FISHERIES RESEARCH IN INDIA[1]

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PART I

(*With eight plates*).

CONTENTS

1. THE PROBLEMS

The problems of fisheries research in India could be formulated in the following 15-point programme:—

1. A qualitative and quantitative appraisal of our aquatic food resources and the principal species contributing to them.
2. Acquisition of full biological knowledge of those species and factors influencing their abundance and availability for fishing.
3. Application of that knowledge to the management of the fishing programme so that a steady annual yield may be assured.
4. Exploration and charting of fishing grounds in the sea in relation to time and space.
5. Experimental fishing to select types of craft and gear suitable for mechanization so as to increase the range of sea fishing and catch per unit of effort.
6. Investigations to select species which could be cultivated as food, and habitats which could be developed for that purpose taking full advantage of geographical and climatic features.
7. Perfection of field practices which would lead to the development of marine and coastal fish farming.
8. Expansion of fish seed resources as the basis for the extension of fish culture operations.

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[1] The views expressed in this paper are purely the personal opinions of the author and should not be taken as the official views of the organization to which he belongs.

9. Development of improved methods for growing fish in village ponds as an essential contribution to rural economy.
10. Protection of fishery wealth from being wiped out by multi-purpose projects and industrialization.
11. Perfection of methods of handling fish and fish products to reduce wastage by deterioration and to ensure their reaching the consumer in a good condition at a low price.
12. Improvements in methods of processing to utilize the surplus, and the introduction of new and acceptable methods for utilizing surplus landings.
13. Technological improvements in the manufacture of fish oil and other fishery by-products which are at present not or only inadequately utilized.
14. Researches on consumer preferences, price structure, commercial organization and other factors influencing the industry, and on the socio-economic fabric on which the industry is based.
15. Discovery of new aquatic food resources and the techniques for their utilization.

2. Introduction and Retrospect

In the following account an attempt is made to give a brief outline of the various aspects of work above enumerated; what has been done and what remains to be done. At the very outset, it may be conceded that considering the magnitude of the problems, the size of the country and the material value of the resources concerned, the efforts expended towards research is small and work is in the very early stages of fact finding. In many other countries where fishery wealth ranks high, well-developed research organizations have grown gradually for a number of years and work has been steadily carried out, which has taken them past the introductory phases, enabling them to understand their problems and to apply scientific results for the adequate management and utilization of their fisheries. Much of the work which they now do deals with aspects closely related to the actual management of the fishery and fishing industry. On the other hand, in our country little or no attention has been paid to this subject all these years, except within the last five years. A large amount of preliminary investigations remain to be covered before we are in a position even to evaluate our various problems. The gap between scientific investigations on the one hand and obtaining results of immediate practical application to the fishing industry on the other is unfortunately large, and achievements in the field of research judged by short-term standards are often unimpressive. Mistakes have been made in considering fisheries research as a matter purely for Provincial or regional action subservient to the local problems of development. A greater mistake was to consider fisheries research as a commercial investment which should bring direct revenues to administrations in complete disregard of the role it undoubtedly plays in the increase of food supplies, improvements in nutritional standards and attendant benefits to the public health and physical well-being of our people, and the raising of

the standard of life of a very considerable section of our population who are directly engaged in fishing operations and trade.[1] As pointed out by Sewell, Fisheries Research should be regarded as a social service and not as a business enterprise although as work progresses it will be the basis for the expansion of the industry in fish which is already an important article of commerce both in the fresh state and as cured fish for inter-Statal and export trade.[2]

Interest in fish has been evinced from ancient times in India as found from references in Kautilya's *Arthashara* (*c.* 300 B.C.) and some of the Pillar Edicts of Asoka (246 B.C.) (Hora, 1948, 1950). The ancient Hindus had also made comments on the form and behaviour of fishes in relation to their environment and modes of locomotion. The possibility that taboos introduced by Asoka for the consumption of fish during certain phases of the month were based on the knowledge of the breeding habits of fishes like Carps has been indicated by Hora (1950). These views as well as the chronology of some of the earlier texts are controversial, but there seems to be enough evidence to show that the role of fish as food for the people was fully realized. Fishery science in the modern sense has, however, not a long history in this country. It is necessary to draw a distinction between *research on fish* and *fisheries research*, the latter being a modern development of the study of fish stocks in relation to their yield. If this interpretation is taken, fisheries research has hardly made a beginning in this country, although we have a considerable amount of information on the fishes which contribute to our fisheries. Among the earlier contributions on the fishes of India which deserve mention are the account of the fishes of the Ganges by Hamilton Buchanan (1822) and the comprehensive work on Fishes of India by Francis Day (1876–78). These two monumental contributions may be said to form the basis for all ichthyological work in this country and even to-day the two volumes on Fishes in the Fauna of British India Series by Francis Day (1889) constitute the only standard work. During the past fifty years, substantial additions to our knowledge of Indian fishes have been made through the efforts of many investigators, the most outstanding among them being Hora. Till about 1930 the progress achieved was largely in the fields of taxonomy and geographical distribution, but with the growth of departments of zoology attached to various Universities, noteworthy among them being Madras and Calcutta, increasing attention began to be paid to the study of life histories and habits of both freshwater and salt-water species. These studies concerned more with the zoological aspects rather than with fishes as contributing to fisheries. Similarly, a large volume of information has been collected by the many naturalists and sportsmen who have visited various parts of India. It may, however, be mentioned that subsequent to Day, the basic work relating to fisheries was until 1930 carried out at the Zoological

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[1] The number of active adult fishermen alone is estimated at 500,000 while the total fishing population is estimated at 1,600,000. Including those who no longer do fishing, over eight million people belong to fishing communities.

[2] About 43 per cent of the total production is consumed as fresh fish, the remainder being cured. Exports include about 30,000 tons of cured fish valued at about 300 lakhs of rupees and 3,000 tons of fish manure valued at Rs. 3 lakhs. (Pre-partition figures).

of the Zoological Survey of India. It is worth while mentioning here that, in the organization of a central machinery for fisheries work in the country on an all-India basis and in the formulation and implementation of the Central Government schemes, the work of Prashad will long be recognized as a notable contribution. A similar contribution to place fisheries in the scientific programme of the country and to create much needed public interest on the subject, more especially on fish culture, was made by Hora[1] who wrote extensively on the various aspects of fishery research and development.

Apart from research on fish and fisheries, an essential line of exploratory activity lay in experimental operations of new types of fishing in Indian waters. The craft and gear employed by our people remain as they have been for centuries past, both frail and primitive. It is not suggested that they are not efficient, but, on the other hand, considering the material available, the cost and mode of operation, it is impossible to improve on them for the limited use to which they are put. Their greatest drawback lies in their dependence on wind power for propulsion, making them available for use only within a narrow stretch of the coastline, hardly more than five to ten miles off the shore and, in many instances, much less within five miles. They are likewise unable to withstand the fury of the monsoon winds, which limits fishing to certain seasons only. The inadequacy of this craft for large-scale operation lies in its inability to use any large trawl or seine net or in fact any large net which would raise the catch per head to any appreciable extent. Large catches are obtained during favourable seasons, but it is seldom that these can be landed and utilized on the shore before they deteriorate. In spite of their innate efficiency, they are not enough for any large-scale exploitation of the sea, if any substantial progress in fish landings is aimed at.

Realizing this the Governments of Bengal, Bombay and Madras at different times tried to introduce mechanised fishing by experimental operations carried out by trawlers. 'Golden Crown' in Calcutta (1908–9), 'William Carrick' in Bombay (1921–22) and 'Lady Goschen' in Madras (1927–29) carried out such exploratory fishing in waters of the three Provinces respectively. Unfortunately, the employment of trawlers for these experimental operations was based on the presumption that the tropical fisheries would show the same pattern as those of the colder seas where the large majority of exploitable species occur at considerable depths. It was not then realized that in tropical seas where problems of productivity and marine phenomena occur in a different manner, the major fisheries are either pelagic or mid-pelagic. Owing to this fundamental error and the numerous difficulties connected with the introduction of mechanized gear in a country where no industrialization of any type had taken place, these operations were not marked with any notable success. In spite of these difficulties, the catches were moderately good, but sooner or later, all these operations were given up by the respective Governments that undertook the ventures, as they were commercially unsuccessful.

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[1] Hora was also Honorary Chief of the Inland Fisheries Station for a short period after its inception, but was succeeded by T. J. Job who remained as chief of the Inland Station until December 1951.

In 1946, the Central Ministry of Agriculture decided to start fisheries research on an all-India basis together with research operations in mechanized fishing. The advice of foreign experts was obtained, notable among them being Col. R B. Seymour Sewell, F.R.S., who drew up a memorandum for the establishment of a Fisheries Research Institute which he envisaged in the form of two marine stations, one for the East Coast of India at Mandapam and one for the West Coast of India at Karachi, one inland fisheries station at Khulna or Calcutta with a mobile estuarine unit and a power fishing operational unit at Bombay, together with a technological institute at Calicut. These schemes had to be considerably modified owing to the partition of the country and subsequent developments resulting in the Government's decision to have the Marine Fisheries Research Station at Mandapam and the Inland Fisheries Research Station at Pulta near Calcutta. One of the trawlers which became surplus to the requirements of the Indian Navy, H.M.S. 'Berar' was taken over by the Ministry and converted for fishing operations, thus beginning pilot fishing operations at Bombay. By the end of 1947, all these stations had taken shape and by the time our new Constitution had been adopted which makes research and fishing in off-shore waters a definite central responsibility as against the provincial sphere of development and regional research, the nucleus of research organizations to deal with at least the major aspects of Indian fisheries has been laid. A brief account of the three central institutions may not here be out of place.

