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ENVIRONMENTAL CHARACTERISTICS OF THE MARINE AND ESTUARINE HABITATS OF KARWAR - AN OVERVIEW

U.G. BHAT, B. NEELAKANTAN, N. KUSUMA AND U.G. NAIK

Department of Marine Biology Karnatak University Kodibag, KARWAR 581303.

INTRODUCTION

The Karwar coast, on the central west coast of India (Fig.1) lies in the northern limits of the Uttara Kannada coast and is unique in many respects. A few rocky islands lie scattered in the inshore waters. The coast is predominantly rocky with relatively short stretches of sandy beaches and capes projecting into the sea. The coastline in this division is rugged. Karwar bay is one of the many sheltered coastal waters, frequented by three fringing islands at the bay mouth. Among the four rivers joining the sea in Uttara Kannada coast, the northernmost river Kali drains into Karwar bay at this northern boundary. The continental shelf extends to a width of about 96 kms. off Karwar. Sediment gradation at the sea bottom is from sandy near the inshore, to muddy farther away.

There has been a fairly good attempt to characterise the environmental features of the inshore, intertidal and estuarine habitats of Karwar (Annigeri, 1968, 1972, 1979; Ramamurthy, 1967; Noble, 1968; Harkantra, 1975; Ansari, 1978; Gopinath and Joseph 1980; Sudarshana, 1980, 1983; Sudarshana *et al*, 1988, Bhat, 1984, 1985, 1986; Naik, 1986 (a) and (b); Sujatha, 1987; Naik, 1987, Shetty *et al*, 1988; Neelakantan, et al, 1988; Veerayya and Pankajakshan, 1988 etc.). But the lack of an effort to compile and co-ordinate these results has been felt since long. Therefore, in this review, it has been attempted to delineate the environmental features of Karwar waters in the light of some of the previous investigations.

ENVIRONMENTAL FEATURE

As elsewhere on the Indian coastline, the environmental features of Karwar waters owe much of its variation to the prevailing three major seasons namely pre-monsoon (February-May), monsoon (June-September) and post-monsoon (October-January). While the pre-monsoon season is identified by high temperature and salinity, the monsoon season is characterised by heavy rainfall, greater riverine discharge and consequent dilution of the inshore water. The post-monsoon season is known for stable environmental conditions and a high biological productivity.

The monsoon season in Karwar waters spreads over June through September. The onset is characterised by drastic changes in both meteorological and hydrological factors.

The prevailing winds are south westerly during the South West monsoon season with a velocity range between 1.3 and 10.8 knots while the north easterlies of North East monsoon period range from 0.7 to 3.5 knots. The winds are subjected to variation during October and March-May. The period of the year other than the two monsoons may be further divided into a cold dry season (December to February) and a summer (March to May), depending more on the profile of atmospheric temperature. While the cold dry season is characterised by a monthly range in air temperature between 18.7 and 32.0°C respectively (Gopinath and Joseph, 1980).

Currents : The major currents along the west coast of India are seen to be in association with the prevailing monsoons and the speed and direction of them are modulated by the coastal onformations (Sewell, 1929 & 1955; Ramamurthy, 1967). In the more open areas of the sea, the currents drift easterly during the North East monsoon period. The circulation near the coast during the peak of North East monsoon (November to January) is anticlockwise to the equator and flows north and north-westerly. From February to April when the North East monsoon weakens, the direction of the coastal current is reversed resulting in a clockwise circulation which is attributed to the formation of a current covered by temperature differences. with the onset of South West monsoon the clockwise circulation is strengthened.

The physical features of nearshore waters of Binge Bay (Fig.1) was studied by Gopinath and Joseph (1980). Very little change in the hydrographic properties with depth was observed except during August to October, when waters of low temperature (24°C), high salinity (35.5‰) and low dissolved oxygen (3 ml/L) were observed at depths more than 5 m. The resultant currents, compiled from hourly current data over a complete tidal cycle

