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Fisheries of the Asian Countries Bordering the Indian Ocean

N. K. Panikkar and *S. N. Dwivedi*, National Institute of Oceanography, CSIR,
Rafi Marg, New Delhi

I. Introduction

A disturbing factor of world food production and consumption is that the peoples of Asia and Africa who form nearly two-thirds of the world's population have to share among themselves about one-third of the total world food output. Inadequacy of food for the growing populations of these countries poses many problems of concern to the whole mankind. Even among sections of the Afro-Asian peoples who are considered well-fed the nutritional standards are low; malnutrition is widespread and protein deficiency acute. It is universally accepted that one of the most effective means of providing adequate amounts of protein at a comparatively low cost is through fish supplies by utilizing the resources of the sea and inland waters to the full.

This Symposium deals with one of these aspects, namely, the provision of animal protein to the peoples of Asia from fisheries in the context of their growing demands as may be visualized towards the close of this century. We propose to give in this paper a general survey of the status of fisheries in the Asian region and also indicate the probable total requirements of fish products.

An attempt is made to indicate the scope of increase, possible areas where such increase could be effective, the methods which would probably be successful in obtaining larger yields and thereby to give an overall assessment of the future fisheries situation. Special reference is made to the problems of the countries around the Arabian Sea.

II. Nutritional Requirements and Fish Yields

The consumption of total animal protein food in kilogram per head per annum is 241 for North America, 226 for Oceania, 141 for Western Europe, 120 for Eastern Europe and USSR, 51 for Near East, 29 for Far East and 40 for Africa. Of this fish consumption in kg. per head per annum is 5.0 for North America, 4.0 for Oceania, 8.0 for Western Europe, 6.0 for Eastern Europe and USSR, 2.0 for Near East, 5.0 for Far East and 3.0 for Africa [FAO Third World Food Survey, 1963]. Details in respect of recent fish availability per caput per year for different countries are given in Table I. The immediate

Table I. Per caput fish supplies available in some countries
(Figures in kilograms per caput per year)

Country	1952—53	1955—56	1958—59	1961—62	1962—63
Europe					
Denmark	12.6	13.8	15.1	16.1	16.0
Finland	10.4	11.2	11.0	10.5	9.1
Norway	20.2	19.6	17.8	20.2	20.4
Portugal	17.0	17.5	19.7	20.6	20.0
Spain	9.9	10.5	11.2	13.2	14.8
U. K.	9.8	9.9	10.1	9.5	9.2
America					
Canada	6.2	6.0	6.7	5.6	5.6
USA	5.1	4.9	4.8	4.8	4.8
Asia					
Ceylon	5.4	5.1	6.1	6.0	6.2
India	0.9	1.1	1.0	1.0	1.0
Japan	19.5	22.1	24.7	26.6	27.8
Pakistan	1.0	1.6	1.5	1.6	1.6

need to augment protein supply in Asia is obvious from these figures. In the Asian countries which are situated around the Indian Ocean this gap can be filled to a considerable extent by obtaining increased food supply, particularly fish from the oceans and to some extent from inland water resources. This is supported by the knowledge that sea can be quite productive in many regions of the world. It is estimated for example that from an acre of sea water an annual yield of 1 to 3 tons of dried organic matter can be obtained [Finn 1960].

The trend of world fish production in the last few years (Table II) clearly shows possibilities of obtaining higher yields from the ocean to support the needs of the growing world population.

The total world fish catch in 1964 was 51.60 million metric tons which is about 2 $\frac{1}{2}$ times the production in the year 1950. A significant increase in production has been registered, particularly in countries of Asia, South America and in the USSR where in 1964 respectively 19.00, 11.13 and 4.48 million metric tons of fish were produced. In Asia the picture is not as bright as reflected by total production because Japan alone produces about 7 million tons of fish. At the same time this shows that with an overall develop-

ment in technology and a well planned intensive programme of fisheries development, the present fish production and utilization can be increased substantially.

Table II. World fish catch in different regions from 1948 to 1964 (Landings in million metric tons)

Year:	1948	1950	1955	1960	1961	1962	1963	1964
Africa	0.83	1.06	1.71	2.26	2.44	2.57	2.66	2.91
America North	3.62	3.78	3.95	4.08	4.33	4.48	4.37	4.28
America South	0.49	0.53	0.83	4.46	6.27	8.28	8.42	11.13
Asia	6.85	7.62	11.90	17.48	18.23	18.66	18.98	19.00
Europe	6.15	6.15	7.80	8.04	8.30	8.53	8.89	9.66
Oceania	0.09	0.09	0.10	0.13	0.13	0.13	0.13	0.13
USSR	1.49	1.63	2.50	3.05	3.25	3.62	3.98	4.48
Total world catch	19.52	20.86	28.80	39.50	42.90	46.30	47.40	51.60

Fish production from all sources in the Afro-Asian countries situated around the Indian Ocean and fish caught by other countries from Indian Ocean total amounted to 4.5 million metric tons (Fig. 1). If we include subsistence fishing also which does not find a place in fish landing statistics, the total production is probably of the order of 5 million metric tons. However, in this paper we are discussing only a section of this and are concerned with fish production in the Asian countries.

Of the world catch of 51.6 million metric tons, only about 2 million tons come from the Indian Ocean; the marine catch from the Asian countries discussed here is 1.5 million tons.

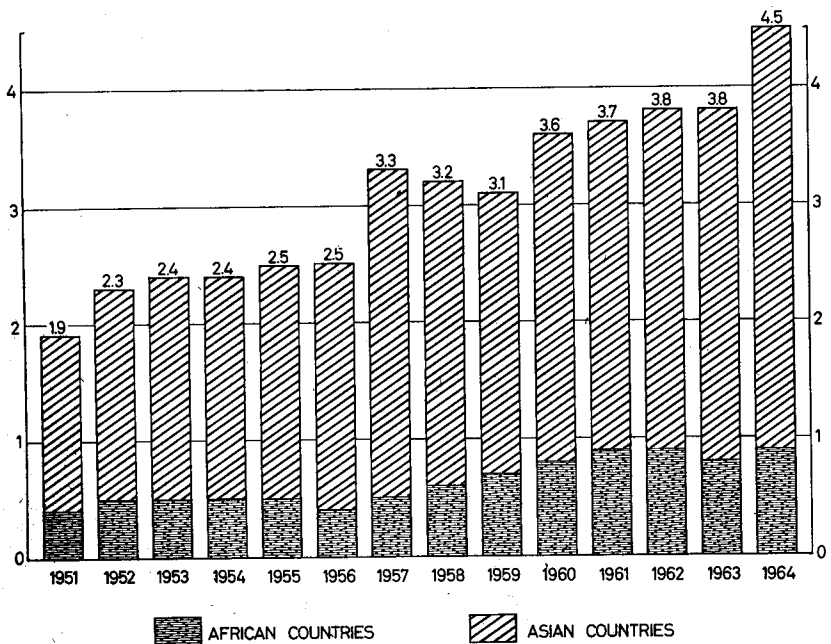


Fig. 1. Fish catch in countries adjoining Indian Ocean in million metric tons.

Apart from these catches, the inland areas of these countries yield about 0.79 million metric tons. Subsistence and unaccounted yields may be fairly high and estimated about 0.5 million tons. Thus the total fish catch of these countries (excluding Japan and China) is of the order of 2.8 million metric tons.

