Investigations on the Creeks of Saurashtra

Shoba Joe Kizhakudan, Joe K. Kizhakudan, H.M. Bhint, D.T. Vaghela and K.N. Fofandi

Veraval Regional Centre of Central Marine Fisheries Research Institute Matsya Bhavan, Veraval - 362 269, India

Gujarat has a rich estuarine system supported by run-off from five major rivers, *viz.*, Narmada, Mahi, Tapti, Banas and Sabarmati. The branches of these rivers form several small creeks which act as outlets to the sea. These creeks are known to have supported traditional fisheries for a variety of shrimps and fishes over the years. However, these fisheries are now on a declining phase. With reduced rainfall in recent years, these creeks remain saline for a major part of the year. Natural flushing is further obstructed by the numerous check dams and small impoundments constructed across the rivers and rivulets flowing into these creeks. A study was carried out to assess the nutrient status of some of these creeks – Hiran, Devka, Meghal, Nodi, Madhuvanti, Gamat and Shingoda, in different seasons and relate the changes to anthropogenic effects and fish availability. During the post-monsoon and pre-monsoon periods, the salinity was found to increase beyond 60 ppt. Some variations in silicate levels were observed during the monsoon whereas phosphates and nitrates did not show much variation. Ammonia, nitrate and phosphate levels were seen to be influenced by anthropogenic effects. Devka, Hiran, Nodi and Shingoda, which receive both industrial and domestic discharge, had maximum levels of ammonia. Mangrove vegetation and fishery resources like oysters, clams, shrimps, crabs, mullets, clupeids, cyprinids and perches are very sparse in these creeks now while semi-fossilized beds reveal a good history of estuarine fauna in the past.

Key words : Creeks, estuarine system, hydrography, Hiran, Devka, Meghal, Nodi, Madhuvanti, Gamat and Shingoda

Gujarat has a coastline extending from the Gulf of Kutch in the northwest, through the Arabian Sea, to the Gulf of Khambhat in the southeast. Coastal districts of the state are Kutch, Porbandar, Rajkot, Jamnagar, Junagadh, Amreli, Bhavnagar, Ahmedabad, Kheda, Navsari, Bharuch, Surat and Valsad. The coastal districts have a fishermen population exceeding 0.36 million, of which around 0.14 million people are actually engaged in fishing and other related activities. Along the coastline there are 44 fishing harbours and 213 fishing villages (Anon, 1996).

Peninsular Gujarat (Saurashtra) possesses one of the most lucrative fishing grounds along the Indian coast. The coastline and inshore areas are characterized by miliolite and limestone occurring in the form of cross-laminated beds and parabola-shaped lithified dunes. Fluvio-marine mud occurs in the tidal flats and creeks while blown sand and soil cover the plains. The limestone reefs provide excellent habitats for a wide variety of reef flora and fauna. These reefs also serve as nursery and breeding grounds for several commercially important finfish and shellfish.

Gujarat has a rich estuarine system supported by run-off from five major rivers, *viz.*, Narmada, Mahi, Tapti, Banas and Sabarmati. The riverine system traversing Saurashtra is formed by branches of these rivers. They are not perennial and hence do not support large estuaries or backwaters as the ones formed by the main rivers themselves. However, they do form small creeks which act as outlets to the sea. These creeks are by and large saline for a major part of the year, experiencing an influx of freshwater only when the state receives monsoon showers. The natural sand bars remained closed most of the year and the creeks practically serve as basins of saline water between the sea and the riverine course during the pre-monsoon and post-monsoon months. These creeks are known to have supported traditional fisheries for a variety of shrimps and fishes over the years. However, these fisheries are now on a declining phase. A preliminary study was conducted to study the nutrient status in different seasons and relate the changes to anthropogenic effects and fish availability, in selected creeks situated in Junagadh and Porbandar districts of peninsular Gujarat.

Materials and Methods

The rivers selected for the study are distributed between the two districts of Junagadh and Porbander, which together account for nearly 75% of the state's total marine fish production. Water samples for hydrographic analysis were collected from the creeks before the barmouth point. The study was conducted in the following selected sites:

Hiran: River Hiran has its barmouth near Somnath in Veraval. There is a check dam present on the course of this river as it flows in from Talwagir.

Devka: River Devka flows into the sea at Jaleswar Bandar in Veraval. This river receives high amounts of industrial effluents before it reaches the barmouth.

Meghal: River Meghal, with two check dams along its course, has its barmouth near Chorwad. There is a good deposit of oyster shells in the river bed and along the banks. Dredging activities are carried out near the river banks for the shells. There is an oyster meat factory also on the river bank.