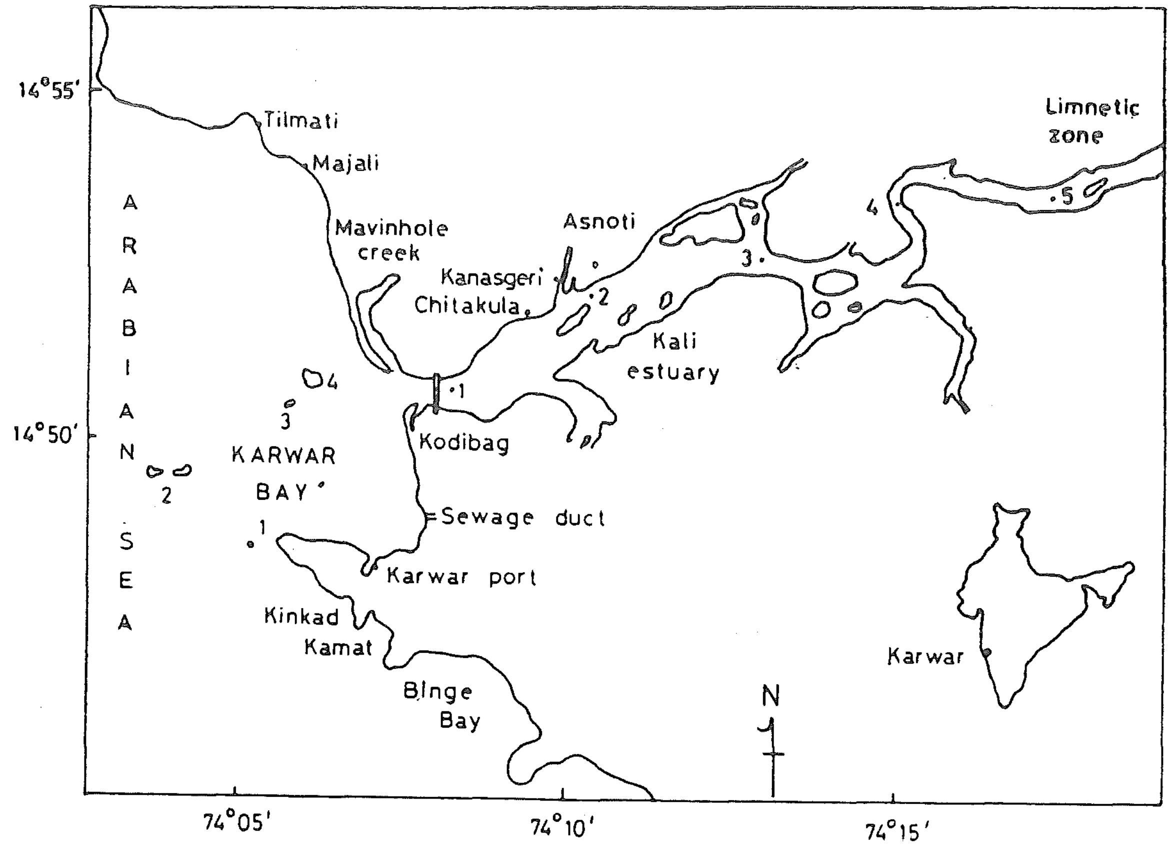

Fig.1 : Map of Karwar Region

at the inshore waters to be westerly in November, west north westerly in December, north westerly in January and south-easterly in September. The currents were relatively stronger (9.6 - 16.5 cm/sec) during November and December and weaker (3.7 to 5.8 cm/sec) during January and September. The resultant surface wind was strong (3.28 m/sec) and north-easterly in December and weak (0.24 m/sec) and northerly in September. Computed resulted speeds and directions of surface wind and currents near surface, middle depth and near bottom and percentage constancies during different months were also investigated.

Waves : Recently, the wave pattern of Karwar inshore region has been investigated by Veerayya and Pankajakshan (1988). They observed that certain stretches of open ocean beaches located on either side of Kali river and the headland bay beaches south of Karwar head experience relatively higher wave heights for IW and WSW waves, the latter bneing more prone to higher wave heights for waves from SW. The higher wave energy zones shift towards the central northern sectors of the beaches, as the direction of wave approach changes from WNW to SW. The northern and southern stretches of headland bay beaches receive partial shelter from the headlands for predominant waves approaching from northerly and southerly quadrants respectively. The Karwar port as well as a greater stretch of the Karwar-

Kodibag beach being on the lee side of Karwar head, receives good shelter for WSW and SW waves and only the extreme northern part of the Karwar beach is affected by these waves.

Further, they found that the converging currents observed for W and WSW waves along these open ocean beaches are similar to those identified along similar beaches on the west coast of India.