Fish requirement for balanced diet: The composition of a balanced diet suitable for a normal adult male to give an approximate nutritive value at 3000 calories per day would consist of 90 g. of proteins, 450 g. of carbohydrates and 90 g. fat. The protein requirement in a balanced diet is met by 10 ozs. (284 g.) of milk and milk products and 3 ozs. (85 g.) of fish and meat along with 1½ ozs. (40 g.) from eggs (one egg). These have been worked out on the basis of a diet which is predominantly based on cereals (which is the food pattern in most Asian countries) at 14 ozs. (400 g.) per day, with 3 ozs. (85 g.) of pulses, nuts and oil seeds. Table III gives the schedule as approved for India.

Table III. Composition of balanced diet

Class of Food	Quantity Ozs.	Quantity Grams
Cereals	14	400
Pulses, nuts and oilseeds	3	85
Green leafy vegetables	4	114
Root vegetables	3	85
Other vegetables	3	85
Fruits	3	85
Milk and milk products	10	284
Sugar and jaggery	2	57
Vegetable oil, ghee etc.	2	57
Fish and meat	3	85
Eggs	1½ (one egg)	40

It may be seen from the above table that milk products have been shown as the main components of protein, but the per capita output of milk is extremely small in most of the Asian countries. Likewise, meat is expensive and both milk and meat contribute to further pressure on land. For the average income group fish would compensate to some extent the reduction in meat and milk. As recommended by the Indian Nutrition Advisory Committee, for calculation purposes, the requirements may be put down at about 2 ozs. (57 grams) of fish per head per day as the essential protein requirement from fish for people who consume fish.

On the basis that about 60 percent of the people in India would accept fish, and 100 percent in all other Asian countries around Indian Ocean, the total requirements of fish for the Asian countries of the Indian Ocean will be of the order of 12 million metric tons. The present population and minimum fish requirement (as for 1965) and projected population and requirement of fish for the year 2000 A. D. are given in the Table IV. At present there is a deficit of approximately 10.5 million tons of fish even to fulfil the minimum fish requirements for a balanced diet.

According to a basic study made in connection with the Freedom from Hunger Campaign organized by FAO the total population in Asia and the Far-East by 2000 A. D. will be of the order of 3,639 million. This pre-supposes an increase in the total food available by about four times from the base value in 1958. Approximately only a third of the population figure given above concern the countries discussed in this paper on the basis of 1965 figures. At 2400 calories per caput per day the total protein requirement is of the order of 75 grams per day of which 20 grams at least must come from animal

Table IV. Estimates of population and minimum fish requirement in Asian Countries bordering Indian Ocean at the rate of 2 oz. of fish per head per day

No.	Country	Present status — 1965		Projected status — 2000	
		Population in million	Fish requirement in thousand met. tons	Population ¹⁾ in million	Fish requirement in thousand met. tons
1.	Bahrain	0.16	3.32	0.32	6.64
2.	Saudi Arabia	1.00	20.74	2.00	41.48
3.	South Arabia	1.00	20.74	2.00	41.48
4.	Kuwait	0.37	7.70	0.74	15.39
5.	Iraq	6.83	142.20	13.71	284.30
6.	Iran	22.18	459.90	44.37	919.80
7.	Trucial Oman	0.11	2.30	0.22	4.60
8.	Muscat and Oman	0.57	11.71	1.13	23.44
9.	Yemen	5.00	103.70	10.00	207.40
10.	Maldive Island	0.09	1.93	0.19	3.86
11.	Pakistan	98.61	2,045.00	197.20	4,090.00
12.	India ²⁾	276.29	5,731.00	552.60	11,410.00
13.	Ceylon	10.63	220.50	21.25	440.90
14.	Burma	23.76	492.00	47.46	984.50
15.	Thailand	28.84	598.10	57.68	1,196.00
16.	Malaysia	10.67	221.30	21.34	442.60
17.	Indonesia	100.05	2,074.00	200.00	4,148.00
Total		586.19	12,156.34	1,172.21	24,260.39

¹⁾ Projected population increase has been estimated at 2% compound rate.

²⁾ Calculations have been made for only 60% of India's population, which is non-vegetarian. The percentage of non fish eaters is likely to diminish in future.

products. Assuming that half of this will be available from milk and animal products, at least 10 grams must come from fish per caput per day. On this 10 grams basis, the total requirement of fish in the Asian countries discussed here is of the order of 2.14 million metric tons as against the present production of 1.5 million metric tons. This requirement is, however, on the low side because in most countries of Asia, milk and meat are expensive and beyond the reach of a large section of the population. It would thus be safer to proceed on the basis of 20 grams fish per caput requirement.

Table V. Population and fish requirements in million metric tons at different nutritional standards

Year	Population projection in million	Proposed fish requirement per caput / day		
		10 grams	20 grams	2 oz. (56.70 gms.)
1965	586.2	2.14	4.28	12.15
1975	714.5	2.61	5.22	14.82
1990	961.6	3.51	7.01	19.95
2000	1172.2	4.28	8.56	24.26

Here we have two estimates of requirements but in both these cases, the requirement is many times higher than the present production (Fig. 2). By 2000 A. D. the earlier calculation pre-supposes an increase from the present 1.5 million tons to about 24.26 million tons whereas the second calculation pre-supposes an increase from 1.5 to 8.56 million metric tons. The estimates of production requirements based on 10 grams, 20 grams, and 2 ozs. of fish per caput/day are given in the Table V.

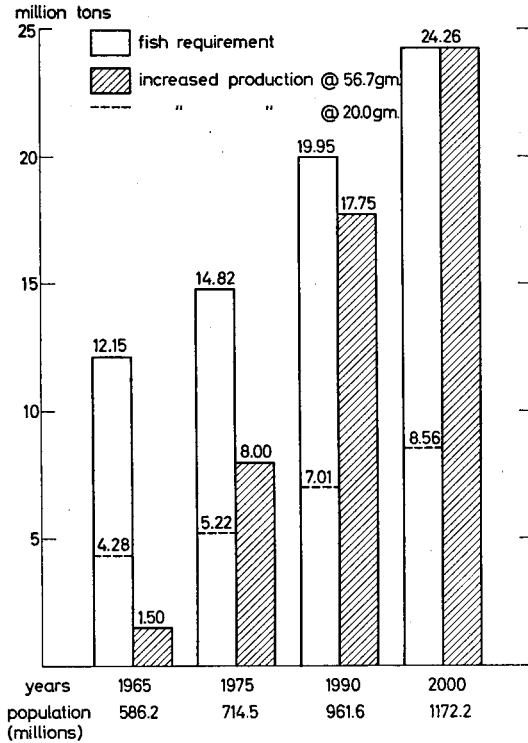


Fig. 2
Estimates of fish requirements for balanced diet and increased production in Asian part of Indian Ocean necessary to attain equilibrium by 2000 A.D. Fish requirement has been calculated at the rate of 56.7 gm. and 20 gm. of fish per head per day.