3. The Research Institutions

(*a*) THE CENTRAL MARINE FISHERIES RESEARCH STATION

The Central Marine Fisheries Research Station was started in February 1947 for handling marine fisheries research on an all-India basis with temporary headquarters in the Biological Laboratories of the Madras University where the staff remained till September 1949 when the Station was shifted to its permanent headquarters at Mandapam. Buildings originally put up as a naval hospital by the Defence Department during World War II were acquired and converted into laboratories and temporary residential accommodation for the staff. Subsequently, an aquarium was built, fittings to the laboratories carried out and an effective means of running sea-water for keeping marine organisms has been worked out and its installation is nearly complete. A capital expenditure of 6½ lakhs of rupees has been incurred on the Station and about a hundred acres of land around has been acquired for expansion and for putting up permanent residential buildings. In addition to the headquarters Station, there is a subsidiary Research Station at Kozhikode to deal with the special fisheries problems of the West Coast of India, a research unit at Karwar in the Bombay State to deal with the mackerel fishery, and another unit at Narakkal in Travancore-Cochin to deal with the prawn fisheries and prawn farming operations. It is also proposed to set up very shortly a research unit at Bombay for carrying out investigations on off-shore fisheries and another at Ennore (near Madras) for handling studies on edible Mollusca. In order to collect fishery data from the large coast-line of India, fishery survey assistants have been posted at twelve centres

representative of the various divisions of our coastline extending from Kathiawar to West Bengal. The data gathered by them are regularly sent to the headquarters where they are analysed and for the first time, a machinery for the collection of all-India marine fishery statistics has been developed and put into execution.

The work of the institution is broadly divided into four categories, Fishery Survey, Fishery Biology, Marine Biology and General Physiology. Fishery Survey aims at assessing the marine fishery resources of the country, computing fish landings and to see if the marine fisheries in general are under or over utilized. The studies relating to Fishery Biology deal with the fish stocks, special habits, distribution, life-histories and such aspects of fish life as have intimate bearing on fisheries problems. The major fisheries of India like the Sardines, the Mackerel, the Sharks and other less known categories of fishes are all investigated in detail in an attempt to understand the causes governing their abundance, and the efficiency with which the fish are caught and utilized. Subsidiary fishery resources like the prawns, the oysters, clams, etc., are also receiving close attention. Sea weeds which occur in considerable abundance in the sea and form a valuable raw material for the production of agar and other industrial products are being investigated in detail to determine the extent of the resources. The third important category of investigations come within the field of Marine Biology dealing with the factors connected with the abundance of smaller forms of plant and animal life which ultimately form the food of fish. This is also correlated with studies on the chemistry of sea-water with a view to understanding seasonal changes in the occurrence of fertilizing substances in the sea. Bacteriology of sea-water and fish products is also investigated with a view to arriving at enforceable standards in the handling of fish products. The physiology of fish and other commercially important forms of marine life are studied with a view to selecting suitable types that would be ideal for large-scale culture in coastal waters which could be developed into marine fish farms. The institution maintains a good library and a reference collection of correctly determined marine fishes.

(*b*) THE CENTRAL INLAND FISHERIES RESEARCH STATION

The Central Inland Fisheries Research Station at Barrackpore near Calcutta handles investigations pertaining to freshwater and estuarine fisheries of India. The Station was started in March 1947 and is located at Pulta (Barrackpore) and it has a sub-station at Cuttack in Orissa. The comprehensive programme of freshwater fishery research which is before the Research Station, is detailed below:—

1. The hydro-biology of fisheries of estuaries, brackish-water and lakes;
2. Studies on Hilsa, the major carps, mullets and prawns of inland waters;
3. Investigations on the micro- and macro-fauna and flora associated with tank and pond life;
4. Pond culture experiments on the development, growth and food of the major carps and other fresh water food fishes under varying conditions;
5. Study of the extent of freshwater fish seed resources;

6. Investigation regarding fish migration and influence of dams and weirs on fish life;
7. Study of the pollution effect of industrial and municipal wastes;
8. Investigation on the use of sewage in manuring fisheries;
9. Substratal variations in the waters and their influence on the fish life; and
10. Comparative study of the fishing methods in different types of inland waters.

The work of the Station is broadly divided into three main sections, Estuarine Fisheries, Pond Culture, and Riverine and Lacustrine Fisheries. The problems under investigation at the Station include rearing and transport of freshwater fish-seed, study of food, growth, maturity, and breeding of freshwater and estuarine fishes of commercial importance. Special fisheries like Hilsa, and mullets are being investigated in detail and problems of hydrobiology in relation to the freshwater and estuarine fisheries of the Gangetic delta are being studied. Pond cultural practices and investigations to reduce the mortality of fish-seed are receiving urgent attention owing to the immediate value which such investigations have in the development of freshwater fisheries. The effect dams have on riverine fisheries is being closely studied owing to the various river valley schemes which are being actively pursued in the States of Bengal and Bihar and the probable effect which they will have on the fisheries of the entire region.

(c) THE DEEP-SEA FISHING STATION

The Deep-Sea Fishing Station was started in Bombay in 1946. As suitable fishing vessels were in very short supply in India and abroad at that time, fishing operations were started in January 1948 with the converted Basset Steam Trawler 'Berar', under the name 'Meena'. The vessel was in commission for 513 days, but on account of several difficulties partly due to congestion in the Bombay Port, it was out at sea only for 212 days. In addition to doing charting and other exploratory work mostly in waters north-north-west of Bombay, she was able to land 4,400 maunds of fish, giving a catch of 20 maunds per day's absence from port. S.T. 'Meena' was a single-screw vessel, 152'–5" in length and with a net registered tonnage of 159·85 tons. An ice-making and cold storage plant was installed on the ship. As the maintenance and operation costs of this large coal burning vessel were unduly high, she was decommissioned in June, 1949. The work that S.T. 'Meena' was doing is being continued with two Dutch motor cutters, M.T. 'Ashok' and M.T. 'Pratap' (of an overall length of 83'–4" and net registered tonnage of 23·44 tons each) and two Reekie boats M F.V. 'Bumili' and M.F.V. 'Champa' (each being 50' long and having a net registered tonnage of 10·01 tons). Both the cutters have been commercially more successful than the S.T. 'Meena'. Cutters 'Sagarika' and 'Baruna' of the West Bengal Government began operating from Calcutta in 1951 with considerable success. Recently a Japanese trawler 'Tayo Maru 17' has been conducting offshore fishing from Bombay with the permission of the Government of India. Com-

mercially this vessel has been very successful and has landed catches on a scale larger than any mechanized vessel so far operated in India. An account of the working of these vessels and analysis of the catches will be given under the section on Power Fishing.

(*d*) INSTITUTIONS OF STATE GOVERNMENTS & UNIVERSITIES

In addition to the three Central Institutes dealt with above, there are centres of fishery research maintained by some of the State Governments and Universities where work on biological problems related to fisheries continue to be carried out. In 1937 the University of Travancore created a Chair for Marine Biology and Fisheries and an aquarium was completed and opened in 1940. Some progress has been achieved there in preliminary studies pertaining to problems of that area. The Taraporevala Aquarium in Bombay which was set up by the Bombay Government aided by a private benefaction was completed and opened in May 1951 as an adjunct to the Department of Fisheries, Bombay. This fine aquarium which is now attracting large numbers of visitors will no doubt go a long way in creating public interest in studies on fishes. It is regrettable that the Madras Aquarium, one of the oldest of such institutions in the East, which was dismantled during the Second World War has not yet been restored. Among other research centres maintained by State Governments reference has already been made to the Biological Station at West Hill and the Field Centres at Krusadai and Ennore. In addition, the Madras State Government maintains a Pearl and Chank Unit at Tuticorin, a Fishery Technological Station at Calicut and a Hydrobiological Unit at Madras to deal with problems of freshwater fisheries. Orissa State has opened a research station on the banks of the Chilka Lake at Balugaon for the study of the fisheries of the lake. The State of West Bengal has a small technological unit attached to the Department of Fisheries, and exploratory power fishing and investigation of the Bay of Bengal have been begun with two Danish cutters. Similar freshwater fisheries centres have been opened by the States of Uttar Pradesh and Bihar. Baroda had plans to open a Biological Station at Port Okha, but owing to the integration of the State with Bombay, the project is probably being re-examined and eventually marine stations may be opened at Ratnagiri and Okha. Among the Universities, Madras has since 1933 carried out a considerable amount of marine biological work which has been so essential to providing a background for fisheries investigations and training workers, while a similar position in freshwater fisheries work has been maintained by the University of Calcutta.

A great handicap in marine fisheries work in India at present is the absence of any fisheries research vessel. Work has necessarily to be restricted to the facilities offered by the commercial catches brought by the indigenous vessels. The recent ventures in power fishing have given added facilities for investigations, but it would obviously be difficult to combine the needs of research with purely commercial operations. The Government of India have already plans for the acquisition of a research vessel for marine fisheries investigations, and it is hoped that exploratory surveys and marine investigations could be soon started in our off-shore waters in the same manner as experimental fishing started from Bombay.

4. Survey of Resources and Statistics

(*a*) STATISTICS OF PRODUCTION

For any programme of improvement of the Fisheries, it is essential to have a clear idea of the resources. Owing to the very diffuse nature of this industry in our country, there are many practical difficulties in obtaining accurate information. Reliable statistics of production are wanting. Based on the survey carried out by the Agricultural Marketing Department during 1941, the following figures were arrived at for undivided India. (*vide* Agri. Marketing Reports).

