FISHERIES OF THE WEST COAST OF INDIA

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THE ARABIAN SEA—MARINE BIOLOGY OF THE WEST COAST

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

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

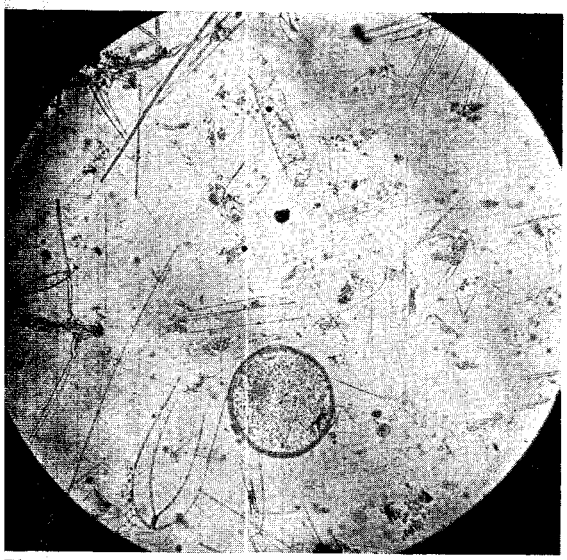
In the first decade of the present century, investigations on the fauna of the Maldive and Laccadive Archipelagoes and the Okhamandal coast of Kathiawar were carried out. These were supplemented by some observations on the bottom and mid-water fauna made during the course of experiments on fishing by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

The Littoral Fauna

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

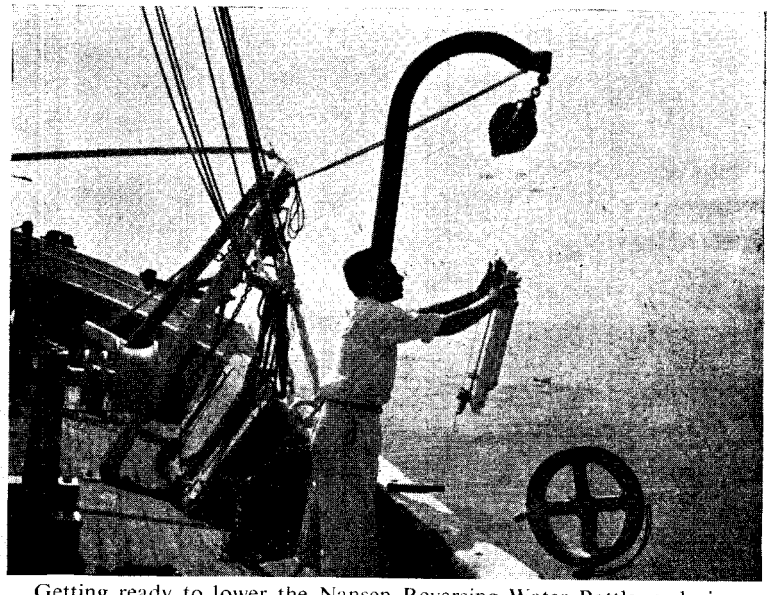
To a casual observer the vast stretches of sandy beach may appear to be poor in animal life but a closer examination of the intertidal region reveals several species of animals inhabiting the area. The inhabitants of these surf-swept sandy beaches usually bury themselves in the sand and some of them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

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



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

Photomicrograph of a zooplankton comm
containing copepods, chætognaths, young l
larvæ of lamellibranchs, gastropods, polycha



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

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

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

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

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

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

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

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

Deep Sea Fauna

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

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

Plankton

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

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

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

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

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

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

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

Nekton

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

Marine Bacteria

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

Marine Algæ

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

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

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

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

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

Mud Bank

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

Oceanographical Background

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

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

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