III. Present Status of Fisheries

The present marine fish production from the South and West Asian countries of the Indian Ocean discussed in this paper is about 1.5 million tons (Fig. 3). Out of this the larger share comes from the Arabian Sea. There has been an increase in the fish catch

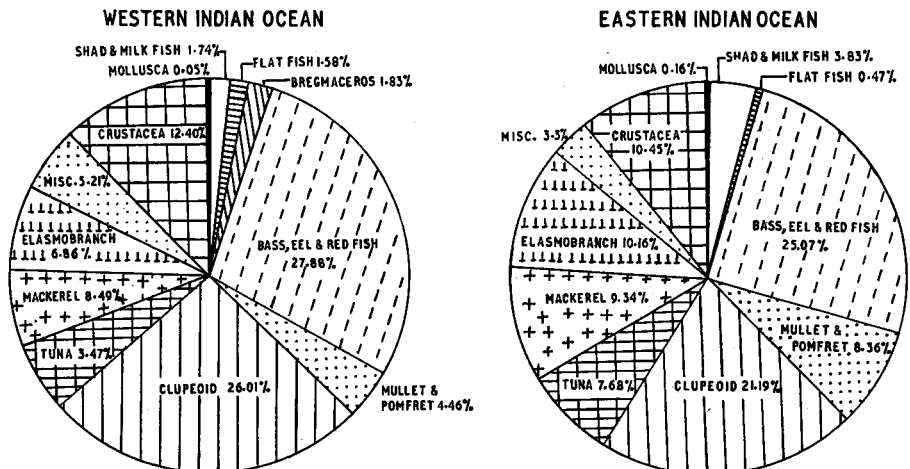


Fig. 3. Fish landings in Western and Eastern Indian Ocean according to commercial groups shown as percentage of total fish catch of the area. (Average 1961—1963.)

of the Asian countries, during the last decade, but as compared with the trends of the world production, the rate of increase has been small and inadequate to the needs.

During 1938, 47 % of world catch was landed in Asia, whereas by 1964 this fell to 37 %. If Japan and China which are the major fish producing countries of Asia are excluded, the picture of rest of the Asian countries is far from encouraging. The gap in fish production between the developed and developing countries has been increasing; on the other hand, in developing countries much greater quantity of fish supply is needed, because the per capita fish consumption is far behind the industrialised countries of the world and also it is far below the minimum nutritional level.

The present trends of fish productions and fishery potentialities of some important fish yielding countries or regions are indicated here (Fig. 4, 5). The composition of commercial catches are summarised in the Table VI.

Table VI. Marine fish landings of commercial groups in some of Asian Countries Bordering Indian Ocean

(Expressed as average % of total catch of the country for the years 1961—63)

Fish Groups	UAR	West Pakistan	West coast of India	West coast of Ceylon	East coast of Ceylon	East coast of India	East Pakistan	Malaysia	Thailand
1	2	3	4	5	6	7	8	9	10
Shads and milk fishes	—	9.87	0.9	18.53	17.20	2.5	14.95	0.25	21.4 ¹⁾
Soles	—	0.55	2.0	—	—	0.6	—	0.13	—
Cods, hakes, haddocks etc.	—	—	—	—	—	—	0.75	—	—
Red fishes and eels etc.	55.52	28.62	31.2	—	—	23.3	45.69	9.43	—
Mulletts, jacks etc.	13.31	1.52	5.5	—	—	13.3	2.57	13.97	—
Herrings and sardines etc.	17.64	8.26	28.8	39.41	31.77	24.8	5.2	13.69	—
Tunas, Bonitos etc.	—	6.46	0.7	28.15	29.96	0.8	3.42	1.95	—
Mackerels, bill fishes	—	6.46	9.9	—	—	14.0	3.88	12.87	7.8
Elasmobranchs	1.4	23.17	4.4	9.62	14.76	10.4	4.93	1.90	1.3
Crustaceans	6.61	14.92	13.4	2.14	3.49	5.8	18.80	11.15	7.2
Miscellaneous (unsorted)	6.6	—	2.3	1.43	1.94	4.6	—	1.90	39.4
Molluscs.	—	—	—	0.71	0.87	0.2	—	5.42	22.8

Fish landings in 1964²⁾ 72.1 87.6 672.4 3.8 5.1 187.7 50.9 241.1 577.0

¹⁾ Relates to fresh water fisheries.

²⁾ Landings in thousand metric tons.

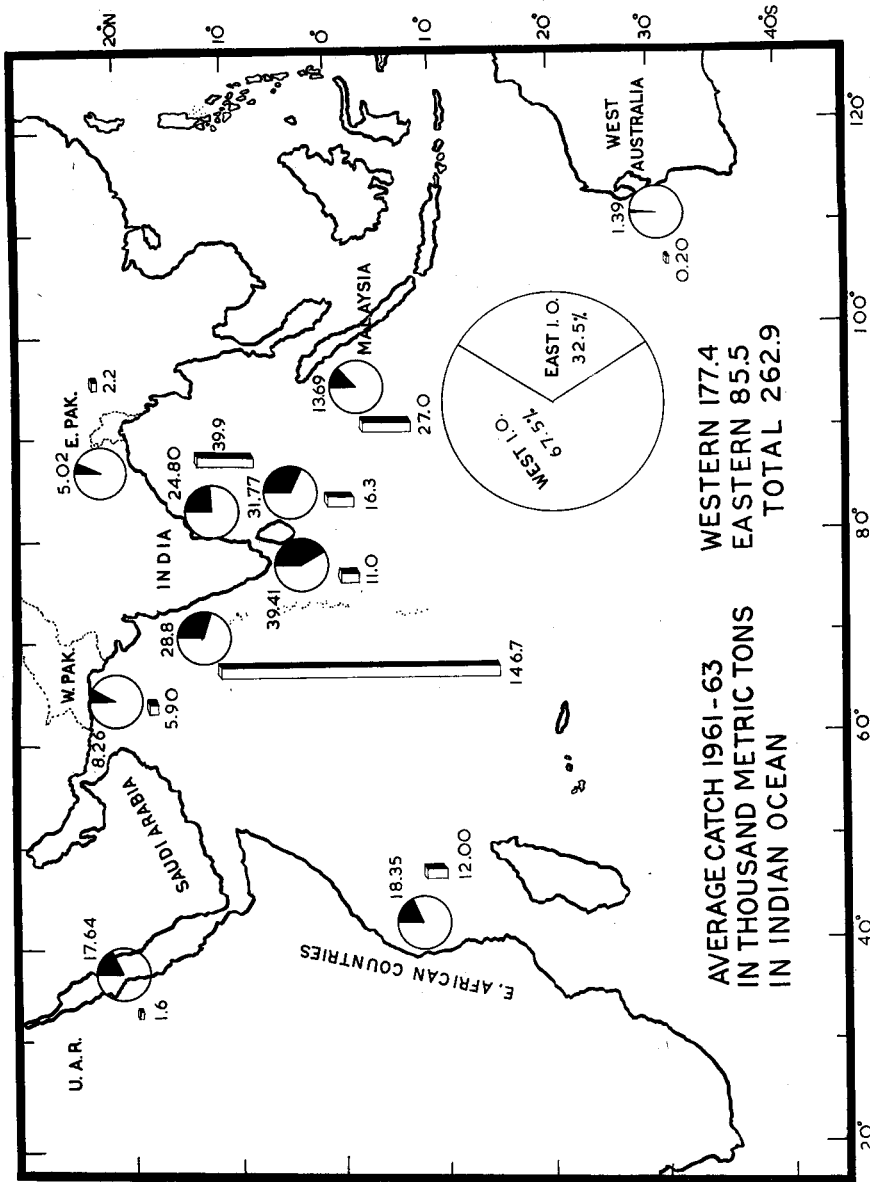


Fig. 4. Clupeoid fishery of Indian Ocean for East Africa, West Pakistan, West coast of India, West coast of Ceylon, East coast of Ceylon, East coast of India, East Pakistan, Malaysia, Australia. Vertical columns show quantity of landings in 1000 m. tons of Clupeoids; black sectors in the circle show percentage constituted by Clupeoids in total fish catch of the respective country.

