

THE INFLUENCE OF BACKWATERS AND ESTUARIES ON MARINE PRAWN RESOURCES

M. J. GEORGE*

Central Marine Fisheries Research Institute, Mandapam Camp

ABSTRACT

The marine prawn resources of the country are functionally related to the vast brackish water ecological system constituted by the various estuaries, inland bays, lakes and backwaters along the entire coastline. This report summarises the knowledge concerning the association of prawns of marine origin with the brackish water environment. The questions of continued productivity of prawn stocks in the face of man's steady incursion of estuaries and the effect of increased prawn fishing activities for the juveniles in brackish water areas on the adults from marine environment are considered. The need for further studies on the above aspects to enable measures to be taken to counteract adverse effects, if any, owing to the rapid agro-industrial development taking place in and around estuaries and backwaters in the country is emphasised.

INTRODUCTION

THE significance of the country's extensive brackish water ecological system, consisting of the various swamps, inland bays, lagoons, lakes, backwaters and estuaries along the entire coastline of India from the point of view of prawn production has not been fully realised yet. Owing to the high productivity and extremely favourable physical and biological conditions for growth and propagation the animals associated with these brackish water environments are rich and varied. In addition to the permanent inhabitants of the area many fishes and invertebrates of marine origin including the commercial prawns temporarily utilise this biotic niche for completing their life-cycle. Thus the estuaries and backwaters play a dynamic role in influencing the overall marine prawn production. Man's activities involving steady incursion of these brackish water systems, such as large-scale reclamation for agricultural purposes, diversion of water flows in and out for industrial and agricultural needs, usage of waters for disposal of industrial wastes, exploitation for extraction of underlying mineral deposits, etc., pose an ever-increasing threat to the dependent fishery resources of which prawn fishery is the most important. As this fishery has of late gained considerable economic significance it is felt worthwhile to make an assessment of the problems such as the extent of the relationship of prawns to the brackish water environment, the effect of changes in these environments on production of the prawn stocks, and possible measures which could be taken to offset the detrimental effects, if any, of rapid agro-industrial development taking place in and around the estuaries and backwaters and these are discussed in the following pages.

IMPORTANCE OF PRAWN RESOURCES OF THE COUNTRY

A quick glance at the fishery statistics concerning world landings would reveal the growing significance of crustaceans especially prawns in world trade (Tables I and II). Exploitation of prawn stocks from the seas around each country is playing increasingly significant roles in furthering the national economies of the countries concerned. The demand for prawns and prawn products is so much that every country is making efforts to bring into utilisation hitherto unfished stocks. From Table I it is clear that in volume of prawn landings India ranks second. The increasing foreign exchange earnings by export of prawns and prawn products from the country can be gauged from

* Present Address : N.I.O., P.B. 1913, Ernakulam, Cochin-18.

data given in Table III. In short, as in every other country the prawn fisheries together with all the segments of the industry concerned with prawn products exports is playing an increasingly prominent position in the economy of the country.

TABLE I
Annual landings of shrimps and prawns during 1958-66 by the major prawn producing countries of the world
(In thousand metric tons)

Country	1958	1961	1962	1963	1964	1965	1966
United States ..	97.0	79.1	86.7	109.0	96.1	110.5	106.4
India ..	86.7	62.8	83.2	81.6	94.9	77.3	90.9
Japan ..	55.6	73.5	79.3	86.7	77.8	66.5	68.7
Mexico ..	50.2	72.3	70.6	72.0	69.0	59.1	65.8
Thailand ..	10.3	16.5	20.1	23.3	29.5	35.2	45.3
Brazil ..	17.4	25.0	35.2	28.9	27.2	34.8	..
Chile ..	13.2	10.5	12.3	12.8	16.6	21.3	24.8
Malaysia (West) ..	9.0	16.1	20.9	19.0	19.3	20.8	24.4
Pakistan ..	14.9	19.5	19.1	18.4	25.7	27.0	22.2
Taiwan ..	4.0	5.5	6.4	9.0	9.8	14.2	17.1
Korea (Rep. of) ..	16.4	22.9	20.4	14.2	18.1	17.2	12.1

Source: *Year Book of Fishery Statistics*, 1966. F.A.O. of the United Nations.