Hydrology of inshore waters : Annigeri (1968) was the first to carryout a comprehensive study of the seasonal distribution of temperature, salinity, oxygen, phosphates, nitrites and silicates in the inshore waters of Karwar Bay at surface, middle and bottom levels during 1964-1966. On similar lines he further continued his studies (1972-1979). The annual temperature values exhibited a bimodal distribution with the primary and secondary peaks in April/May and October/November periods, and their falls during August/September and December/January respectively. pH values varied around 8.2. Salinity which was very low during monsoon months, raised gradually towards the month of May. Dissolved oxygen exhibited a bimodal variation. Inorganic phosphorus recorded a single peak during September/October whereas the nitrite distribution did not have any annual rhythm. Silicate and salinity values exhibited an inverse relationship.

While investigating the plankton distribution, Naik (1986) noted a range in water temperature of 28.77 - 29.87°C in different localities of Karwar Bay. Salinity varied between 23.83 and 25.83‰ while dissolved oxygen and pH values did not show much variation in their values (4.59 - 4.69 ml/L and 8.2 respectively). Variation in the values of suspended load (0.67 - 0.73 gm/L), vertical extinction coefficient (1.70 - 2.67), Phosphate (0.43 - 0.65 ug at/L); Nitrite (0.33 - 0.42 ug at/L) and Silicate (87.79 - 157.49 ug at/L) were also recorded.

Bottom features of the bay : Sudarshana (1983), while investigating the benthic ecology of Karwar bay observed that the depth varied from 2 to 15 metres. Temperature and salinity of bottom waters attained highest values during March and May, being similar to the findings of Noble (1968) in these waters. The mean salinity observed was between 20.36 and 23.57‰. Temperature showed the mean lowest of 26.92°C in station 2 of Karwar bay (Fig.1). Better oxygenated conditions prevailed in all the stations, the range being 1.635 to 3.237 ml/L. The enormous supply of suspended load of SW monsoon by Kali estuary was found to be responsible for the decline in dissolved oxygen values.

Nutrient (Phosphate, Nitrate) concentrations were considerably high (P:0.56-2.85;N:0.84-2.14 ug at/L). Suspended load was as high as 0.306 gm/L during monsoon.

Colour of sediment was dark greyish green and the nature of bottom was sandy silt except near the estuarine mouth, where it was predominantly sandy. Organic matter content of sediment varied between 1.02 and 3.12%.

INTERTIDAL ENVIRONMENT

The Karwar beach has diversified habitats ranging from a near estuarine environment to a typical sandy beach of the open sea. The major changes occuring in the environment are during the monsoon season which is characterised by high precipitation.

Sujatha (1987) observed that the water quality of the surface water does not vary drastically along the beach. The seasonal changes in the hydrological parameters except during monsoon was considerably low. But some parameters like primary production nutrients and salinity are influenced by nutrient rich water from the Kali estuary and also from the sewage outfall resulting in high nutrient content and primary production and relatively low salinity in the region close to the sources.

She further noted that the slope of the beach and sediment characteristics of the study stations vary widely. The northern part of the beach comprises of coarser to medium sized grains while the southern part of the beach had a higher percentage of medium and fine sand grains. She attributed it to the tidal currents coupled with estuarine currents, which demarcates geologically the Karwar beach into two regions. These changes are not only brought about by the physical parameters like waves, tide etc., but also due to human activity like dredging and reclaimation of land. The eroding activity of estuarine current is also fairly evident, especially in the northern part of the beach as it is indicated by the low gradient of the intertidal region.

The case study of an intertidal stretch, 1 km. south of estuarine mouth (Naik, 1987) revealed that the area is more of an accretion or constructive beach than erosion and the beach is predominantly sandy in nature. Accretion and erosion occurred simultaneously during pre-monsoon and early monsoon period (January-July) whereas peak monsoon period (August) marked the period of continuous accretion, followed by a post-monsoon erosion phase (September-October). He came across a subtidal depression, followed by a sand bar parallel to the shoreline, and protrusion of the shoreline towards the north of the study site, which are indications of the presense of probable longshore current and a rip current at the study site. He attributed the high range in salinity (2.23 - 27.5‰) and dissolved oxygen values (2.9 - 4.12 ml/L) of the intertidal water, to the massive monsoon discharge of Kali estuary.

The spatial and temporal changes in the foreshore zone of the same intertidal stretch by an earlier group of investigators (Sudarshana *et al*,1983) exhibits the active hydrodynamic processes in its foreshore area. Short variations in space and time within the foreshore fractions of various beach profiles were described by them with their correlations to waves and tides.