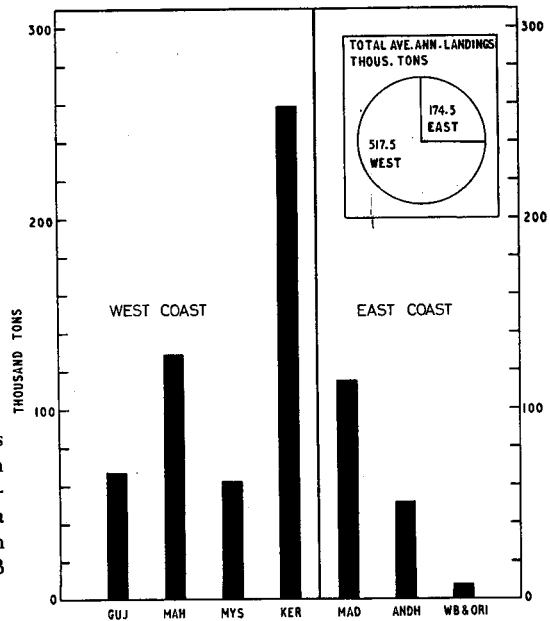


Fig. 5
Marine fish landings in different States on east and west coast of India from 1958 to 1964. Gujarat (GUJ), Maharashtra (MAH), Mysore (MYS), Kerala (KER), Madras (MAD), Andhra Pradesh (ANDH), West Bengal and Orissa (WB and ORI).

a) West Pakistan

The continental shelf along the greater part of the coast of West Pakistan is about 25 miles wide except across the Indus delta where it becomes 60 miles wide. The principal fishing season in the open sea lasts for approximately eight months starting from September till April. During the other months when monsoon is active fishing is restricted to coastal areas and creeks, the estuarine fisheries are, therefore, quite important. The total marine fish landings in 1964 were 87.6 thousand metric tons¹⁾. Bases, eels and redfishes on an average constitute about 29% of the marine fish landings. The average landing of this group during the year 1961-63 was 20.63 thousand tons. Quantitatively the next important groups are the Elasmobranchs and unsorted miscellaneous fishes each of which constitute about 23% of landings. Their average landings during the years 1961-1963 were 16.70 thousand tons. The Crustaceans are fourth in order of importance and constitute about 11% of landings. These are followed by shads which form 7% of landings by weight. It is very significant that the landings of pelagic fishery are highly fluctuating and were poor during the years reported. The landings of sardines, tuna and mackerels range between 5 to 6 thousand tons and sardines constitute about 8%, the tuna and mackerels each constitute about 6.5% of total landings. There is considerable scope for increasing catches of pelagic fisheries. The average total production from East and West Pakistan together is 340 thousand metric tons of which 220 thousand tons come from the inland waters and the rest 120 thousand tons from the sea.

¹⁾ The figures of fish production are taken from different publications of FAO. The group bases, eels, and redfishes as understood for European waters is different from the types of fisheries in tropics where it denotes miscellaneous neritic fisheries. In this group Bombay duck, croakers, goat fishes, perches, eels, catfishes, and silver bellies are important. Also the group of prawns and shrimps mentioned here refer to Penaeids.

b) India

The West and East coasts of India have very different characteristics and this is well illustrated by the fact that most of the marine fish production of India comes from the West coast. On the West coast the continental shelf is comparatively wider, between 20 to 100 miles. It is wider North of Bombay particularly off Gujarat coast but tapers slowly and becomes narrower to the South. Waters are muddy; corals are absent; so almost the entire coast is trawlable. The most productive regions are off South Gujarat and Bombay coasts and parts of Kerala coast lying between Cape Comorin and Mangalore. The East coast on the other hand has relatively narrow continental shelf throughout the entire length except on Bengal coast off the mouth of the river Ganges. Coral reefs are also present at some places. The more promising regions of the Bay of Bengal are the areas off Andhra coast and the head of the Bay.

The present marine fish landing in India are of the order of 0.8 million metric tons and is soon expected to touch the million ton mark. India at present accounts for the highest production amongst the Asian countries of the Indian Ocean. Analysis of landings of the two coasts of India show that the West coast of India flanked by Arabian Sea on an average produce more than 75 % of total fish landings in India. Fish catch for last few years on both the coasts is shown in the Table VII.

Table VII. Marine fish catch on East and West coasts of India (Catch in thousand metric tons)

Region of fish catch.	1960	1961	1962	1963	1964
East coast	148.5	162.2	157.1	163.7	187.5
West coast	729.7	521.3	487.1	491.7	629.9
Total catch:	878.2	683.5	644.2	655.4	860.4

The fisheries of the two coasts differ in the magnitude of landings as well as in the species composition and relative abundance of various groups of fish of commercial importance. During the year 1964, 860 thousand metric tons of fish was caught in India; out of this 630 tons which accounted for 78 % of total catch came from the West Coast of India and remaining 188 tons which constituted only 22 % of fish catch were landed on the East Coast of India. The composition of fish landings on the two coasts clearly bring out the differences which are shown in Table VIII.

The major components of the Indian marine fisheries, based on the landing of past few years on long term average, are the various type of Sardines (48 % of total), the Indian Mackerel (11 %) and the prawns (15 %). Amongst sardines the oil sardine of Malabar, *Sardinella longiceps*, is the most valuable. Sea fisheries are particularly important in the States of Gujarat, Maharashtra, Mysore and Kerala. In the States of Madras, Andhra Pradesh, Orissa and West Bengal although having important sea fisheries, the average landings per fisherman per annum are small being only 0.55 ton as against 4.8 tons for West coast. The difference in catch per unit of effort may also be seen in Table IX. Catches have increased slightly in recent years.

The Gujarat coast is well known for the Bombay duck which has a great demand in other Asian countries and the pomfrets which are top class table fish all over India. The prawns in the Gulf of Kutch area hold out promise for higher yields. The Maharashtra state has extensive resources of prawns, pomfrets, Bombay ducks and the Indian Salmon; Mysore and Kerala coasts are equally noted for the oil sardines (*Sardinella longiceps*)

Table VIII. Composition of commercial groups of fishery on East and West coast of India (Catch in thousand metric tons)

Fish groups	East coast		West coast	
	Quantity of fish landed	% of the group in total catch	Quantity of fish landed	% of the group in total catch
Shads, Milk fishes etc.	4.0	2.13	5.9	0.87
Flat fishes	1.2	0.63	4.9	0.72
Bregmaceros	—	—	3.7	0.55
Red fishes, Eels, Perches,				
Goat fishes, Silver bellies	48.0	25.59	137.6	20.45
Mulletts, Barracudas	20.1	10.71	38.2	5.67
Herrings, Sardines, Anchovies	47.5	25.31	323.4	48.7
Tunas	2.9	1.54	2.2	0.32
Mackerels,				
Ribbon fishes, Seer fishes	25.1	13.37	35.9	5.33
Elasmobranchs	13.5	7.19	21.4	3.18
Miscellaneous	9.5	5.06	15.3	2.27
Crustaceans	15.7	8.36	83.8	12.45
Total:	187.5	—	672.3	—

Table IX. Marine fish catch per unit of effort on the East and West coast of India (Catch / Unit effort in kilograms)

Year	East coast	West coast
1954	0.61	3.18
1955	0.67	2.85
1956	0.92	2.95
1957	0.95	3.59
1958	0.85	3.19
1959	0.95	3.36
1960	1.30	6.75
1961	1.55	4.88
1962	1.27	5.06
1963	1.66	4.94

Unit effort = Man/hour

while extensive beds of prawns occur adjoining the coast of Kerala. Further south and around Cape Comorin and also on the Coromandel coast of Madras State are considerable quantities of the seer fish and miscellaneous fisheries formed of various percoids and trichiurids. Various species of sharks and rays yielding considerable quantities of liver oil are found in both the East and West coasts of India. Andhra Pradesh and Orissa fisheries consist of miscellaneous groups of sardines, percoids, sharks and many other species. Towards the head of Bay of Bengal large concentrations of prawns and percoids exist along with other groups of small fishes. All these areas show potentialities for increasing fish yields. Studies during the International Indian Ocean Expedition period have shown that this area has a very high productivity. Within the next ten years India hopes to increase her fish production substantially by an integrated programme of development, mechanization, deep sea fishing and fish culture.

c) Ceylon

Ceylon has a narrow continental shelf extending from 2 to 20 miles all round except in the region of Palk Strait and in another small area off the North East coast. These two areas are the important trawling grounds and some Ceylonese trawlers also fish on the Wadge Bank off Southern India. Beach seining combined with gill netting and longlining for tuna are the techniques commonly used. Rafts usually 15–18 ft. long are commonly used for fishing, but recently under the development programme about 1,200 small (26 ft) decked rafts suitable for many kinds of fishing have been introduced [Hall 1964]. Mechanized vessels are being increasingly used.