TABLE II
Prawn products during 1958-66 in the major prawn producing countries of the world
(In thousand metric tons)

Country	1958	1962	1963	1964	1965	1966
United States ..	36.0	36.4	52.1	48.9	50.0	49.3
Mexico ..	25.7	34.9	34.6	32.1	27.0	29.9
Thailand ..	3.6	6.5	11.3	11.9	16.8	26.8
India ..	5.2	4.9	7.0	8.9	8.7	10.1
Brazil ..	2.9	7.3	9.9	7.0	10.9	..
West Germany ..	5.9	5.1	8.5	5.2	5.7	7.4
Korea (Rep. of) ..	12.6	6.2 2.9	7.9 3.7	7.4	9.3	7.0
Netherlands ..	2.7			5.0	4.6	4.0
Japan ..	3.1	2.8	3.3	2.0	2.5	..

The most important prawn resource of the country is the fishery for the marine prawns (penaeids), especially of the west coast, mostly concentrated in areas near estuaries and backwaters. Major portion of these prawns caught from the sea as well as the larger sizes from the estuaries and brackish waters are frozen and exported as frozen products. To a certain extent the smaller sizes are canned for export as well as internal consumption. In addition the juveniles mostly from the backwaters support the prawn pulp export. The demand for prawns and their products are ever on the increase. In general the outlook for the prawn fisheries seem to be encouraging except for certain heavily fished areas like off Cochin where at present too many fishing boats are concentrated. Consequently steps like the distribution of the fishing boats to different areas and exploitation of the grounds hitherto not fully exploited can, no doubt, meet the growing demands for prawn products. Meanwhile the adverse effects of man's activities, either in the form of exploitation of particular areas only or of general destruction of the habitat of prawns, are to be investigated carefully.

TABLE III
Export of prawn and prawn products from India in metric tons and value in rupees from 1959-67

Year	1959	1960	1961	1962	1963	1964	1965	1966	1967
Total prawn and prawn products export	5633.5	7866.3	6794.8	6323.2	8261.9	10464.2	9985.3	11556.3	15051.6
Value in Rupees (thousands)	17413.9	16588.4	24297.6	26345.9	38188.4	48533.1	56445.7	95993.4	170168.8

RELATIONSHIP OF PRAWNS WITH BRACKISH WATERS

The commercial marine prawn fishery which has relationship with brackish water environment is concerned with a group of prawns belonging to the family Penaeidae in which the eggs are shed into the water, unlike in the other group of caridean prawns in which the females carry their eggs under the belly till a comparatively advanced stage of development. As a rule the penaeid prawns of commerce are found to be closely associated with the shallow brackish water environments. Nearly 35 species of this group of prawns, with varying geographic distribution, support important coastal fisheries in different regions of the world. The penaeids of commercial significance in India include nearly a dozen species, the most important of which are *Penaeus indicus*, *Metapenaeus dobsoni*, *Metapenaeus affinis*, *Metapenaeus monoceros*, *Metapenaeus brevicornis*, *Penaeus monodon* and *Parapenaeopsis stylifera*.

