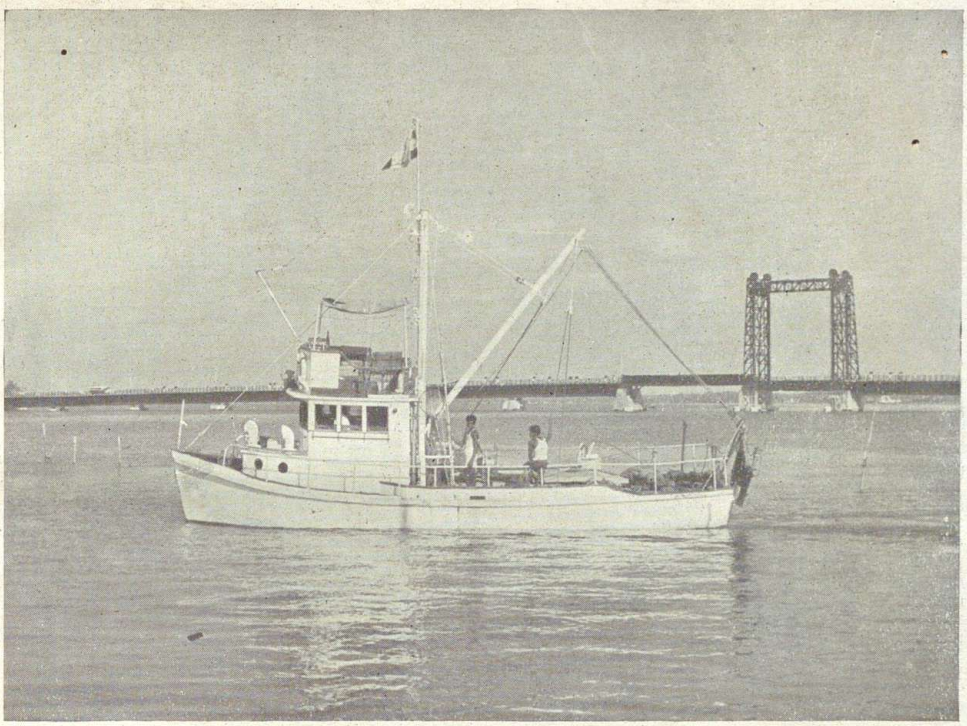
cured free from stress because of the internal water pressure. Finally the pipe ends are cut and the pipe taken to storage.

At present some 120 persons are employed in the factory which is operating with 2 shifts.

The production is at present nearly 7 pipes per shift, each pipe is nearly 17 feet long (5 metres) and 28 inches diameter (700 mm.). The weight of one pipe is just over $1\frac{1}{2}$ tons.

The factory was erected in order to provide a water-supply line from Sasthamcottah Lake to Quilon, a distance of some 18 miles. This pipe production programme will be completed by the end of 1958 and the factory handed over to the Government of India.

The Cochin Branch of the Project.—Fishing from a harbour is much easier than from the beach but most fishermen in India live near the beach so it was only just that the Project should start in a beach area. But in 1955 work was also taken up in developing a balanced fishing industry with the Cochin harbour as a station. At the moment seven offshore fishing vessels are operated there by the Project. Five of these have now Indian skippers trained in the Project. In 1957 substantial quantities of fish and prawn were landed but the effort to map fishing grounds and test the economic feasibility of various types of boats must continue. In September 1957 one of the INP fishing schooners started on its first cruise as an oceanographic research vessel in collaboration with Government of India's Central Marine Fisheries Research Institute. Since then a considerable amount of information essential in studying the environment of the fishing has been collected and probably more than in any other equatorial waters. This endeavour is the first attempt to study scientifically, on the spot, the riches of the seas of Kerala. It will help in verifying—and, we hope, confirming that the food resources of the sea are substantial, renewable by nature, and thus an important although hitherto neglected wealth of the nation. Although this work was started recently most of it is now being taken over by Indian personnel. Plans are now being worked out for the construction of model shore facilities with slipway and workshop so that the boats may be properly serviced and thus become effective means in the national drive for more food for the people of Kerala.



A fishing trawler of the Indo-Norwegian Project

One of the mechanised fishing boats built by the Indo-Norwegian Project at Neendakara, Quilon

MECHANISATION OF INDIAN FISHING BOATS

By P. B. Ziener

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Mechanisation of fishing boats means the installation of engines for propulsion and mechanical devices for handling of fishing gear. This as a rule results in bigger catches. Experience in recent years in India confirms this, as for instance, in Bombay where the installation of engines in numerous Satpati and Versova boats in 1953 resulted in approximately four times increased catches, and in Madras where the introduction of mechanised craft enabled an increse in the catches with various types of fishing gear in different localities.