The total marine fish landings in Ceylon have been on the increase and during the last 15 years the catches have more than doubled. The total fish catch in the year 1964 was 96.1 thousand metric tons. The East coast of Ceylon is more productive and it accounts for roughly 65 % of total marine fish catch. On the East coast the Clupeoids constitute the most important fish group and tunas follow closely. These groups respectively constitute 32 % and 31 % of the total catch (average 1961–63). Trawl fishes and Elasmobranchs come next and together constitute about 22 % of total catch. On the West coast also the Clupeoids and the Tunas are the principal groups and form respectively 39 % and 28 % of the catch. Like the East coast the next in importance is the group of trawl fishes and elasmobranchs. Though the production on the West coast is less as compared to the East coast but on both the coasts the pattern of fishery and the importance of different groups is similar. During recent years the tuna catches have been increasing and there are potentialities for further expansion of tuna fisheries.

d) East Pakistan

Along the entire coastline the continental shelf is broad, varying between 80 to 100 miles and the shelf has an area of approximately 170 sq. kilometers. It is shallow in many parts, the average depth has been estimated between 50 to 100 meters. The northern part is medium productive and the remaining area has a low productivity. In some parts localised seasonal upwelling has been reported which considerably influences fish catch.

The total marine fish production during the year 1964 was 51.0 thousand metric tons. The most important group consists of the Percoids, Leiognathids and Congers which alone on an average (1961 – 63) constitute about 46 % of total catch. Penaeid prawns form 19 % of total marine fish catch. Shads (hilsa) and milk fish (chanos) also constitute an important group and along with the Indian salmon constitute 15 % of the marine catch. Fishing is carried out with primitive gear and craft, and the potential of Bay of Bengal is virtually untapped. Fresh-water and estuarine fishes are very important and consequently, marine fisheries in East Pakistan have received very little attention though there are prospects for manifold increase in the production.

e) Burma

The continental shelf off Burma is in continuity with that of East Pakistan and is comparatively wide, ranging from 40 to 100 miles. The nature of the bottom in many places is rocky and coralline and there are no good shelters along the coast. The northern portion of the coast towards the Bay of Bengal becomes rough during the southerly monsoon and this adversely affects fishing.

The Burmese fisheries are in the initial stages of development. For the last few years the production has been reported at a stable figure of 360 thousand metric tons. We are inclined to think that these figures are high and probably incorrect. The detailed figures

of landings of different commercial groups are not available. It is estimated that the total fish catch is of the order of 60 thousand tons, a third of which is from the Bay of Bengal. Fresh water and estuarine fishery have greater importance in the North of Burma; in the delta of Irrawaddy catches are mostly prawns, sardines and leognathids, which are caught by surface gill nets along with the more valuable seer-fish, pomfrets, dorab and hilsa. Fisheries of Burma offer substantial scope for increased production.

f) Thailand

Thailand has two distinct parts of the coast line, in the Indian Ocean area; the coast line is small facing the Andaman Sea, where the continental shelf is rather narrow. The second part is Gulf of Thailand which is actually a part of the South China Sea. In this area all the fishery activities of Thailand are concentrated and approximately 750 trawlers operate. The fish production in Thailand has been increasing for the last 16 years but significantly so since 1959. In 1964 the quantity of fish landings totalled 577.0 thousand metric tons, which include fresh water fish which constitute about 21 % of total landings. Amongst marine fisheries miscellaneous unassorted fisheries constitute about 39 % of landings. Molluscs are very important and constitute about 23 % of the catch. The mackerel is an important fish and constitutes about 8 % of the total catch. The Crustaceans are the next important group and they constitute 7 % of landings. The seas around Thailand are highly productive and offer good scope for increased production.

g) Malaysia and Singapore

Malaysia and Singapore have a wide continental shelf all around peninsula. The East coast comes under the influence of the northerly monsoon and is more productive and about a quarter of the total fish landings of Malaysia are landed here. The use of classical fishing stakes for catching prawns particularly and also many varieties of small fishes is very common. On the Eastern part small mechanized vessels of 100 ton capacity are prevalent. Some of them undertake distant water fishing.

The Malaysian fish catch has been continuously increasing and it has nearly doubled in the last ten years. The increase had been steady and significant from the year 1959. The total fish landings in the year 1964 was 241 thousand metric tons. The pelagic fishery is important; Clupeoids, mackerels and tuna constitute about 30 % of total catch. The mackerels constitute about 14 % of total fish catch, and Clupeoids constitute about 13 %. The next important are the prawns which constitute 11 % of total marine catch. The trawl fishery is becoming increasingly important and the prospects for increased production of fish from the sea as well as from freshwater of Malaysia and Singapore are quite good.

h) South Arabia

The present annual production from the Southern Arabian coast is 52.3 thousand metric tons (average 1961–63). The principal fisheries are for Clupeoids (69.9 %), Percoids (13 %) and Crustaceans (7.5 %). Tuna fishing and substantial increase in the Clupeoids appear quite feasible.

i) Iran

Total production in 1952–55 averaged 25 thousand tons but later figures are not available. Persian Gulf has a miscellaneous neritic pelagic fishery with a high percentage of Clupeoids and Elasmobranchs. Freshwater production is considerable.

j) Iraq

An average total production of 15 thousand tons has been reported. Information on catch composition is lacking but the inland fishery resources are considerable.

k) Kuwait

Production figures are not available but it is known that over fifty mechanized vessels are operating bringing considerable quantities of miscellaneous marine fishes, principally Clupeoids.

l) Aden

Towards the West of Aden the continental shelf is approximately 20 miles wide but towards the East it becomes narrow. The important local fishery is pelagic. Sardine stocks (*Sardinella* spp.) are abundant forming a high percentage of the catch by beach seining. When there is no other good fishing, fishery for rockcod and snappers is undertaken by longlining. Yellow fin tuna fishery is an annual feature occurring between October to March. Other tuna and skipjack are fished throughout the year but their maximum catches are obtained between November to January. The best tuna grounds are situated off East of Aden.

Total chlorophyll and biomass values obtained during the International Indian Ocean Expedition indicate that the Gulf of Aden area is one of the most productive areas of the world. Exploratory longline fishery for tuna have shown a very high catch rate. This area, therefore, has potentialities for yielding considerable quantities of Clupeoid and tuna fisheries.