From the biological as well as conservational point of view the interesting feature in the case of these species is the fact that most of these penaeid prawns of commerce have a peculiar life-history characterised by a period of more or less predictable length which is passed in an estuarine or brackish, shallow water environment. In most of these important species the parent population breeds in the sea at various distances from the shoreline, producing large numbers of microscopic eggs which are shed into the sea. These semi-buoyant eggs quickly hatch into small planktonic larvae known as nauplii. Metamorphosis takes place rapidly through protozoal and mysis stages, all the while being transported towards the shore, especially towards mouths of rivers or openings of shallow lakes and backwaters. Depending on the species the time taken between hatching in the offshore waters and entry of the small postlarvae into the brackish waters varies, usually from 2 to 4 weeks. In certain species they arrive in these shallow areas in the late larval stages while in some others they arrive in the early postlarval stages. Once in the brackish waters they leave the planktonic existence and descend to the bottom, reaching the different parts of the shallow waters. Over the subsequent 6 to 9 months they grow rapidly and reach certain sizes, varying with species,

After these sizes are attained they return to the sea where the life-cycle is completed. Considerable variations occur among the commercial penaeids, both in the degree to which the brackish water environment is utilised by each species in the life-history and in the distribution of the parent and juvenile populations in the gradient zones of the brackish marine environments. For example, in one of the Indian commercial species *Parapenaeopsis stylifera*, the young ones do not come into the brackish water or estuarine environment. In the case of *Metapenaeus affinis* the juveniles do not penetrate estuaries as deeply as in some other species like *Penaeus indicus* and *Metapenaeus dobsoni*. The question arises as to what will happen if the estuary-dependent prawns are deprived of the same environment? Will the prawns adjust to the new conditions wrought by changes in the environment? These are questions still to be answered. But all indications are that the fertile estuarine environment play a major role in the life and survival of the prawns, and the least possible disturbance of the brackish water habitat is essential for continued high productivity of the resources.

BRACKISH WATERS AS HABITAT OF PRAWNS

The penaeid prawns of commerce move in and out of the brackish waters and estuaries in the manner described earlier because that is the way they are evolved. What are the peculiar features of this highly dynamic environment which plays an important role in the life-history of these prawns? It is known when and where the young prawns occur and it is also possible to describe their surroundings. But in defining the functional role of this environment occupied during the juvenile phase of their life-history, we fall far short of the mark. The major factors regulating the occurrence and development of the immature prawns in the estuarine environment are water circulation, temperature, salinity and other chemical properties, turbidity and fertility, vegetation and nature of substratum.

Among the more important physical features of the brackish water system the wind-generated and tidal currents causing the circulation of water is the master factor which play an important role in making these waters a highly complex environment according to Chapman (1960). It is the water circulation patterns which govern factors like distribution of other chemical components of the water in addition to salt content, physical properties like temperature, suspended matter and biological populations, especially of those species with planktonic stages in their life-history. Throughout the young prawns, occupancy of the brackish water nurseries circulation probably plays the key role in establishing indirectly the limits of environmental suitability.

Temperature of water is a significant environmental factor controlling productivity at all levels of the estuarine food chain. It appears that the optimum temperature range in certain months brings about the attainment of greatest biomass by a given generation of prawns. Under extreme temperature conditions salinity and other chemical properties play varying roles in controlling the survival of young prawns. Salinity perhaps, more than any other property, is the single factor which characterises the brackish water environment. It affects both directly and indirectly the phase of life of prawns in estuarine nursery areas. Salinities in the backwaters of Cochin are found to vary from nearly 1.0 to 35.0‰ during the course of an year (George, 1958; George *et al.*, 1968).

Other chemical constituents like dissolved oxygen, nitrate, phosphate, etc., may have their own parts to play in making the estuary a complex ecological system. Turbidity and fertility of the water and bottom structure are other factors which need mention in this connection, although the exact role played by these features in the estuarine phase of the life of prawns is not clearly understood. It must be emphasised that all the above factors play complex interactive roles in determining the distribution, survival and growth of young prawns during their sojourn in the estuaries. The mechanics involved and the extent to which changes in these factors influence the productiveness of commercial prawn resources remain to be fully elucidated.