Nodi: River Nodi, originating from Meswan, flows into the sea at Mangrol. There are several check dams present along its course. The river bed has good deposits

of oyster shells which are exploited for preparation of poultry feed. The creek, formed by the river before the barmouth, receives large amounts of domestic discharge and effluents from the fishing industry.

Madhuvanti: Originating from Mendarda village, Madhuvanti river flows into the sea at Madhavpur, in Porbander district. This is a large river with a good flow of freshwater during the monsoon. Several check dams have been constructed along the riverine course.

Gamat: Gamat is a reservoir near Mul-dwaraka, formed by the collection of freshwater streams flowing in from several nearby villages. There are no impoundments as such along these streams but the reservoir is situated very close to a cement factory.

Shingoda: River Shingoda originates from the Gir forest and flows into the sea near Kodinar. There are two check dams along the course of this river. The river receives a considerable amount of domestic and industrial discharge.

The pH levels were measured at the sites using pH meter. Salinity was determined by titrimetric method (APHA 1981). Estimation of ammonia was done by the method of Solorzano (1969), involving indophenol blue reaction. Total nitrates were estimated by cadmium reduction method (Morris & Riley, 1963) with some modifications as suggested by Grasshoff (1976). Phosphorus levels in the form of dissolved orthophosphates were determined by the ascorbic acid method (Murphy & Riley, 1962). Silicate levels were estimated by the method of Mullin & Riley (1955) with modifications as suggested by Strickland & Parsons (1968).

Results and Discussion

Seasonal levels of pH, salinity, ammonia, nitrate, phosphate, and silicate and fishery resources observed in the different creeks are presented in Table 1. The pH was in the range of 8.0-8.5 in the pre-monsoon and post-monsoon periods in all the creeks. During the monsoon season, lower pH values (6-7.5) were observed, with the lowest value (6.0) in the Devka creek. Salinity conditions were more or less uniform in all the creeks. Freshwater conditions lasted for about a month in July-August. The salinity went up to 50-60 ppt during December-May. Ammonia values were lowest in the monsoon. Post-monsoon stagnation led to higher values during the rest of the year. Ammonia values were found to be highest in Devka creek throughout the study, ranging from 0.7 $\mu mol.l^{-1}$ in the monsoon to 15 $\mu mol.l^{-1}$ in the pre-monsoon. The lowest values were observed in Gamat (0.02 $\mu mol.l^{-1}$ in the monsoon and 2.4 $\mu mol.l^{-1}$in the pre-monsoon).

Table 1. Seasonal levels of pH, salinity, ammonia, nitrate, phosphate, and silicate and fishery resources observed in selected creeks of Gujarat

Station	Season	pH	Salinity, ppt	Ammonia, μ mol.l^{-1}	Nitrate, μ mol.l^{-1}	Phosphate, μ mol.l^{-1}	Silicate, μ mol.l^{-1}	Resources
Hiran	Pre-monsoon	8.4	36.8	6.8	1.8	4.1	48	Mullets, cyprinodontids, crabs, oysters
	Monsoon	7.1	5.4	0.39	0.55	1.44	388.8	
	Post-monsoon	8.1	33.2	4.1	2.1	2.7	85.6	
Devka	Pre-monsoon	8.1	57.8	15	1	4.6	26.7	Mullets (March-July)
	Monsoon	6	7.9	0.7	0.06	1.57	96.4	
	Post-monsoon	8	40.1	10.9	1.9	3.01	36.7	
Meghal	Pre-monsoon	8.5	41.1	3.6	1.3	3.3	33.5	Mullets, small perches, small penaeid shrimps
	Monsoon	7.5	5.1	0.09	1	1.21	221.8	Shrimps, oysters, therapons
	Post-monsoon	8.2	35.6	1.8	2.1	1.9	89	
Nodi	Pre-monsoon	8.1	49.1	7.7	0.54	4.1	17.8	Mullets, cyprinodontids, small shrimps
	Monsoon	6.4	6.2	0.46	0.01	1.51	22.4	Oyster shells
	Post-monsoon	8.1	39.8	4.2	1.8	2.7	21	
Madhuvanti	Pre-monsoon	8.5	39.6	2.8	1.9	3.1	45.2	
	Monsoon	7.5	2.8	0.04	1.01	1.26	351.2	Mullets, cyprinodontids, therapons,
	Post-monsoon	8.5	36.5	1.4	2.1	1.7	111.2	Lutjanids, shrimps, crabs
Shingoda	Pre-monsoon	8.3	53.2	3.9	1.2	5.2	41.8	
	Monsoon	7.1	3.1	0.18	1	1.6	187	Mullets, small shrimps, small perches
	Post-monsoon	8	48.1	1.9	2	3.8	64	
Gamat	Pre-monsoon	8.5	56.4	2.4	2.2	2.8	43	
	Monsoon	7.5	1.4	0.02	1.9	1.2	254.5	Mullets, cyprinodontids, therapons
	Post-monsoon	8.4	42.1	1.3	2.5	2.1	108.3	Crabs