IV. General Survey of the Arabian Sea Fisheries

The investigations carried out during the International Indian Ocean Expedition (I.I.O.E.) have clearly demonstrated that certain regions of the Arabian Sea are comparable to the most productive areas of world oceans. There are important oceanographic differences between the two arms of the Indian Ocean, the Arabian Sea and the Bay of Bengal, and these differences are reflected already in the substantial difference between the amounts of fish landed on the East (Bay of Bengal side) and West coasts (Arabian Sea side) of India which have already been discussed. The West coast of India and Pakistan have a wide shelf and they already support a fairly large fishery. Promising fishing is indicated to the South of Arabia, Gulf of Aden, the Somali coast and the South West coast of India. Large scale upwelling of nutrient laden waters of low temperature and low oxygen takes place on the South West coast of India, in the region of Somali current off Gulf of Aden. It is probably the result of this large turnover of the nutrients and consequent plankton production that we find extensive fisheries for pelagic species in the Arabian Sea, the most notable among these being the sardine (*Sardinella*) and the mackerel (*Rastrelliger*). These species being directly dependent on the plankton have a much closer relation to the nutrient cycle than the demersal species.

The Red Sea which is an adjunct of the Arabian Sea has not been noted for its extensive fisheries. Its oceanographic features are high temperature and high salinity. The Red Sea waters considerably influence the circulation of the Arabian Sea. The principal fisheries are the sardines, percoids, mullets and a large number of neritic species. The mackerel forms a fishery of some magnitude on the U.A.R. side. The expansion of fishing is possible for sardines as has been demonstrated by the purse seining operations in the Suez area. The present yield of 20,000 tons could be considerably raised although not to the same extent as in the Arabian Sea proper.

The entrance of the Red Sea, the Gulf of Aden, has been known for good potentialities for fisheries. The Somali coast in the Gulf of Aden has a narrow continental shelf which extends to about 130 miles. The tuna and tuna like fishes are important in this area. The most important is yellowfin tuna, but Eastern little tunny (*Euthynnus affinis*), skipjack (*Eupelamis*), bonito (*Sarda orientalis*) and frigate mackerel (*Auxis thazard*) are also caught in small numbers. Apart from tuna the Indian mackerel (*Rastrelliger canagurta*) and various species of sardines are also commercially important [Fraser Brunner—1953].

The Persian Gulf is also an area of high salinity and as compared to the Western Arabian Sea, the productivity is low. There is however a moderately developed miscellaneous fishery consisting of sardines, Elasmobranchs and various Percoids. Shrimp resources appear to be considerable. Mechanized fishing from Kuwait has been quite promising but separate figures from Iran, Iraq and Kuwait are not available.

V. Oceanographic Aspects

The Indian Ocean is land locked on the North and has characteristic sea and air circulation, the latter resulting in the South-West and North-East monsoons. Their influence is pronounced both in the Arabian Sea and in the Bay of Bengal.

The combined effects of surface circulation and winds are complex but have an important bearing on the fisheries of the Arabian Sea. During summer strong off shore winds along the Somali coast result in upwelling. These cold waters move along Somali current in a Northerly direction, later along the Arabian Coast, are then deflected at least partially towards coast of West Pakistan and may even reach up to the West coast of India. This pattern is reversed with the North East monsoon when off shore winds off the Kathiawar peninsula result in upwelling particularly in the region of Gulf of Cambay [Jayaraman and Gogate 1957]. Similarly, large scale upwelling occurs during the South-West monsoon on the South West coast of India. This results in large scale movement of high nutrient laden, low temperature and low oxygen waters to the surface. Sometimes even in these productive waters, surfacing of minimum oxygen may occur and cause mass mortality. There are also instances of small scale upwelling in Bay of Bengal off Andhra coast and in some parts off East Pakistan. This results in high productivity of these regions and consequently offer good possibilities for development of pelagic fisheries.

In the waters of Arabian Sea oxygen concentrations are considerably reduced and these reach the minimum between 200 to 500 m. depth. This oxygen minimum layer is subject to movement and may come close to the surface. Very high productivity and plankton intensity may itself result in bloom. This may have been one of the conditions of death of planktonic organisms but surfacing of low oxygen waters as observed during some cruises is a probable reason for extensive fish mortality in the open Indian Ocean as reported in the year 1957. In the mid-Arabian Sea between long. 60° and 70° and lat. 10° to 20° N, mass mortalities have occurred on several occasions. Also along the West coast of India, during the west monsoon period surfacing of oxygen minimum layer has been observed [Panikkar and Jayaraman, 1966].

On Somali coast, R.R.S. *Discovery* during August–September 1964 observed dead fish concentrated in an inshore area south of Ras Maber; they also found dead fish in small numbers, southwards as far as EL Cheil and northwards to Cape Guardafui and into the Gulf of Aden. The contributory factor is divergence on the coast south of Ras Maber bringing to the surface upwelled water some 7° C cooler than normal to that region [Foxton, 1965].

The investigations during I.I.O.E. show that mass mortality in the open Arabian Sea may probably be caused in some areas by surfacing of water layers deficient in oxygen (Fig. 6, 7) and in other areas by upwelling of cold water resulting in differences of

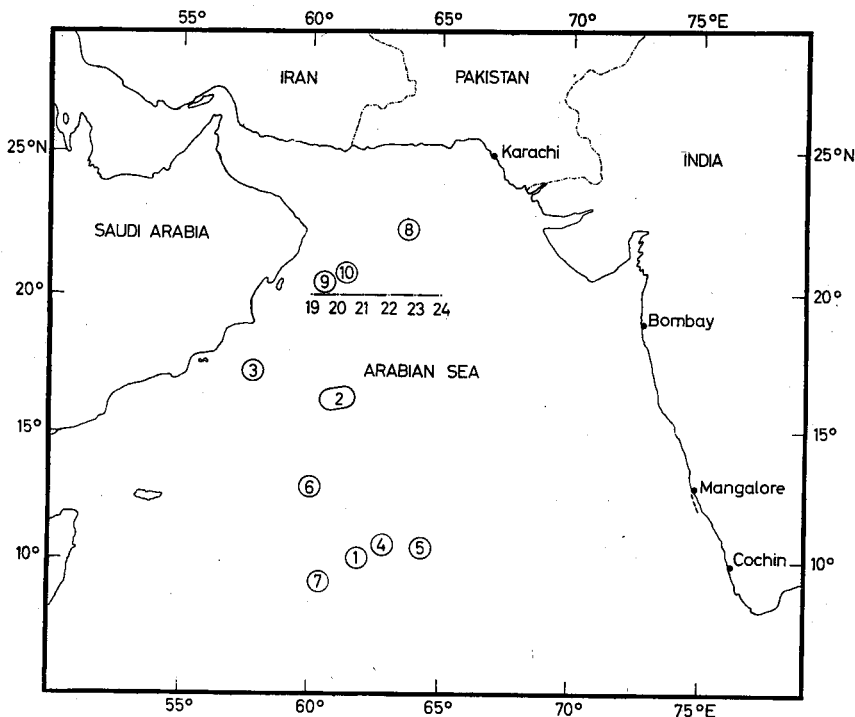


Fig. 6. Locations of mass mortality of fish in open parts of the Arabian Sea from 1955 to 1957; position of INS Kistna, Station Nos. 19—24, worked during October, '62.

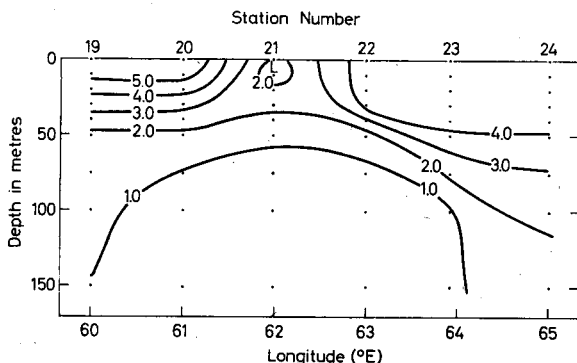


Fig. 7. Vertical distribution of oxygen along 20° N during September—October, 1962.

temperature or surfacing of matter which sets in a series of reactions ultimately causing pollution and mass mortality. The entire phenomenon is very complex and more investigations are necessary to form a complete understanding of the various causes responsible for mass mortality in these parts of the Arabian Sea.