	Quantity in lakhs of maunds.	Metric tons.	Value in lakhs of rupees.
Sea fish (including estuarine fish) ...	116·7	4,35,909	302·7
Freshwater fish (excluding that caught by non-professional fishermen)	62·6	2,33,829	742·3
Total ...	179·3	6,69,738	1,045·0

The generally accepted figures for partitioned India based on 1948 figures of the Marketing Department are :—

	Quantity in lakhs of maunds.	Metric tons.	Value in lakhs of rupees.
Sea fish (including estuarine fish) ...	100·9	3,76,891	868
Freshwater fish	41·2	1,53,894	927
Total ...	142·1	5,30,785	1,795

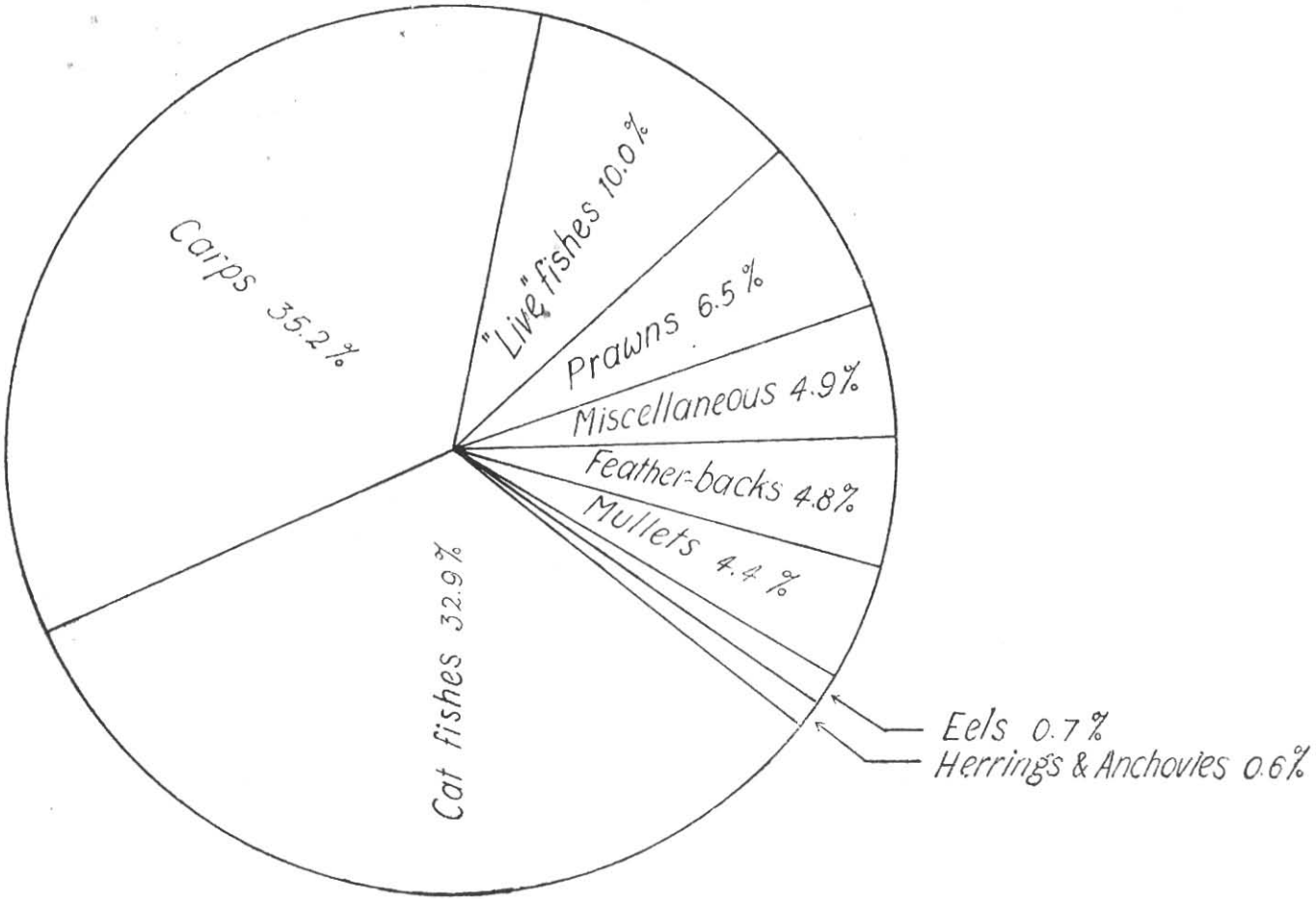
These figures give only a very rough idea of the total production and value. The sea fish comprise some 70 per cent of the total production, but owing to the fact that a large fraction is converted into manure, the average value of sea fish is considerably less than what it would be if adequate shore facilities existed to utilize the surplus production as fresh fish or as processed food. Although the total production is small, the freshwater fish contribute to a larger share of the total value owing to the fact that the bulk of it is sold fresh to the consumers over areas scattered throughout the country. This is the reason why freshwater fisheries have a great importance in the development of village food resources in a stable rural economy as will be indicated in a subsequent section. It is also obvious that any appreciably large-scale increase in production is possible only from the marine resources, because, it is here that unexploited areas remain to be developed. Similarly it has been computed that if better use is made of sea fish instead of allowing a good fraction of it to be cured or converted into manure the value of sea fisheries would be about thrice the present value, a portion of which

could be advantageously transferred to the consumer to make fish less costly to him than at present.

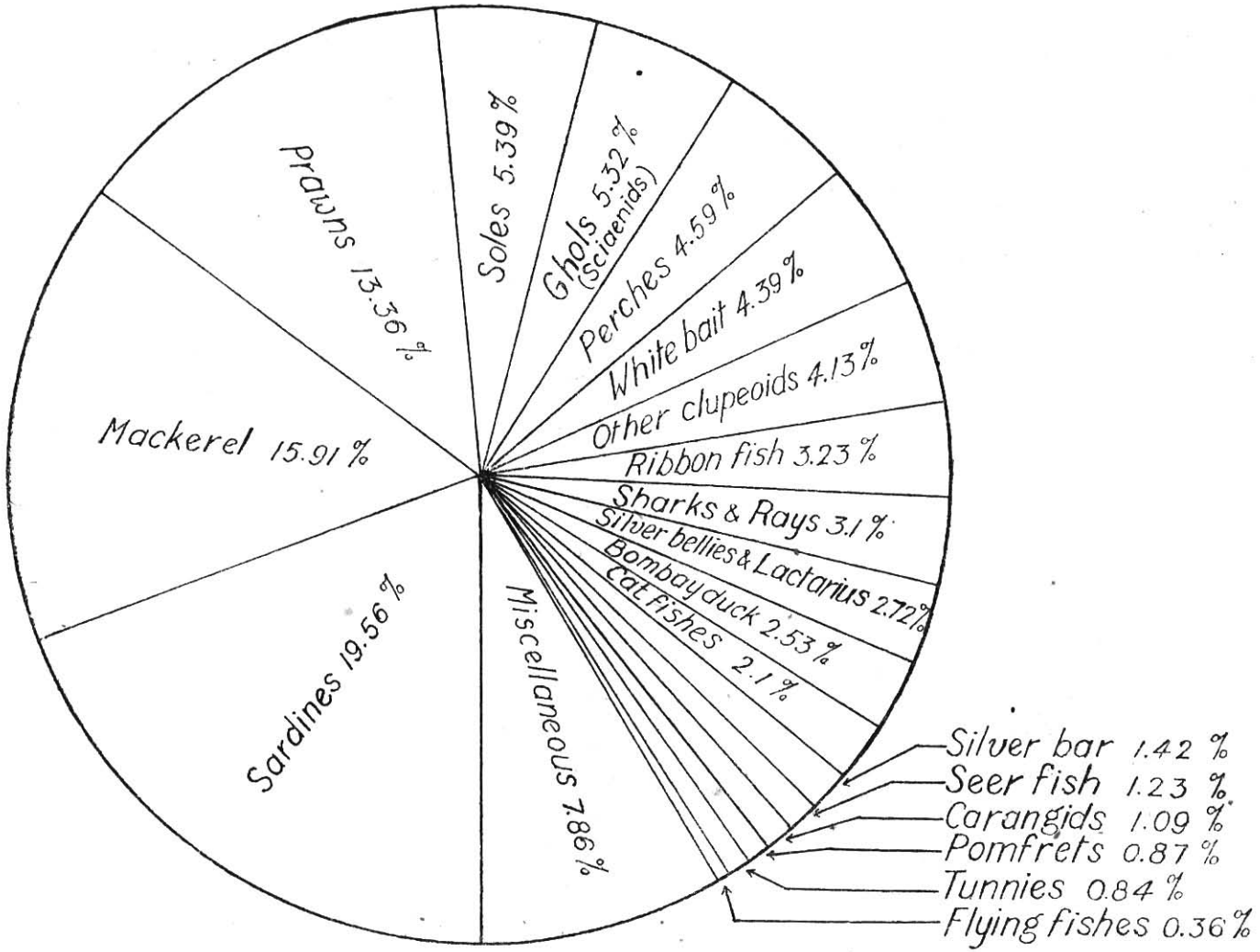
It is necessary to indicate here that we have no adequate machinery for the collection of fishery statistics. The difficulties of obtaining accurate fishery statistics, both as regards landings and disposal, are immense. Further, the scale of subsistence operations is always a problem to estimate. Any organization which aims at perfection should take into account the fact that there is no proper registration of craft and gear; the fishermen are illiterate and owing to the fear of taxation are by no means willing to give correct figures even if their cooperation is assured except under their own voluntary effort. Total enumeration would require an army of workers to deal with the fishing operations carried out throughout the country by the most infinitely varied type of fishing boats and nets and such an undertaking would obviously be expensive. Until recently no machinery for the collection of statistics existed. Some of the State Governments, notably Madras and Bombay, were obtaining figures for the total landings of fishes in the places where the coastal fish curing yards existed. But these figures were by no means complete and with the abolition of salt duty, which resulted in many fishermen not utilizing the services of Government fish curing yards, this machinery has practically broken down. With the introduction of subsidized issue of salt, the value of fish curing yards as an agency for statistics will again prove useful, but only a part of the production will be covered and that only of marine fisheries of Madras, Travancore-Cochin and Bombay States.