It is commonly agreed that mechanisation of the fisheries in almost all parts of India must be undertaken with Government aid. It is likely that the fishing boat development will be a continuous process guided by craft and gear research, trial fishing and harbour planning. Fluctuations in developments consequent to experience and resultant to research investigations must be closely watched by technical and administrative personnel capable of meeting new requirements and also possessing authority to suitably modify, if needed, projects already initiated. It is easy enough to design fishing boats when all factors of a fishery are known. However, there are still too many unknown factors in Indian fisheries to make it possible to predict the future development of boat types, boat sizes and fishing methods. This points to a step-by-step development in which boat designs are made with a view to immediate needs rather than to long-term planning.

There are in India today about 22,000 boats of indigenous types (of 2 tons and above) engaged in inshore and estuarine fishing. They are sailing boats. Many of them are well-built and can be mechanised if slightly modified. In addition there are 9,000 dugouts and other small craft and 20,000 catamarans which, in due time, undoubtedly must be replaced by more efficient craft. Of recent date there are also about 1,300 mechanised fishing boats of improved local types or new designs, profitably exploiting old and new fishing grounds. Since 1953 the boat development is furthered

along two parallel lines, *viz.*, the gradual mechanisation and modification of the indigenous boats and the introduction of new mechanised boats suitable for new fishing methods. It should be understood that mechanisation of available boats is only a transitory event, necessary for utilizing thousands of good but not ideally suited boats as long as they last, but that the real improvement of the Indian fishing fleet is in the field of new designs.

Considering that mechanisation of boats requires the introduction of more advanced techniques in boatbuilding and marine engineering and training of technical personnel, the pace of development is impressive. On the Kathiawar coast more than 50 local boats have been equipped with inboard engines and about 70 small craft with outboard engines. On the Konkan coast more than 950 well-built and seaworthy indigenous craft of great utility are engine-powered, and the fleet is rapidly increasing. In South Kanara and Malabar coast the 135 mechanised boats introduced up to this date are, unlike those of Kathiawar and Konkan, of new designs. Some are designed and built by the Indo-Norwegian Project at Quilon or in Norway, and some designed in co-operation with FAO and built in the region. Dugout mechanisation is being tried in South Kanara with satisfactory result.

On the east coast mechanisation has advanced rapidly in the south with the introduction of the so-called " Pablo " type boats. More than 50 such boats have been built under Madras Government scheme and distributed to the fishermen. The Government scheme provides for building of more mechanised boats of similar and bigger types. In the extreme south as well as around the Godavari delta indigenous types of boats are being motorised, with best results so far in the last-mentioned area where 12 locally developed boats are engine powered. In the deltaic areas of Orissa and West Bengal much prominence has not been given to the mechanisation of the numerous indigenous boats. But Orissa has introduced a small, efficient fleet of mechanised fishing boats and fish carriers embodying to some extent the features of the local boat types. The peculiar pattern of estuarine and river fishing in these north-eastern areas require a different approach to the mechanisation problem. Exploratory fishing is required and progress must necessarily be slow. The total number of mechanised indigenous and new boats is perhaps not yet exceeding 15, and West Bengal has in addition a new, specially designed exploratory fishing vessel for the estuaries. Also in these areas boat designs have been worked out in co-operation with FAO and all mechanised boats, except one, have been built in the country.

A "cottage" boatbuilding industry is found in every district where fishing boats are in use. It has built the Indian fishing fleet. It is organised on a sound economical basis and displays great skill and experience in exploiting local resources. Maintained by primitive production methods, this industry is capable of building boats cheaper than the yards provided with modern machinery and skilled staff. This in itself is full justification for its existence. But the greatest value of the cottage boatbuilding is in its presence everywhere. For fishing boat maintenance its decentralised activity is invaluable. Any fishing boat can be repaired in its own port or near its fishing ground. If the cottage boatbuilding is mechanised to some extent and expanded to cover the field of simple marine engineering, it seems that the ideal condition for servicing a fishing fleet of small and middle-sized craft would be achieved.

However masterful in practical boatbuilding, the cottage industry lacks knowledge of modern naval architecture which is imperative for full development. Aware of this fact, the Central Government have organised the Craft Wing of the Central Fisheries Technological Station with the main purpose of investigations on new boat designs and materials, technique of building, and training & extension work. Already two Training Centres have been organised at this Station in collaboration with the FAO, for training of State Government Officials and representatives of private boatbuilding industry in the basical aspects of fishing boat Naval Architecture. Pilot fishing-boat building-yards have been established under Government supervision in several martitime States for construction of prototype boats and introduction of new boatbuilding techniques. It is only through training, research and extension that the ultimate development of the Indian fishing fleet on modern lines can be achieved.

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Editor

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