Amongst the nutrients, distribution of phosphates is a good measure of fertility. The phosphates are present in high concentrations in the Northern part of the Arabian Sea along the Pakistan coast West of Karachi and up to areas off Muscat and Oman (60° to 68° E and 22° to 23° N). The values range between 94 and $153 \mu\text{g-at P/m}^2$. The other are is along the West coast of India, from Ratnagiri to Cape Comorin, where concentrations vary from 70 to $130 \mu\text{g-at PO}_4 - \text{P/m}^2$ with a mean of $100 \mu\text{g-at/m}^2$.

In the Bay of Bengal high concentrations of $\text{PO}_4\text{-P}$ have been reported from Thailand-Burma coasts and East of Andaman-Nicobar islands, the values ranging from 60 to $88 \mu\text{g-at P/m}^2$ (*Anton Bruun* data).

Moderate concentrations of PO_4 ranging from $40\text{--}50 \mu\text{g-at/m}^2$ have been observed on the either side of the Equator in the Western Indian Ocean. The phosphate distribution shows potentialities of fishery in the areas discussed earlier and also in the Equatorial region.

During the International Indian Ocean Expedition considerable work has been carried out in the different parts of the Indian Ocean regarding primary production, chlorophyll content, phytoplankton and the zooplankton biomass.

The primary productivity was studied during the cruises of *Galathea* and *Vityaz*. The general picture shows low productivity in southern part of the Indian Ocean below the equator and high production towards the Eastern boundary in waters off Western Australia. The Arabian Sea is a region of high productivity with values in open parts ranging from $50\text{--}120 \text{ mg.C/m}^3$. The average values in the coastal regions of Arabian Sea are 1800 mg. C/m^2 per day.

The studies on chlorophyll content show that in the Arabian Sea the areas of high productivity are the upwelling regions along the Somali-Arabian coast and the West coast of India. The area around Ceylon is the region of moderate productivity (*Atlantis II* data).

In the Bay of Bengal the Northern part of the Arakan coast of Burma is productive (*Anton Bruun* data I); the other areas have low productivity.

The phytoplankton studies indicate [Zernova and Ivanov, 1964] that the areas in the Bay of Bengal between 12° N to 8° N are rich in phytoplankton, whereas in the same latitudes some barren patches were found in the Arabian Sea.

The zooplankton biomass is being studied at the Indian Ocean Biological Centre, Cochin [Prasad, 1966]. In the Arabian Sea largest volumes have been recorded off South Eastern coast of Arabia between $10^{\circ} - 25^{\circ}$ N and $50^{\circ} - 25^{\circ}$ E and towards the open sea the volumes of biomass decrease. The production is also high along the west coast of India and around Ceylon, in the head of Bay of Bengal and in the Eastern part of the Andaman Sea.

VI. Methods of Increasing Marine Production

a) Nature of the resources

To examine the question of marine fish production in Asian countries it would be useful to indicate the resources which could give higher yields than at present. This is particularly so because the types of fisheries of the Indian Ocean are substantially different from that encountered in the colder waters of the Atlantic and the Pacific. The environmental and ecological associations on which these fisheries are based are also substantially different. As has been discussed elsewhere, the continental shelf for most countries is narrow and consequently the extent of trawling grounds is reduced which places serious limitations on the expansion of demersal fishstocks. The dense concentrations of Gadoids and Pleuronectids encountered in the north European waters are conspic-

ous by their absence. Some of the very high class table fishes are taken inshore, and in the trawls offshore are species of the families Scienidae, Stromateidae, Polynemidae and Serranidae but in terms of abundance they form only small fractions of the yield.

The most important single group of fish in the area are the Clupeoids which include the sardines, the anchovies, the engraulids and a number of related species. The most important are the species of *Sardinella* and as referred to elsewhere, *Sardinella longiceps* is one which is capable of unusually heavy yields in certain years on West coast of India and Gulf of Aden. There are, in addition, smaller fisheries composed of many other sardines distributed throughout the region, including the less productive regions of the Persian Gulf and the Red Sea. In the Gulf of Aden, on the Mekran and Pakistan coasts and on the South west coast of India and to some extent on the East coast of India, the Clupeoids form mixed fisheries in which several species are taken together. The abundance of these species and their close connection with the nutrient and plankton cycle clearly indicate that a large fraction of increased production in the Arabian Sea will come from Clupeoid fishes. These can not only serve directly as food, but also will form the basis of reduction plants for manufacture of fish meal which could be used in animal and poultry production. In times to come and if the yields are exceptionally high, as they may well be, the question of using them for protein concentrates would also arise. The general features worth remembering about the tropical fish stocks is that most of the sardines, mackerels and prawns form fisheries based on zero and first year classes, and their average size is somewhat small.

Next in abundance in our opinion are the mackerels belonging to the genus *Rastrelliger* which have similar feeding habits as the sardines and are in fact exploitable by similar fishing techniques. Apart from *Rastrelliger* there are a number of species of Carangoids which occur along with *Rastrelliger* and occur in considerable abundance. The third major group in which substantial increase is possible are the crustaceans mainly supported by shrimps and prawns of the families Sergestidae and Penaeidae of which the latter consisting of several species is by far the most important. Prawn production ranks high even now and owing to the high value of the product, economic incentives are available for substantial expansion.

Another category which could provide large scale expansion and attract capital investment is the tuna whose abundance in the Laccadive and Maldiva regions and the Gulf of Aden give a promising outlook for the future.

Lastly the resources which are at present most inadequately utilised are the Molluscan fisheries. Although adequate production data are not available at present, the coastal bivalve resources are quite considerable and could provide a large output if systematically developed.

b) Oceanographic research

It might be asked as to what type of research would help better exploitation of the above mentioned resources. The limited oceanographic information available with the Indian Ocean countries and the results of the International Indian Ocean Expedition give certain pointers in this direction. As already discussed, the upwelling regions of the Arabian Sea have given clear indications of likely areas where better yields could be expected. Accurate mapping of these areas by the adoption of certain key parameters like temperature and oxygen distribution might be helpful in the seasonwise and even monthwise indications of fish concentrations. It is becoming apparent that if the operations in these regions have to be economical, the fishing techniques have to deal with methods to concentrate schools of fish, or make full use of the oceanographic phenomena which con-

centrate them, such as the movements of the low oxygen layers and the thermocline. A close study of the inshore stocks and their relationship with the offshore are also needed to stabilise many fisheries at present only fished near the coast.

c) Improved fishing techniques

In the techniques of improving catches, the introduction of synthetic yarn and the use of mechanised boats as against the traditional sailing boats have to play an important part. There is great scope for rapid increase in the number of smaller mechanised boats to operate from the many smaller harbours and fishing havens throughout the coast line of the Asian countries, and this does not involve problems of large scale harbour development and attendant facilities essential for bigger vessels.

Considering the fact that fish schools in many regions of the Indian Ocean are sparse, fuller utilization of tropical marine resources would depend on the application of newer techniques involving light, electricity and even sound. These are all avenues for future research the results of which will help increase catches. The tropical climate creates many problems of handling and distribution which could be overcome by ice, refrigeration and improved transport, or manufacture of new fish products all of which will increase the availability of fish to people by ensuring better utilization of the existing and new resources.