Realizing the importance of the marine fishery statistics in any organized programme of marine fishery research in the country, the Central Marine Fisheries Research Station has paid attention to this aspect even from its inception. A preliminary survey of the Indian coast was carried out and the entire coastline was divided into twelve zones, each zone being placed in charge of a survey investigator. Centres for observations and for enumeration of landings were chosen and a multistage random sampling method perfected for the collection of data based on which the total landings of the whole zone were computed. The observations made involved both a quantitative and qualitative assessment of the catches so as to develop the biological programme on the basis of the relative abundance of the various commercial species. As work progresses the centres where the survey investigators work are expected to serve as regular biological observatories for the study of commercial species in addition to their value as centres for the collection of statistics.

At present this is the only machinery in existence in India for the collection and coordination of Indian fishery statistics. In 1946 when this programme of survey was drawn up it was hoped that the State Governments would likewise develop survey organizations and the Centre would primarily deal with the methodology and coordination of the all-India statistics. Progress in this direction has not been achieved although it is hoped that with the increasing consciousness regarding the value of accurate statistics, some stable all-India machinery will be perfected. The Indian Council of Agricultural Research has already carried out some small-scale pilot investigations for evolving suitable techniques.



Principal Groups of Freshwater Fishes of India. After data in Marketing Report of Fish in India.



Principal Groups of Marine Fishes of India excluding estuarine fishes. Data from Central Marine Fisheries Station.

As regards the collection of statistics of freshwater fisheries there are several regional problems and hence they can only be tackled on a regional basis where the only agency which may be utilized lies in the State fishery departments.

The diagrams on Plates I and II show the various categories of marine and freshwater fishes of India and their relation to total production. Table I shows production by zones.

TABLE I

Table showing total landings of marine fish in India during 1949 and 1950

(Based on data at the Central Marine Fisheries Research Station.)

		In Metric Tons		
		1949[1]	*1950*	
1.	West Bengal and Orissa (part)	18,842	15,686	
2.	Andhra Coast (from south of Gopalpur to north of Visakhapatnam)	54,273	40,463	
3.	Andhra Coast (from Visakhāpatnam to Masulipatam)	24,426	41,237	
4.	Andhra Coast (south of Masulipatam to north of Pulicat Lake)	1,308	969	
5.	Coromandel Coast (Pulicat Lake to Cuddalore)	12,685	30,284	
6.	Coromandel Coast (south of Cuddalore to Devipatanam)	11,850	9,652	
7.	Palk Bay and Gulf of Manaar (south of Devipatanam to north of Cape Comorin) ...	2,600	4,030	
8.	Travancore-Cochin and South Malabar (Cape Comorin to Ponnani R.)	48,659	93,600	
9.	Malabar and South Kanara (north of Ponnani R. to Mangalore)	85,512	1,66,321	
10.	Kanara, Karwar and Konkan Coast (north of Mangalore to south of Ratnagiri)	72,840	40,426	
11.	Bombay and Gujarat (Ratnagiri to Broach) ...	48,447	1,17,712	
12.	Kathiawar Coast (north of Broach)... ...	...	...	Data not available
	Total ...	3,81,442	5,60,385	

(*b*) SURVEY OF FISHERY RESOURCES[2]

(i) Freshwater Fisheries:

The biogeographical and ecological conditions against which the fishery resources have to be examined may here be indicated. It is obvious that freshwater fisheries would flourish only in areas where large quantities of water are available either from rain or rivers. The river systems of India provide the backbone of freshwater fisheries because apart from the extensive riverine fisheries themselves, the rivers alone provide the means of providing water to many other culturable waters and also form the source from which sufficient spawn for cultural purposes could be obtained. The great freshwater basins of India are (1) the Ganga System stretched across the Indo-Gangetic

[1] 1949 figures are probably incomplete.

[2] For a detailed survey of the resources, *vide* Handbook of Indian Fisheries edited by B. N. Chopra, Ministry of Agriculture, Government of India, 1951.

plain and composed of the tributaries of the Ganga; (2) the East Coast system comprising principally the Mahanadi, the Godavari, Krishna and Kaveri; (3) The West Coast system covering the narrow strip of land between the Western Ghats and the Arabian Sea which enlarges in the northern part to cover the Narbada and Tapti rivers; (4) the Brahmaputra system covering Assam; and finally (5) the Indus system which is now of negligible proportions in India after partition.

Water system	*Catchment area lakhs of sq. miles*	*Length of rivers*	*Rainfall*		*Annual run-off Million/Acre/Feet.*
		Miles	*Range*	*Average*	
Ganga system ...	3·75	5,000	25″ – 77″	43″	20″ 397
East Coast system ...	4·70	6,400	28·8″ – 61·5″	42·77″	135″ 334
West Coast system ...	1·90	2,100	15″ – 115″	48″	25″ 252
Brahmaputra system ...	2·00	2,500	40″ – 83″	48″	30″ 310

It will be obvious from the above that the Ganga system constitutes the most important region from the freshwater fisheries point of view and covers the States of West Bengal, Bihar, Uttar Pradesh and a portion of Madhya Bharat. The rivers also support several perennial and seasonal jeels and ponds and a wide variety of freshwater habitats at varying elevations and having different temperatures and harbouring a rich fish fauna of game fishes, loaches, culturable carps and prawns. The second in importance is the more diffuse East Coast river system which has rich carp fisheries in the northern sector but gives place to the more miscellaneous assemblage of warm water fishes in most other parts. The carps and game fishes and various other freshwater groups are also noteworthy in the other systems. Freshwater lakes in India are few but mention may be made of the Kumaon lakes in Uttar Pradesh which have valuable Mahseer fisheries and the Mettur lake in the south, developed artificially by the construction of the Mettur Dam, which is now yielding an extremely rich carp fishery.

The freshwater fishery resources of India comprise (1) the major carps, (2) the catfishes, (3) prawns, (4) mullets, (5) the live fishes, (6) the feather backs, and (7) the miscellaneous category which includes a number of minor carps, freshwater perches, eels and the small number of freshwater clupeoids. Both from the point of view of resources and potentials for increased production the carps are the most important and include the well-known forms Rohu [*Labeo rohita* (Ham.)], Calbasu [*Labeo calbasu* (Ham.)], Mrigal [*Cirrhina mrigala* (Ham.)] and Catla [*Catla catla* (Ham.)]. Less known but equally valuable in future expansion are *Labeo fimbriatus* (Bloch) and *Cirrhina cirrhosa*. The large-scaled barbels belonging to the genus *Barbus*, and under which comes the well-known Mahseer, form fisheries of considerable value in freshwaters and the large species are excellent game fish. The catfishes are a mostly carnivorous group and although some of them are excellent table fish, they are mostly active predators like the freshwater shark *Wallagonia attu*, and should not be allowed to grow along with carps.

Nevertheless at present a large yield, almost as big as that from the carps, comes from catfishes of the genera *Wallagonia*, *Bagarius*, *Pangasius*, *Silonia*, *Mystus*, *Eutropiichthys*, *Rita* and *Callichrous*. The category called 'live fishes' form a taxonomically divergent assembly having one common character, viz. their powers of aerial respiration and ability to be transported and kept alive outside water, which has been of much value in meeting the demands of fresh fish in various places. Species of *Clarius*, *Heteropnestes*, *Anabas* and *Ophicephalus* are included in this category; in many places in the Deccan special attention is paid to the culture of species of *Ophicephalus*. The 'feather backs' (*Notopterus chitala* and *N. notopterus*), the freshwater mullet *Mugil corsula*, eels and spiny eels of the genera *Anguilla*, *Amphipnous* and *Mastacembalus* and prawns of the genus *Palaemon*, principally *P. carcinus*, contribute to the remainder of the freshwater resources. Estuarine species which are taken in freshwater include *Hilsa*, *Setipinna* and *Etroplus* all of which are valuable and will be dealt with in the various sections below. The freshwater and estuarine fisheries are best exploited at present in the States of West Bengal and Orissa.

(ii) Estuarine Fisheries:

A second geographical peculiarity of the country which has influenced the pattern of Indian fisheries is the extensive development of estuarine and brackish-water tracts either as estuaries proper at the mouths of rivers as part of the river systems or as embanked brackish-water tracts near the coasts fed by rain and sea-water. The size and physiography of these coastal tracts vary a great deal, depending on whether they are in association with rivers, tidal creeks, backwaters or with large lakes, among which mention must be made of the Chilka and Pulicat Lakes on the east coast of India, both of which are typical brackish water lakes. They all have the common feature of extremely variable salinity conditions, but as the marine fauna of India has a large number of euryhaline species, the estuaries and brackish waters support a rich fauna including several commercially valuable fishes and crustacea. In fact as these estuarine and brackish water areas are zones of high biological productivity, they form excellent nursery grounds even for many coastal species of fish and prawns. Biologically, and from the fisheries point of view, the estuaries have close affinities with the sea as their fauna is predominantly marine and in almost all cases with the exception of *Hilsa*, the fisheries depend upon the colonization of these areas by young ones of marine species. A factor which has led to the extensive development of estuarine fisheries in the country is the fact that the areas covered are mostly shallow and exploitable without the employment of complex craft and gear.

Among the estuarine fishes, the most important is *Hilsa*. It is a migratory species of great value in the lower reaches of the rivers in Bengal and Orissa on the east coast, and of the Narbada and Tapti on the west. Mullets form another valuable group of estuarine species. The well-known Bekti, *Lates calcarifer*, the threadfins, which include species of *Polynemus* and *Eleutheronema* and many other euryhaline fishes, prawns and crabs contribute to highly productive fisheries in most coastal parts of the country.