EFFECT OF ENVIRONMENTAL CHANGES ON PRAWNS

The animal life found in the brackish water environments are generally endowed with wide range of adaptability to withstand extreme fluctuations in physical conditions. Panikkar (1951) initiated studies on the regulatory capacity and physiological adaptations in estuarine-marine fauna including prawns. Later investigations by Rao (1958), Williams (1960), Dobkin and Manning (1964), Zein-Eldin and Aldrich (1965) and Gnanamuthu (1966) impart considerable understanding as to how prawns adjust physiologically to varying environments. Although these investigations partly answer the questions of why and how these organisms satisfactorily cope with their dynamic environment it is still not clear as to what degree does permanent environmental changes affect the magnitude of their stock.

Changes in the brackish water environment are brought about in two different ways, viz., by natural adversities and by activities of man. Among the former may be mentioned the changes brought about as a consequence of unpredictable meteorological events like heavy floods, droughts and storms. The shallow brackish water systems are particularly prone to the effects of these occurrences. Although the real nature and extent of such effects are still not properly understood, it is clear that changes are brought about by abrupt changes in one or more of the physical properties enumerated earlier.

The changes brought about by the activities of man are those caused by (1) changes in totals area of brackish water habitat resulting from large-scale reclamation for agricultural purposes a happening in the southern half of the Vembanad Lake, bulkheading and filling, and dredging of navigation channels, (2) protective works such as stream diversion spillways, salt-water barriers like the Thanneermukkam bund being constructed in Vembanad Lake, and tide control structures, (3) pollution of the waters by domestic, industrial and agricultural wastes and (4) development of mineral resources by dredging of fossil shell deposits. These changes in the environments affect the estuarine phase of the life of the commercial prawn in any one or more of the following ways, namely, general reduction in acreage of the habitat, change in circulation and thus affecting distribution of salinity, temperature, etc., lessening of average depth, impeded exchange of fresh and salt-water, loss of tidal exchange benefits, restricted influx of salt-water, change in water chemistry due to presence of toxic compounds, increased silt load, etc. In general the estuarine habitats are affected in two major ways, either by a net loss of total acreage available or by a change in mean salt content and chemical composition. Among others Menon (1967) expressed grave concern about the possible detrimental effects of environmental changes in Cochin backwaters to the prawn resources of the area.

It is highly problematical whether the estuary dependent prawns of commerce can adjust to the environmental changes and consequent modifications in the various factors and still maintain their stocks at the present levels. Our knowledge of the biology and dynamics of the prawn resources in relation to the various environments is slowly being enhanced by various researches. As mentioned by Kutkuhn (1966) "much remains to be accomplished before we can muster the basic information that would provide an unassailable defence concerning the inadvisability of wholesale modification of vitally important coastal marshes".

POSSIBLE MEASURES TO COUNTERACT ADVERSE EFFECTS

As a result of a rapidly advancing civilisation, undoubtedly there is deterioration in estuarine habitat as envisaged earlier. The question is what steps could be taken to prevent serious damages to the important biological resources of the estuaries and consequently on the dependent marine resources. Supposing, for instance, that the erection of a particular spillway or salt-water barrier would create a situation of chronically high or low salinity in an area and that over the years this

condition in turn would result in decline in production from the coastal fisheries, the amount of projected monetary loss and the benefit-cost ratio will have to be taken into consideration before finally arriving at a decision concerning the project. Often the fishery scientist finds himself in an unenviable position when called upon to make recommendations concerning the effects on fisheries. However, in schemes of salt-water extrusion projects like the Thanneermukkam bund to be constructed in the southern half of the Vembanad Lake a rational approach is highly essential in planning projects like these, entailing the curtailment of the valuable brackish water areas vitally important for the prawn resources.