A city sewage duct emptying about 1,87,000 litre/day of untreated domestic sewage is seen at the southern limits of Karwar beach (Fig.1) and its impacts on the intertidal environment has been studied recently (Shetty *et al*, 1988). The sewage is characterised by human refuse, excreta, animal waste etc. During the summer season it imparts foul smell all around, whereas during rainy season it gets diluted substantially and makes the flow uninterrupted. The physico-chemical features recorded at the sewage disposal site reveals that it is strong enough to enhance the nutrient budget of the disposal site and nearby waters.

ESTUARINE ENVIRONMENT

Among the four estuarine systems of Uttara Kannada coast, Kali is the major one, which spreads approximately 23 kms. in axis, draining into the Karwar Bay (Fig.1). Its terrigenous transport into the coastal waters has been found to enhance the nutrient budget of the area, consequently supporting a rich biological production. Accordingly, several workers have investigated the estuarine environment for characterising the water, sediment and biological components (Harkantra, 1975; Bhat, 1984 Naik, 1986; Neelakantan *et al*, 1988 etc.).

The seasonal variation in various parameters Neelakantan *et al* (1988) reveals that temperature was comparatively low during monsoon (20.63 - 28.04°C), increasing during post-monsoon (27.13 - 31.20°C) and reaching maximum in the pre-monsoon (30.20 - 33.55°C) period. Salinity was high during pre-monsoon season (mean value was 16.21 ‰), with lesser values observed during monsoon (5.51 ‰) and post-monsoon periods (11.03‰). Dissolved oxygen values varied between 2.76 - 5.29 ml/L, with moderately high values during monsoon (4.36 ml/L) and post-monsoon (4.02 ml/L) seasons. An increasing trend in suspended load values was noticed from pre-monsoon (0.0965 g/L) to monsoon (0.3349 g/L) with intermittent values in post-monsoon (0.1085 g/L) period. The nutrient budget was influenced by south-west monsoon, with the high silicate values at the upper stretches of the estuary (Neelakantan *et al*, 1988).

While studying the hydrology of bottom waters of Kali, Bhat (1985) has observed that temperature ans salinity had similar trends of variation while salinity and silicate values had an inverse relationship. Primary production increased in the post-monsoon period to reach its peak in November, following that of the nutrients. peak of primary production was followed by that of suspended load which he has attributed to the sinking of organic matter and detritus, produced in the water column. He concluded that post-monsoon (September-December) is the period when the estuarine water gets enriched with nutrients and basic food.

The sediment nature of estuarine bed varied from sandy silt (at stations 1,3 & 4) to sandy (at stations 2 & 5) and the sandy silt sediment was found to contain comparatively higher concentration of organic matter (4.06%) and interstitial water (33.04 %) as observed by Bhat (1985). Further, stations 1, 3 and 4 (Fig.1) had comparatively well sorted sediment than that of stations 2 and 5. The sediment grain size ranged from 0.03 mm (at station 4) to 0.22 mm (at station 1).

FUTURE PROSPECTS

Of late, the inshore intertidal and estuarine waters of Karwar have been found to be subjected to greater and greater stress (Fig.2). With the establishment of an all weather port during 1987, the dredging of a channel became inevitable. This resulted in increased wave energy acting upon the adjacent intertidal region and the subsequent mass errosion of beach, especially during the south-west monsoon season. Needless to say, the sediment nature of the area would necessarily alter due to intense dredging activity, making the bottom inhospitable for the existing life forms. Also, due to the increased activity of fishing and commercial water crafts, the impairment of inshore waters is becoming manifold (Fig.2.)