(iii) Marine Fisheries:[1]

As regards the marine fisheries of India the striking feature is the differences between the western and eastern coasts of the Peninsula. As judged by the present day landings which are predominantly based on the fishing carried out within the narrow coastal range of 5-7 miles from the shore, about two-thirds of the total landings of marine fish come from the west coast, where apparently the water masses adjoining the coast are of an oceanic character and enriched by the nutrient-laden waters of the Bottom Antarctic Drift as well as by the Somali Current, which moves northwards from the coast of East Africa and sweeps round at the head of the Arabian Sea moving downwards along the west coast of India. The turbulance of the inshore waters, within the continental shelf which has an approximate width of about 50 miles, caused by the heavy Southwest Monsoon winds, the mud suspensions which probably act as reservoirs of nutrients, the presence of submarine ridges like the Carlsberg and Murray Ridges in the Arabian Sea are all factors which make the west coast having more productive fisheries than the east coast. The pattern of the east coast is largely influenced by the river systems opening into it, and the somewhat enclosed nature of the Bay of Bengal prevents active oceanic circulation. There is nothing at present to show that east coast marine fisheries are poor in off-shore waters; in fact rich marine fishing grounds have been located in waters off the mouths of the Ganga and Mahanadi at the head of the Bay in the exploratory activities of the cutters operating for the Bengal Government. The scientific evidence available at present points to the western coast being more productive.

Notwithstanding the broad demarcation indicated above, the fisheries of either coast are not uniform in character throughout the length of each coast. This may be seen from the following enumeration of the chief biogeographical zones as understood from the fisheries point of view. Starting from the north western part of India, the coast of Kathiawar has, in common with the Pakistan coast, an extremely valuable fishery of Sciaenids (*Ghol* and *Dhoma*) which appear in large numbers during certain seasons of the year, considerable landings of Polynemids (*Rawas* and *Daras*), Clupeids, perches and sharks and rays. Ghol, Daras, Rawas and Pomfrets are first class table fish occurring in large concentrations off Kathiawar. The Gulf of Cambay and the strip of the coast north of Bombay share many features with the Kathiawar coast, but owing to the influence of the Narbada and Tapti there is a development of the estuarine fisheries as well and, further down, the fishery for Bombay Duck, *Harpodon nehereus*, and eels is well marked. Both the *Ghol* and Bombay Duck are not pelagic in the sense we understand the mackerel and sardine fisheries which are best developed to the south of Bombay. The Konkan coast is noted for the mackerel, *Rastrelliger kanagurta*, enormous shoals of which appear during the October-January period. Mackerel is a most important fishery throughout the west coast of India from the Konkan to the Travancore coast, but shoals are not encountered to the south of Quilon. On the Kanara and Malabar coasts, the mackerel, although

[1] This section is adapted from the author's article in the Handbook of Indian Fisheries, op. cit.

seems to be the absence of large shoals of mackerel and oil sardine, although small numbers of them are noticed; their place seems to be taken by the less valuable clupeoids, horse mackerels and leiognathids. It will be obvious from this survey that the fisheries of the east coast, which now yield only about a third of the total, are more diversified in character than those of the west. It is probable that the smaller output is correlated to socio-economic factors, not least of which is that the west coast fisherman is a better seaman and that conditions of transport and utilization here are not as well developed as in Malabar. While the west coast will be suitable for large-scale production followed by industrial exploitation of fewer fisheries like the clupeids, mackerel and prawns, the east coast would, if developed, substantially increase the supplies of sea fish for consumption in the fresh state in an area where the level of nutrition is already very low.

5. Fishery Biology & Fishery Management

General

It is futile to attempt fishery management without adequate knowledge of the biology of the fishes concerned, and in the present stage of our development it is natural that much attention should be paid to studying the biology of our commercially valuable species. This work is made somewhat difficult owing to certain natural factors over which we have no control. In countries with colder climates, speciation takes place less rapidly than in the tropics, and it is a common experience that in the place of single cold water species of importance we find in our waters a large number in the same family. In many instances instead of single species fisheries, there is in our waters groups of species comprising combined fisheries, most of them having such very similar features and apparently similar habits as to render their separation and study extremely difficult. Both in marine fisheries as well as in inland fisheries, sound taxonomic work is necessary for the correct recognition of species and subspecies. Much work on fish taxonomy has already been done in India, and excellent work continues to be done by the publication in parts of the series Fishes of the Indo-Australian Archipelago, started by Weber and De Beaufort, now being continued by the latter.

New Systematics

In former days most species have been described from single specimens and even when large series were available, the emphasis has been to find the extremes of characters rather than the range of common occurrence of particular characters. In recent times, thanks to the development of statistical concepts, increasing attention is being paid to the analysis of characters, based on frequency distributions and the correlation of characters with specific delimiting factors. Although we have a considerable number of workers on the taxonomy of fishes, their background is even now the museum concept rather than the genetical concept. This criticism can, in fact, be applied to many centres of taxonomic work all over the world. It is unfortunate that close study and analyses of characters based on large populations of species with a view to revising the taxonomy of groups of fishes of commercial value is not being taken up by any one. Investigations of this type are closely bound up with the problem of racial stocks of fishes which is so funda-

mental to understanding fisheries made up of species widely distributed as are most of the Indo-Pacific forms.

The 'New Systematics' which has emerged by the impact of genetical concepts on problems of taxonomy is equally dependent on physiological ideas on species and races. Physiological investigations have generally been lagging behind in India owing to the paucity of qualified workers, but the development of this discipline will be essential if we are to make sound progress in fish cultural practices relating to coastal, estuarine and marine fisheries.

Morphological Studies

Considerable progress has been achieved in morphological studies relating to fishes owing to the facilities for such investigations being available at most places. Many publications have appeared on various aspects of marine and inland fishes, their food, growth, occurrence, larvae, spawning seasons, life-history, parasites and a host of similar problems, but the large majority of these studies are random contributions and, even now, there are few species of fish of which it could be said that a reasonably all round picture is known. Examination of fish stocks, year classes, rate of recruitment, exploitable margin and such basic information relating to fisheries has not been obtained for any of our commercial species, although workers at the Central Fisheries Stations have begun to apply themselves to these aspects. Controlled growth studies, so essential for the development of fish culture on scientific lines, have hardly been attempted but here again recent efforts are being made both at Barrackpore and Mandapam. It could perhaps be said that on the whole the work at present does not match with the standards set by the more advanced centres of fisheries research, but the answer to this may be found in the introductory section. Apart from the late beginning, the preliminary stages required the development of almost a new discipline unfamiliar to the majority of Indian workers who also had to cope with inadequate facilities at various levels in their programme. What has been achieved during the past five years is encouraging, and one can say with confidence that considering the various difficulties which had to be surmounted in the initial stages, it is doubtful if more could possibly have been accomplished by any other band of investigators under similar circumstances. Objective fisheries research as has been developed in other countries has placed emphasis on varying aspects and in the integrated development of this science in our country, the orientation needed is for increased exploitation in marine fisheries, conservation of coastal fisheries and expansion of the culture fisheries.

Applied vs. Pure Research

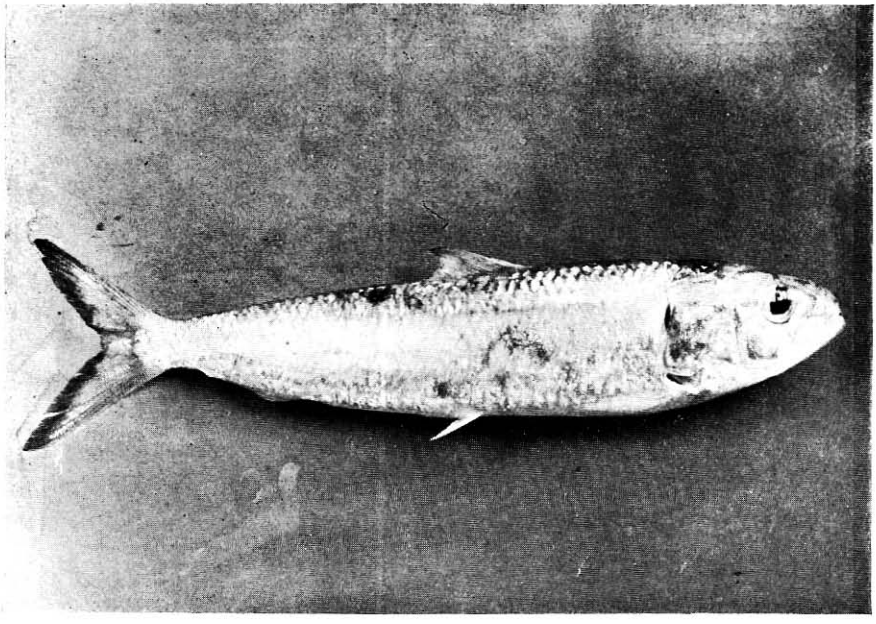
There is a small but influential school of thought in Indian scientific circles which considers that the fisheries institutions are devoting far too much time and energy to problems which are purely of an academic nature, unconnected with actual fisheries. This criticism is in a large measure unjustified, but it does not mean that there is no further room for improvement in the research programmes and their execution which, as workers become experienced, are bound to improve. On the other hand, inconsiderate criticism as has been voiced in certain quarters will react adversely on the overall necessity to obtain a larger measure of public support for scientific work on fisheries than is now available. It has already been indicated that there is much

preliminary ground to be covered in the purely zoological and botanical aspects, which it would have been unnecessary for fishery workers to devote to, had knowledge of aquatic animals and plants in this country been sufficiently advanced. When any fishery problem is bound up with groups of organisms whose scientific study is inseparable from that problem, such studies have to be pursued by some members of the teams. Similarly it would be disastrous to the growth of scientific knowledge if workers begin completely ignoring any new fact or relationship which they may discover during the course of their work, although it may not be possible to give it the 'fishery' stamp. There cannot be any sharp distinction between pure and applied research. For the success of the latter, there will arise problems which have to be pursued with that amount of thoroughness necessary to establish facts with sufficient experimentation and control, which might give others the impression of an academic approach. Similarly, what some of these critics consider as academic are some of the very problems to which much attention is paid elsewhere. It would never be in the interests of fishery research and, in fact, of scientific advancement of the country to ignore the fundamental aspects of the various sections of a composite subject like the fisheries which is the meeting place of a number of disciplines of knowledge. Healthy development of new ideas and techniques can be expected only if the researchers are allowed a certain measure of freedom within the programmes without subjecting them to judgment based on short-term achievements of applied value. Nothing would please a fishery scientist more than the discovery of facts of practical value to the industry and to the country as a whole, but it is not his fault if short cuts to such findings do not exist.