In view of the inseparable link between prawns and brackish water environments one step that suggests itself in the context of improving the marine prawn resources is the total prohibition of the fishery of the small juvenile prawns from the backwaters and estuaries, thereby allowing all the juvenile prawns to return to the sea and catch them there at bigger sizes. But putting a stop to centuries old fishing practices involving the livelihood of lakhs of people all of a sudden is a measure wrought with great difficulties in implementation, especially in view of the fact that the smaller sizes fished from these waters support an export industry. If not complete prohibition of fishing throughout the year, to begin with at least closing the areas for prawn fishing at seasons when maximum numbers of small juveniles are fished would be advantageous and thus stage by stage it could be tried to bring in complete stoppage of prawn fishing in the inside waters for penaeid species. In this connection the shrimp fishery of the Gulf of Mexico coast may be cited as an example. Three species of the genus *Penaeus* contribute to the fishery of the region. Here also the vast expanses of inland bays and bayous connected to the Gulf are extensively used by these prawns as nursery grounds. But shrimp fishing is mostly confined to the Gulf waters, the inland bays and estuaries being closed for fishing except in certain seasons when the sizes of the prawns are quite large and commercially acceptable for freezing and as live bait for sport fishing. The live bait fishery for shrimps in the inside waters is active in certain areas throughout the year, but with minimum size regulation (Inglis and Chin, 1959; Kutkuhn, 1962). It would appear that implementation of such methods with suitable modifications in the estuaries and backwaters of India might be beneficial in improving the marine prawn resources in the matter of size as well as quantity of prawns landed.

The culture of prawns on a commercial scale in marine or brackish water farms is another step which deserves due attention. The tapping of the prawn fry as they approach the shore and enter the backwaters and estuaries and culturing them for varying periods may prove to be quite useful in improving the overall production.

REFERENCES

- CHAPMAN, V. J. 1960. *Salt Marshes and Salt Deserts of the World*. Interscience Publ., New York. 1-392.
- DOBKIN, S AND R. B. MANNING 1964. Osmoregulation in two species of *Palaeomonetes* (Crustacea: Decapoda) from Florida. *Bull. Mar. Sci. Gulf Carib.*, 14: 149-157.
- GEORGE, M. J. 1958. Observations on the plankton of the Cochin backwaters. *Indian J. Fish.*, 5 (2): 375-401.
- , K. H. MOHAMED AND N. NEELAKANTA PILLAI 1968. Observations on the paddy field prawn filtration of Kerala, India. F.A.O. World Scientific Conference on the Biology and Culture of Shrimps and Prawns, Mexico, F.A.O. Fish. Rep. (57) Vol. 2: 427-42.
- GNANAMUTHU, C. P. 1966. Changes in volume of a brackish water prawn in different media. *Proc. Indian Acad. Sci.*, 64 B (2): 96-109.
- INGLIS, A. AND E. CHIN. 1959. The bait shrimp industry of the Gulf of Mexico. *U.S. Fish and Wildl. Serv. Fish. Leaflet*, 480: 1-14.
- KUTKUHN, J. H. 1962. Gulf of Mexico commercial shrimp populations—Trends and characteristics, 1956-59. *U.S. Fish and Wildl. Serv. Fish Bull.*, 62: 333-402.

- KUTKUHN, J. H. 1966. The role of estuaries in the development and perpetuation of commercial shrimp resources. *Symposium on Estuarine Fisheries, American Fish. Soc. Special Publ.* No. 3, 16-36.
- MENON, M. D. 1967. "Carpe Diem," *Seafood Trade Journal*, 2 (1): 99-106.
- PANTIKKAR, N. K. 1951. Physiological aspects of adaptation to estuarine conditions. *Proc. Indo-Pac. Fish. Coun. 2nd Meet., Sec. B*, 168-175.
- RAO, K. P. 1958. Oxygen consumption as a function of size and salinity in *Metapenaeus monoceros* Fabr. from the marine and brackish water environments. *J. Exp. Biol.*, 35 (2): 307-313.
- WILLIAMS, A. B. 1960. The influence of temperature on osmotic regulation in two species of estuarine shrimps (*Penaeus*). *Biol. Bull.*, 119: 506-571.
- ZEIN-ELDIN, Z. P. AND D. V. ALDRICH 1965, Growth and survival of postlarval *Penaeus aztecus* under controlled conditions of temperature and salinity, *Ibid.*, 129: 199-216.