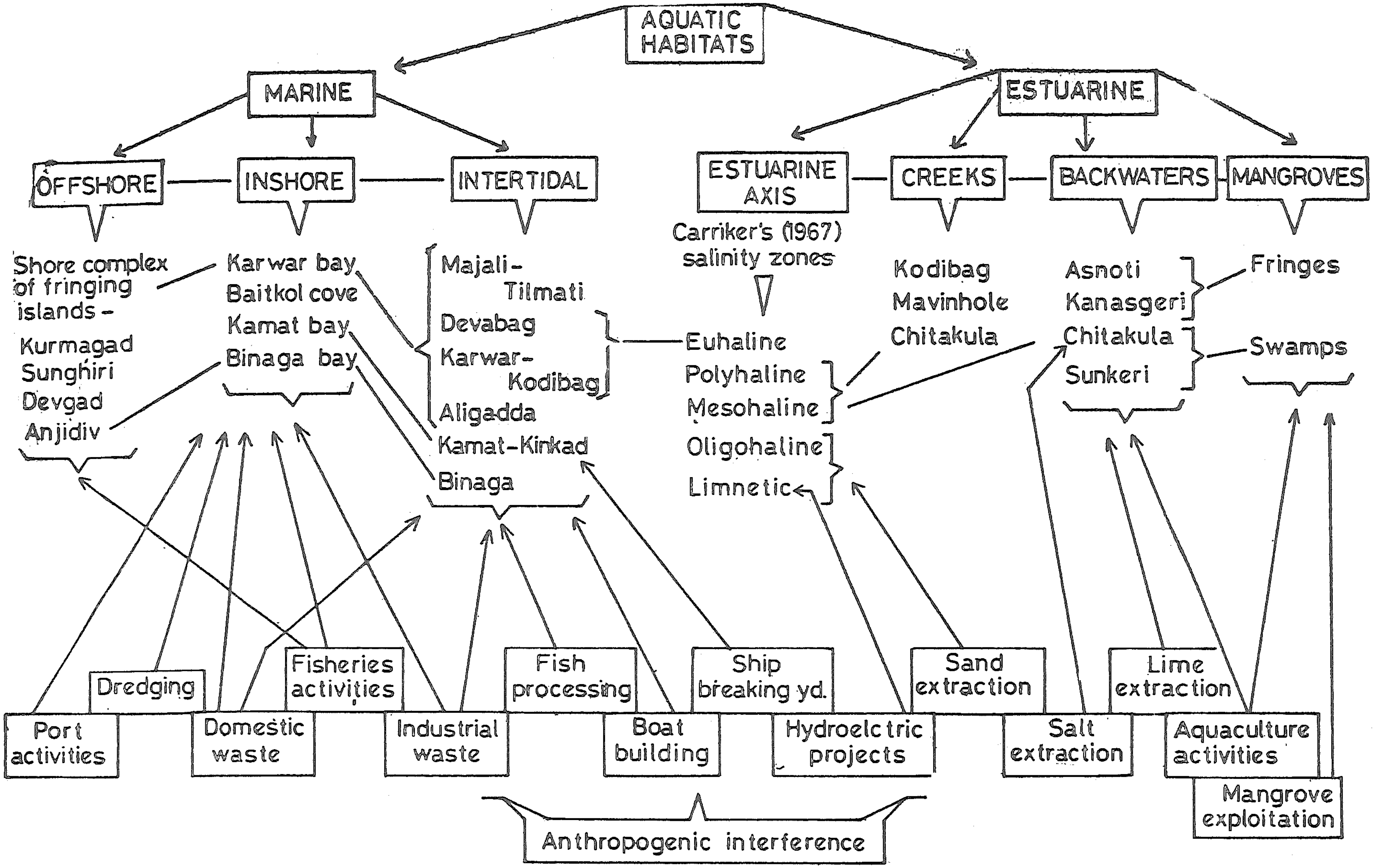

Fig. 2 : Schematic representation of the habitat coherence and anthropogenic interference in the marine and estuarine habitats of Karwar.

While considering the industrial wastes, there exists only a single caustic soda factory, emptying its effluents into the Binaga Bay of Karwar, the impacts of which on the inshore waters is worth monitoring. Other sources of wastes are the fish processing centres and domestic sewage, both of which are bound to increase at the instance of increased fishing activity and enhanced urban habitation.

If the Karwar coast is well known for a lucrative fishery resource, it owes much to the Kali estuary, which serves as an ideal nursery ground for the young-ones of the fin-fish and shell-fish (Nagaraj and Neelakantan, 1982). But very recently it has been observed that the salinity profile is gradually changing, which is attributed by the altered freshwater discharge, affected by the hydro-electric projects established near the distal end of the estuary (Fig.2). In the near future it may lead to shifting of the productive mangrove environments (nursery grounds), thereby affecting the fish and shell-fish seed resources of the locality.

Yet another impact of the developmental projects that are being undertaken in the Karwar region is the indescriminate exploitation of river sand for the purpose of erecting concrete structures. This, apart from interfering with the natural flow pattern of the estuary, may finally alter the topography, sediment nature and productivity of low lying areas.

It can be concluded by stating that, due to more and more anthropogenic influence on the diversified habitats of Karwar (Fig.2), there is a drastic change in the overall environment, over a period of time. The alleged decline of commercial fishing resources of the coast, though not entirely but partially can be attributed to the impairment of the environment through human interference. Added to this, some more major development projects such as 'Sea bird' naval project and Kaiga atomic power plant are coming up. Under these circumstances, the present review would serve as a document of the past history in order to monitor the unhealthy alterations of the environment in future.

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