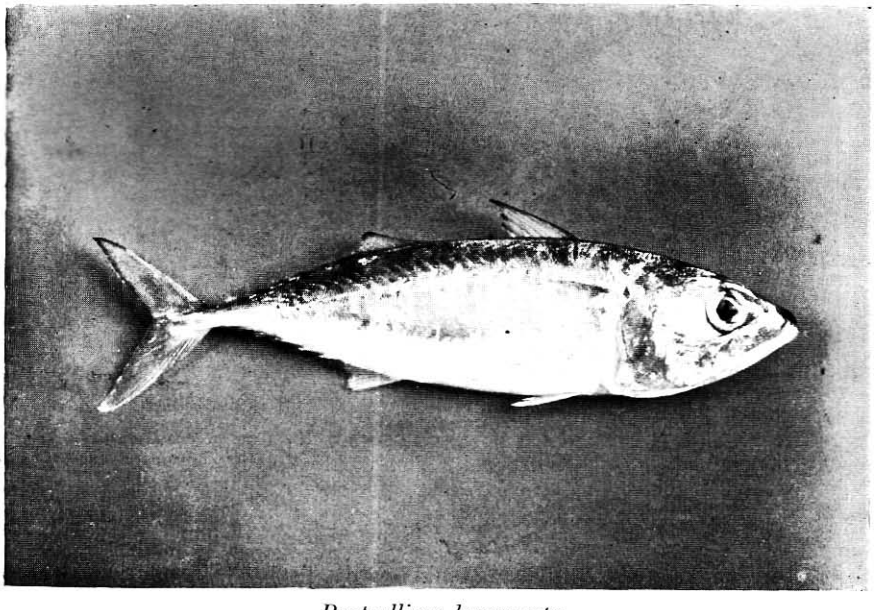
We may now examine the problems presented by some of the major fisheries both marine and freshwater. The oil sardine of Malabar and the Indian mackerel and the Hilsa will be discussed as they form outstanding fisheries in the country formed of single species. This will be followed by problems relating to group fisheries.

Sardines: The fishes belonging to the family Clupeidae rank first in world production; in India too they constitute about a third of the sea fish production represented by the oil sardine (*Sardinella longiceps*) and other related sardines (*S. fimbriata, S. gibbosa* and *S. sirm*), the anchovies (*Thrissocles* spp.), the white bait (*Anchoviella* spp.), the rainbow sardine (*Dussumieria acuta*), the white sardine (*Kowala coval*) and many other clupeoids yielding small-scale fisheries. There is large fluctuation in their annual yield, which is most pronounced in the oil sardine, the most valuable clupeoid of India. The species is widely distributed and is landed on the coasts of Arabia, Iran, Pakistan, Ceylon, Andamans and Indonesia, but large-scale shoals seem to be limited to certain areas only, for example the Malabar and Kanara coasts alone in India. The fishery starts after the commencement of the South-west Monsoon but the peak period is after September extending to January, a time when the entire coastal fishing population concentrate their efforts to catch sardines with large boat seines and gilling nets so efficiently operated in Malabar.

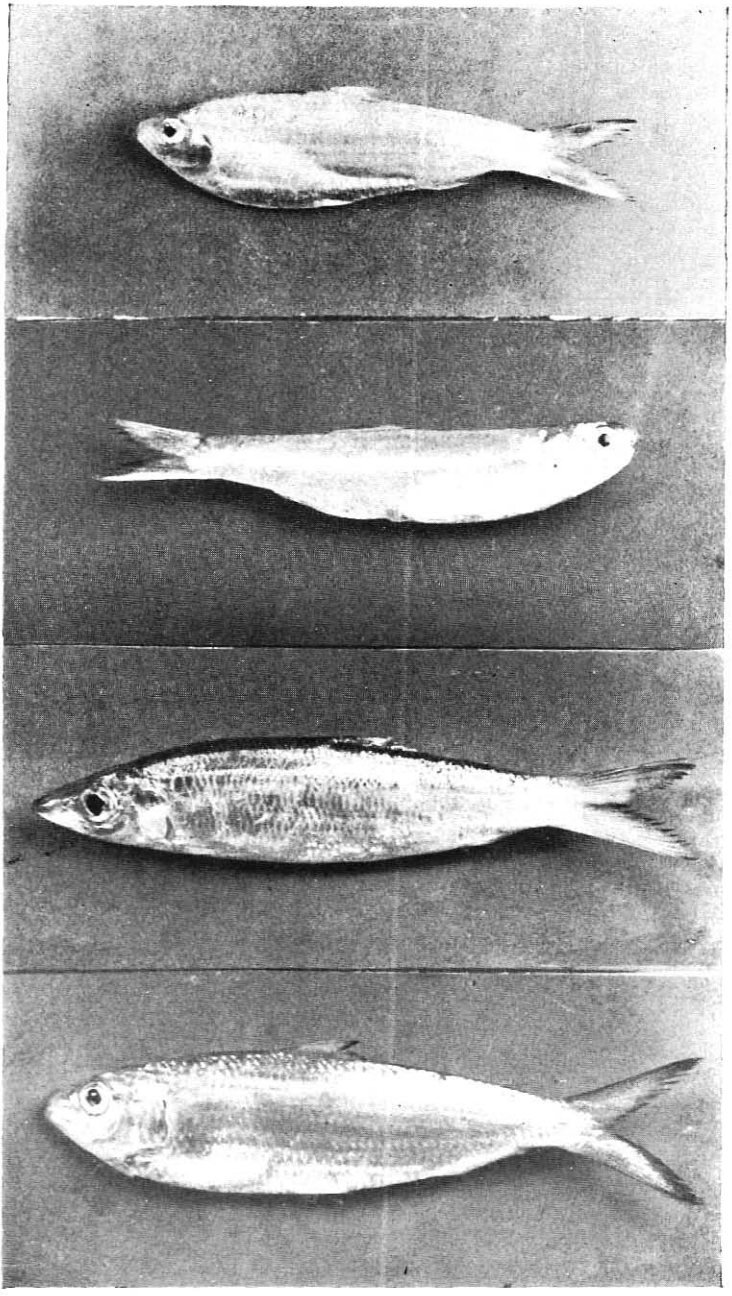
It will be easy to picture the calamity that would befall the industry if shoals which are accustomed to appear on the coast do not appear in certain years, or the shoals arrive at unforeseen times. But it is



Sardinella longiceps
The Oil Sardine of Malabar



Rastrelliger kanagurta
The Indian Mackerel



Other Common Sardines from the Malabar Coast

1. *Kowala coval*; 2. *Anchoviella commersonii*; 3. *Dussumieria hasseltii*; 4. *Sardinella fimbriata*

precisely the irregular and undependable nature of this fishery and the great decline of the shoals in recent years which have constituted a serious problem. Nair & Chidambaram (1951) have reviewed the subject. From their work the following table of landings for the oil sardine is reproduced below after adding the figures for 1950-52.

TABLE II

Statement of estimated landings of Oil Sardines from the fish-curing yard registers in the South Kanara and Malabar Districts

Seasons	Oil sardines landed in maunds		Total in maunds
	South Kanara	Malabar	
1925-26 ...	6,50,707	5,41,742	11,92,449
1926-27 ...	74,021	3,22,626	3,96,647
1927-28 ...	63,673	1,29,339	1,93,012
1928-29 ...	8,465	39,968	48,433
1929-30 ...	42,122	31,656	73,778
1930-31 ...	4,824	1,11,048	1,15,872
1931-32 ...	17,175	41,378	58,553
1932-33 ...	212	29,901	30,113
1933-34 ...	7,96,805	11,26,788	19,23,593
1934-35 ...	10,796	5,47,414	5,58,210
1935-36 ...	961	39,188	40,149
1936-37 ...	1,22,365	6,05,361	7,27,726
1937-38 ...	76,445	3,79,592	4,56,037
1938-39 ...	66,873	24,576	91,449
1939-40 ...	78,240	1,11,724	1,89,964
1940-41 ...	2,90,603	3,86,406	6,77,009
1941-42 ...	13,442	1,05,789	1,19,231
1942-43 ...	690	23,948	24,638
1943-44 ...	5,867	5,991	11,858
1944-45 ...	17,472	123	17,595
1945-46 ...	195	281	476
1946-47 ...	30	207	237
1947-48 ...	25,494	6,419	31,913
1948-49 ...	6,645	1,144	7,789
1949-50 ...	16,083	74,744	90,827
1950-51 ...	41,102	1,29,462	1,70,564
1951-52 ...	19,500	2,71,694	2,91,194