VII. The Role of Inland Fisheries

The Inland fisheries constitute an important source of protein for Asian countries (Table X). In terms of total production the yield is small as compared with marine resources but the fact that the fisheries are spread inland and that they are capable of development through cultural practices give special significance to inland fisheries. Needless to say, these figures can only be of consequence in places where water is in plentiful

Table X. Fish catch from inland areas in some Asian countries bordering the Indian Ocean (Catch in thousand metric tons)

Country	1960	1961	1962	1963	1964
Iran	...	7.3	6.3	6.5	...
Iraq	7.9	9.8	17.8
Pakistan	195.0	216.1	217.6	222.0	222.0
India	281.7	277.4	329.6	390.4	459.9
Ceylon	0.4	3.4	4.6	4.4	...
Burma	360.0	360.0	360.0	360.0	360.0
Thailand—Malaysia	70.9	69.1	66.3	92.0	78.9
Indonesia	346.7	385.1	402.0	377.2	...
Total	1254.7	1318.4	1394.3	1462.3	1138.6

supply or where there are lakes, rivers or a large number of smaller cultivable ponds. Reservoirs or man-made lakes resulting from harnessing of rivers are new bodies of water which if stocked could give additional yields. The arid land regions like the middle East, Arabian Peninsula, desert regions of West Pakistan and India do not naturally figure very much in inland fisheries although the rivers do supply fish in some quantities. The rest of the Asian region, however, especially East and South India, Burma,

East Pakistan, Ceylon, Malaysia and Indonesia have extensive culturable areas with an assured supply of water throughout the year. In India and the south east Asian region, there are also coastal lakes and lagoons with profitable fisheries based on migration of larval juvenile stages from the seas. The annual yield from coastal or brackish water culture of this type is of the order of 500 to 1000 kg. per hectare. Such fish cultural practices offer further scope for extension to areas where they are not at present in vogue, but where young and juvenile stages of cultivable marine species are found, for example, chanos, *Mugil* spp., penaeid prawns etc. The reported total production from inland sources for the whole of the Asian continent excepting mainland China, is about 0.79 million tons. But it is felt that this figure is an under-estimate. At any rate, substantial increase in production from these sources could be anticipated. Inland fish ponds yielding about 400 kg. per hectare per annum without artificial enrichment are quite normal; with good pond management the yield could be raised to a higher figure of about 1000 kg. per hectare. Much higher values of about 5000 kg. per hectare are known from Israel, and up to 10,000 kg. per hectare in China. Values up to 17,800 kg. per hectare has been reported from Thailand for *Tilapia* but it is unlikely that this rate of production could be obtained for most other cultivable species. The surveys of available fish culturable waters in Asian countries indicate the possibility of 4 — 5 times increase of the present production from inland waters.

VIII. Summary and Conclusion

Fish production of the countries of South and West Asia fall far short of the actual requirements based on minimum nutritional standards for animal protein in a balanced diet. The gap between the actual production and the estimated demand will be very wide towards 2000 A. D. Fishery resources of the Indian Ocean, especially of the Arabian Sea can, however, meet to a very considerable extent these demands of animal protein but this calls for a very large and sustained effort by modernization of traditional fisheries by newer technology of fishing, processing and marketing with skilled personnel employed in all these activities.

The main fisheries of the Western Indian Ocean which are capable of much larger yields in terms of quantity are the pelagic and neritic pelagic stocks of sardines (*Sardinella* spp.), mackerel (*Rastrelliger*) and these are mostly zero to two years classes feeding on plankton. Large populations exist in the upwelling areas in the South West coasts of India, coasts of Arabia, Gulf of Aden and the regions of the Somali Current. There are also smaller populations of many species forming miscellaneous fisheries. Full harvesting at the maximum sustainable yield will depend on good biological and oceanographic research combining oceanographic and fishing conditions. Intensive synoptic studies on selected parameters like thermocline and oxygen minimum layer might prove useful to locate economically valuable concentrations of fishes.

Tuna and prawns are valuable resources capable of much higher yields than now. Although these may not be high in terms of percentage of total as compared with the Clupeoids and the smaller Scombroids, the economic incentives for large scale effort will probably depend on prawns, tuna and trawl fishing for Percoids, Stromateids, Polynemids, Sciaenids and other top class table fish. Shelf areas for trawling are limited and mostly not as productive as temperate shelf waters.

Brackish-water fisheries supported by marine migrants and inland fisheries developed by cultural techniques can make significant supplements to the marine catches. The overall picture is that although the full requirements of fish for the population could not be met, the outlook is one of moderate optimism that the seas of Asia can make a substantial contribution to the nutrition of the Asian peoples.

Table XI. Statement of fisheries of some Asian countries bordering Indian Ocean

Country / Region	Continental shelf	Annual yield (Thousand metric tons) 3 years average	Major fisheries	Prospects	Remarks
1	2	3	4	5	6
Indonesia	Complex Archipelago, Indian Ocean narrow shelf.	115.0	Rastrelliger Clupeoids, Penaeids, Carangids.	Penaeids, Tuna, Scombroids	Catches on the Indian Ocean sides small.
Malaysia and Singapore	The whole of the straits of Malacca.	25.6	Rastrelliger Carangids Clupeoids,	Sardines, Mackerel and Neritic stocks.	Main fishery is outside Indian Ocean. Monsoon Influence.
Thailand	Narrow shelf on the Andaman Sea side.	10.0	Neritic, Pelagic Stocks.	Rastrelliger, Clupeoids.	Productive areas like in Andaman Sea. Monsoon Influence.
Burma	Wide shelf 40—100 miles.	20.0	Large Scombroids, Dorab, Hilsa, Prawns, Sciaenids	Neritic, Pelagic stocks of Andaman Sea.	Monsoon influence. Strong estuarine influence near coast.
East Pakistan	Wide shelf 80—100 miles.	40.0	Hilsa, Kurtus Prawns, Silver Bellies.	Trawling Penaeids.	Strong monsoon and estuarine influence.
India East Coast	Narrow up to 20 miles.	188.0	Clupeoids, smaller neritic pelagic stocks as on W. Coast.	Trawling Productive area east of Andamans.	Strong estuarine influence in North. Influence of N.E. Monsoon.
India West Coast	100—20 miles wide, tapering southwards.	673.0	Sardinella, Clupeoids, Rastrelliger, Penaeids, Sciaenids, Sharks and Rays, Percoids, various misc. fisheries. Trawl fisheries to North and near Cape.	Increase in Sardinella, Rastrelliger, Trawl fish, Prawns and Tuna. Large overall increase possible.	Strong influence of S.W. monsoon. Upwelling in Southern Part.
Ceylon	Narrow shelf 5—20 miles	East 59.5 West 28.7	Rastrelliger, Scombroids, Percoids, Tuna, Trawl Fish.	Trawling; Rastrelliger and Tuna.	Strong monsoon influence.
West Pakistan	Fairly wide 25—60 miles.	87.6	Eels, Percoids, Sharks and Rays, Penaeids, Prawns, Threadfins, Scombroids.	Trawling, Penaeids, Prawns, and other neritic stocks.	Monsoon influence and Somali current.
Gulf of Aden	Shelf fairly wide.		Larger Scombroids, Tuna, Sardines Lobsters, turtles.	Good prospects for Tuna.	A promising area for commercial fishing. Somali current influence.
Red-Sea (U.A.R., Ethiopia, Sudan etc.)		20.0	Miscellaneous catches. Sardines, Percoids, Mackerels.	Increase in Sardines.	
Suez Canal and Gulf of Suez	Shelf moderate	6.0	Croakers, Lizard fishes, Sardines.		
Iraq	Shelf moderate	19.2	Neritic pelagic stocks.		
Iran	Shelf moderate	8.0			

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