TABLE III

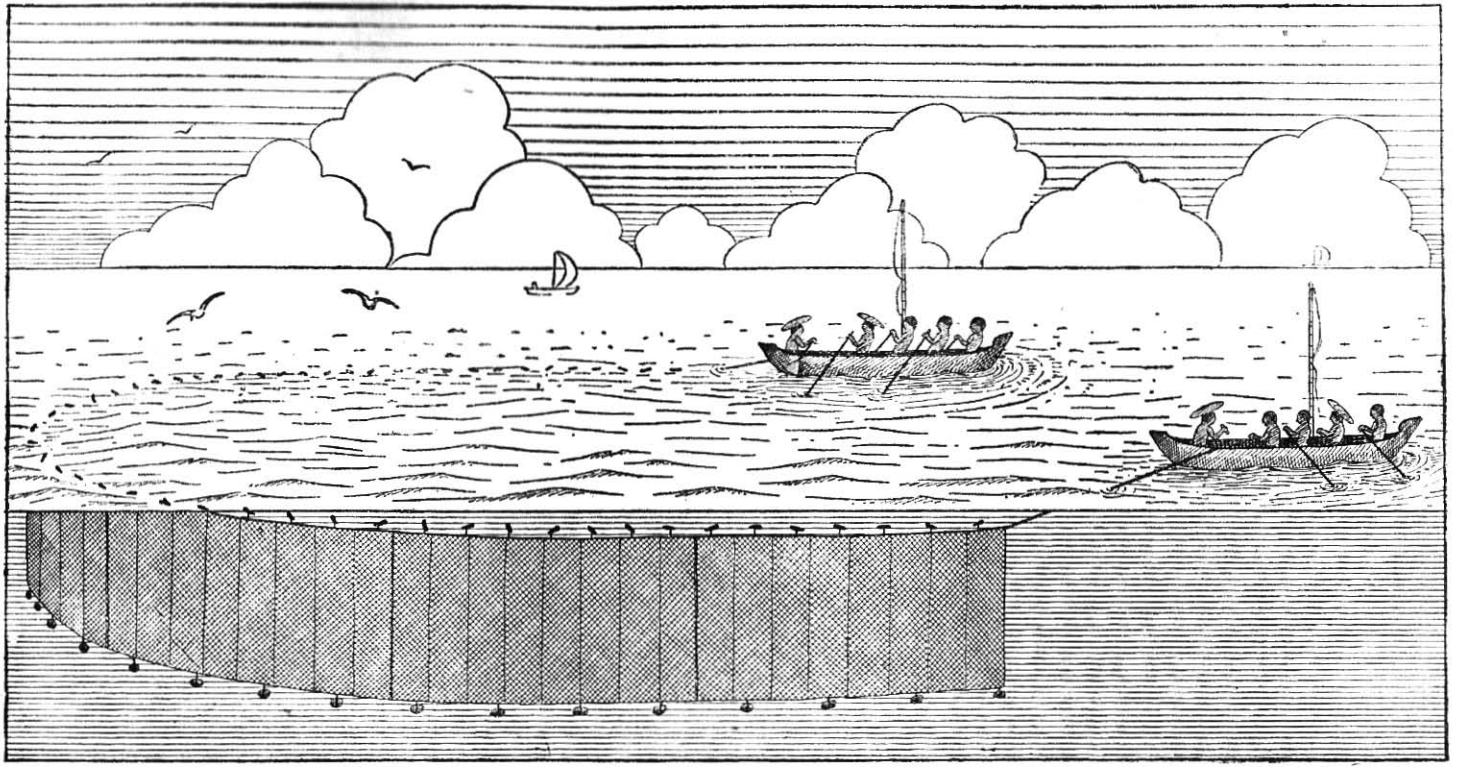
Table showing the approximate landings of Oil Sardines in South Kanara and Malabar for the years 1950–52

Month	S. Kanara	Malabar
	Mds.	Mds.
1950		
July	—	660
August	50	3,975
September	—	276
October	490	2,932
November	4,615	17,180
December	27,199	64,011
1951		
January	6,860	31,398
February	1,888	9,725
March	—	40
April	—	265
May	—	—
June	—	—
July	—	905
August	810	6,705
September*	11,595	71,590
October	6,475	1,58,444
November	—	1,010
December	520	5,070
1952		
January*	100	18,110
February*	—	5,110
March*	—	4,750

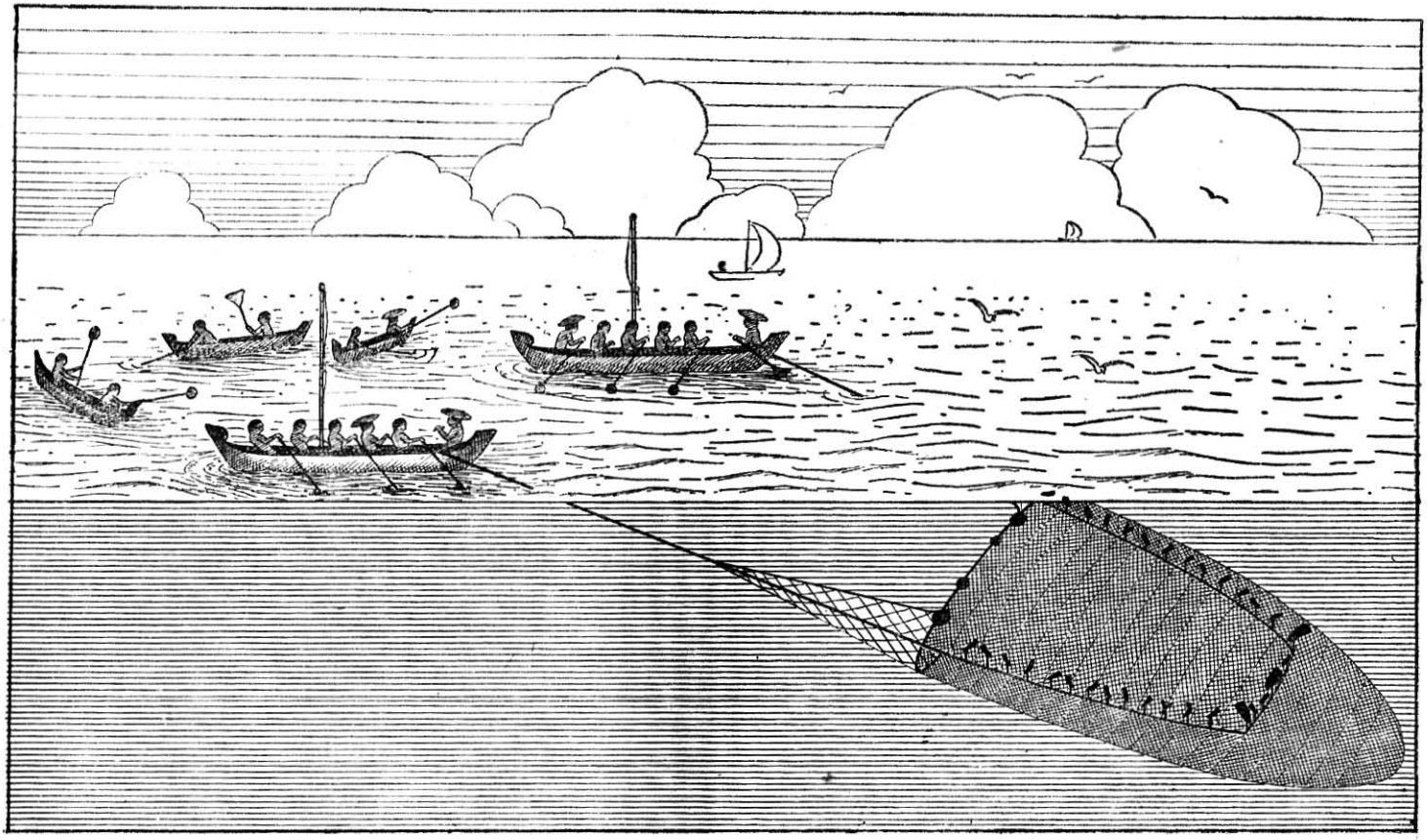
*Data incomplete.

The available statistics show that the fishery was extremely rich in the latter half of the last century which resulted in the oil extraction from sardines forming a lucrative industry with the increase in value of the oil. Large fluctuations were, however, evident in the landings even in those days, but from 1926 a new and unprecedented phase of decline set in. There was again a notable recovery in 1933-34 followed by further falls and slight recoveries, but the fishery dwindled to practically nothing in 1941-42. Improved landings were noticed again in 1949-50 and there has been an encouraging increase in sardines from that date; in fact the fishery as may be seen from the tables has been of some magnitude during the current year.

The oil sardine has been the subject of study by the scientists of the Madras State Government for a number of years; since 1947 the work has also been taken up by the Central Marine Fisheries Research Station of the Government of India. Various views on the length of life, spawning, rate of growth and other biological features have been put forward, but it is obvious that more reliable data are needed to establish many facts relating to its biology. The fish has a maximum size of 22-23 cms.; the commercial catches are predominantly the juveniles varying from 12–15 cms. All investigators are unanimous in ascribing



Sardine fishing in Malabar. Operation of the *Mathi-Chala Vala* (gill net) handled by two boats. The net is seen encircling a shoal of sardines. (Sketch by Shri R. V. Nair).



Sardine fishing by the *Mathi-Kolli Vala* which is a specialized seine net exclusively used for the oil sardines. (Sketch by Shri R. V. Nair).

the success of the fishery to the abundance of immature young sardines. The sardine is a plankton feeder and spawning is from August to November, probably commencing with the onset of the S. W. Monsoon. Sexual maturity is attained by 15 cm. sardines when they are certainly more than a year old, but the exact age of spawners is not established. According to Nair the life span is 3-4 years and sexual maturity is at the end of two years.

In the scientific study of this fishery one of the major problems to be solved is how far intensive fishing is inimical to the fishery. From the time of Day the possibility that the sardine fisheries were being over-worked was constantly in the minds of all investigators on the subject and it was believed by the fishermen that the introduction of the close-meshed 'Kolli vala' which was a much more efficient net for catching small-sized sardines than other nets, was one of the chief causes for the decline of the fishery. In olden days the sardines were caught only by the large Boat Seines or 'Paithu vala', but when the industrial demands for the fish grew regardless of size (which was immaterial in oil extraction) the more destructive nets were introduced.[1] In 1943 the Madras Government introduced legislation to protect the fishery in the Malabar and S. Kanara Districts. The legislation which was mainly intended to prevent the more efficient nets being used to capture the small-sized sardines throughout the year and to protect the spawners, lapsed in 1947. During the time the legislation was in force there have been many practical difficulties in its enforcement. It is fairly evident at present that enough is not known of the sardines to formulate legislative measures.

It would obviously be of the highest practical value to determine the causes responsible for the great fluctuation in the fishery, and thereby modify fishing operations so as to obtain a steady annual yield, at least avoiding total failures which would throw the entire shore establishment idle and, finally, to have a system of predicting the time and magnitude of the fisheries beforehand. If the fish cannot be had in their normal haunts, can they be fished elsewhere? If the recent decline has been due to overfishing, the establishment of close seasons to protect spawners and probably other measures will be necessary. The sardine fisheries is a world problem because their decline has been observed in various parts of the world. There is a considerable body of experts who attribute the wide fluctuations in these fisheries to cosmic factors beyond the control of man, and consider that under these circumstances protective legislation would serve no purpose. If the decline and fluctuations in any fisheries cannot be controlled, researches would all the same be extremely necessary to develop the prediction side of these fisheries by the correlation of oceanographical or other conditions with the abundance and availability of the fishes for fishing. The relationship of the oil sardine populations with other sardines, notably *S. fimbriata*, has also to be closely established to secure an overall picture of their relative abundance in successive years.

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[1] A seasoned fisherman of Mahé once told the author that the decline in the fishery was caused by the larger sardines forsaking the coasts in sheer disgust, on finding, from the refuse thrown back into the sea after oil extraction, what is happening to their young ones!

The Indian Mackerel *Rastrelliger kanagurta* Cuvier[1] is probably the most important marine fish of India. The fishery is composed of only a single species, it has a long season of occurrence, and the annual variations in the catches are not so high as in the sardine. It has been known for many years that lean sardine fisheries coincided with good mackerel fisheries and with the decline in sardines, it is only natural that mackerel is receiving much attention even in areas where they formerly had only the second place. The genus *Rastrelliger* is widely distributed, ranging from the Iranian Gulf to the South China Seas, and although three species have been described it is fairly certain that the Indian mackerel fishery is composed of a single species; further, it seems probable that the *Kembong* fisheries of the Malayan coast, and the *Pla-thu* of Indo-China and Thailand are all contributed by one and the same species. The districts of North Kanara in Bombay State, South Kanara and Malabar in the Madras State and the northern part of Travancore-Cochin State provide the chief areas of mackerel fishery, the actual range of the fishery on the west coast being from Ratnagiri south of Bombay to Quilon in Travancore. The season commences in September and continues till February. On the east coast of India, the fish appear rather erratically contributing to local fisheries near Mandapam, Madras, and occasionally as far up as Kakinada and Orissa. On the eastern coast of Ceylon there is a fishery from November to December. In essentials, its appearance throughout India corresponds to the colder part of the year although small landings of the species are by no means uncommon in many parts of the west coast during what is usually spoken of as the off-season. The fish is a plankton feeder and its shoaling on the west coast corresponds to a period of rich plankton production.

The mackerel of the commercial catches of the season are juvenile examples ranging from 18-21 cms. having very poor development of the gonads. In the monsoon months irregular catches of mackerel of all sizes varying from 7 to 24 cms. are not uncommon in Malabar (Chidambaram *et al.* 1951) and in the Kanara Districts. The juvenile examples of 18–19 cms. appear in shoals during October, and as may be expected the average size increases in the succeeding months registering the higher figures of 21–22 cms. by February and March. Although shoals disappear in the subsequent months, the mackerel obtained in small numbers are progressively larger, the maximum size being in the summer months, July and August (24–25 cms.) by which time the gonads are ripe, indicating a spawning period which corresponds with the Southwest Monsoon. This is supported also by the fact that very small mackerel from 9 to 11 cms. occur in the August/September period in Karwar, and small ones of varying sizes from 6 to 11 cms. in Calicut. It seems reasonable to consider that these small individuals do not form the fishery in the immediately succeeding months, the present indications being that it is the second year class that comprise the fishery. It is also a remarkable fact that mackerel collected in any one lot present an extraordinary similarity in the size of individuals comprising the catch, a uniformity that is most unusual in fish popula-

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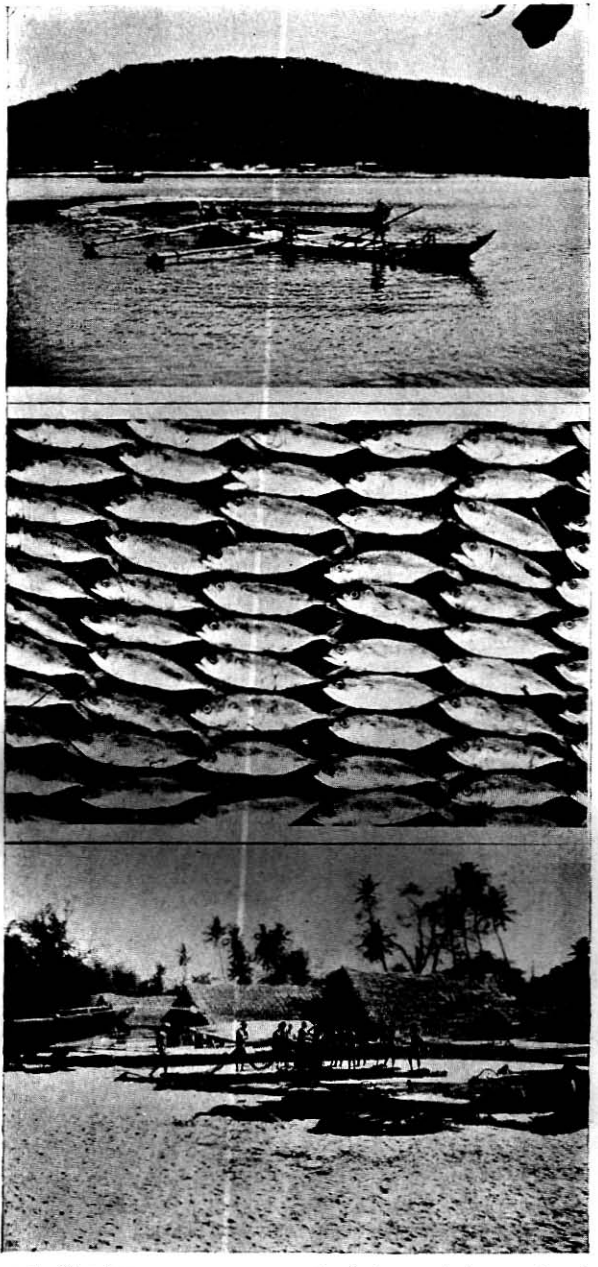
[1] *Scomber microlepidotus* of Day's volumes. For recent account of taxonomy *vide* Beaufort in fishes of the Indo-Australian Archipelago. Vol. 9, 1951, Leiden.



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1. Outrigger canoes are extensively used in mackerel fishing. Photograph shows a canoe with mackerel in Karwar Bay.

2. Fresh mackerel gibbed, salted and kept for drying. Note the uniformity in size.

3. Mackerel fishing village on N. Kanara coast. Note the outrigger canoe, nets, fishermen, huts and curing yards.

1

2

3

1. The Rampani nets, which are very large shore seines, are extensively employed in mackerel fishing in the Kanara coasts. The photograph shows one arm of the net being drawn ashore.

2. The mackerel encircled in the net are kept impounded near the shore until the arrival of launches from Bombay. Photograph shows the boats and impounding net with their floats.

3. Impounded mackerel are hauled ashore in batches as required. At the back may be seen a launch loading mackerel with ice for being transported to Bombay.

tions.[1] While such a uniformity may be expected of smaller examples not many months old, the very narrow range of size variation in a second year class is so pronounced as to throw suspicion on their age. It is needless to add that much remains to be known, but we shall have achieved much when a complete story of the Indian Mackerel is available to us: Where do the first year fish disappear to their feeding grounds? Which are the spawning grounds? Is spawning intermittent and extending for a long time as in the Atlantic Mackerel? What are the factors which control their movements and cause fluctuations in the fishery? We have no data to show whether the fishery is worked at its optimal level. The present operations are more or less coastal and it remains to be found out whether mackerel operations could be extended to the off-shore waters. Both sardines and mackerel appear earlier in the south and slowly extend northwards and their disappearance from north to the south also follows a similar pattern. These two fisheries require close study under an integrated programme because it is becoming increasingly clear that they form two major aspects of the *neritic pelagic complex* [2] of the west coast waters. Information is badly needed on the extent of off-shore stocks of both these fishes which are unexploited at the present time.

The introduction of carrier launches for the mackerel in 1936, and the steady increase in the fleet of launches operating between Bombay and the mackerel centres of Malwan and Karwar have had a healthy effect on the development of this fishery because it has become possible to land large quantities of mackerel for the people of Bombay at a reasonably low price. The operators have already shown a way of minimising the risk involved in the trade by the practice of impounding mackerel on the Karwar Coast, in the large Rampani nets in which they are caught, between the time of capture and the time they can be packed in ice in carrier launches arriving from Bombay. Researches on mackerel should further help in the prediction and assessment of the annual fishery, improvement in the efficiency of operations by closer knowledge of the habits of the mackerel and, above all, to assure that nothing is done to the stock of fish which might lead to decline in the yield as has occurred in the sardines.

(To be continued)

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[1] I am indebted to Prof. W. Rich who drew my specific attention to this point.

[2] The term was coined at the first meeting of the Indo-Pacific Fisheries Council at Singapore to denote the problems relating to the pelagic fisheries of the coastal areas as against true pelagic fisheries of off-shore waters.