Nitrate values were lowest during the monsoon and highest in the post-monsoon. Maximum nitrate values in all the seasons were observed in the Gamat (1.9 μmol.l^{-1} in the monsoon and 2.5 μmol.l^{-1} in the post-monsoon) while the lowest values were observed in the Nodi creek (0.01 μmol.l^{-1} in the monsoon and 1.8 μmol.l^{-1} in the post-monsoon). For phosphates, lowest values were seen in the monsoon while highest values were observed in the pre-monsoon. Maximum levels of phosphates were observed in Shingoda creek (1.6 μmol.l^{-1} in the monsoon and 52 μmol.l^{-1} in the pre-monsoon) while lowest levels were seen in Gamat (1.2 μmol.l^{-1} in the monsoon and 2.8 μmol.l^{-1} in the pre-monsoon). Silicate levels were highest during the monsoon and lowest during the pre-monsoon season. Maximum values were observed in Hiran (388.8 μmol.l^{-1} in the monsoon and 48 μmol.l^{-1} in the pre-monsoon) while lowest levels were seen in Nodi creek (22.4 μmol.l^{-1} in the monsoon and 17.8 μmol.l^{-1} in the pre-monsoon).

From the observations made in the present study, it is evident that discharge of effluents and obstruction of freshwater flow into these creeks have a bearing

on the levels of ammonia and nutrients. There is not much documentation on these creeks to serve as a baseline information for any comparative study. However, a Rapid Environmental Impact Statement for the Veraval Industrial Association in 2001 reports high levels of arsenic and mercury in the waters from Hiran dam, thus exemplifying the effects of human interference on the ecosystem. The extent of effects of effluent discharge, if any, into these creeks need to be assessed and levels of pollutants in effluents released into these water bodies must be in compliance with the disposal standards laid by statutory bodies to ensure minimal damage to the ecosystem. The sub-fossilised deposits of oyster shell beds observed in creeks of rivers like Hiran, Devka, Meghal and Nodi and local enquiry reveal a good history of estuarine fauna in the past while in the present study, the only resources observed were some mullets, cyprinodontids , shrimps and crabs of low economic value. Reduction in the average annual rainfall, an increasing number of man-made impoundments along the course of the river and degradation of the natural ecosystem through pollutants from anthropogenic activities have contributed to the transformation of these once fertile creeks into virtual deserts.

Estuarine ecosystems are parts of the shelf-zones of the world's oceans where contact and interaction between plants and animals and their environment occur much faster than in other biological habitats. Rivers are an important source of sand and estuaries act as sinks for sediment deposition. The construction of dams and other impoundments obstruct the transport of sediments to the estuaries. The river beds become shallower and eventually the riverine course itself gets altered. In the absence of proper riverine outflow, pollution from domestic and industrial discharge into the creeks builds up. In the absence of proper sediment transport into the estuaries and natural flushing through the barmouth, there is increased encroachment of the sea into the estuary and eventually the estuary is transformed into a saline basin with high levels of pollutants, low levels of nutrients and low productivity. The result is seen directly on the flora and fauna of the ecosystem and the estuaries fail to perform their role as breeding / nursing grounds for several groups of finfishes and shellfishes which support the marine fish production of the state. When impoundments of watersheds become fully operational, the river-coastal sea continuum becomes mortally wounded and the fisheries supported therein start to fade away (Rozengurt, 1999). Justic *et al.* (1995) reported significant changes in the surface nutrient ratios of two river-dominated coastal ecosystems - the northern Adriatic Sea and the northern Gulf of Mexico, primarily due the construction of dams. Humborg *et al.* (1997) reported a reduction in the dissolved silicate load of the Blue Danube running into the Black Sea, following the construction of dams in the early 1970s. Lakshmanan *et al.* (1987) reported extensive changes in the hydrographic conditions of Cochin backwaters by way of inter-basin transfer of water from Periyar river to Muvattupuzha river to facilitate a hydro-electric project and construction of a water barrier (Thanneermukham Bund) on the southern part of the estuary.

Considering the vast number of fishery resources thriving in the coastal waters of Gujarat and the importance of the state with regard to marine fish production in the India, the observations made in the present study underline the need for urgent and detailed investigations on the status of the several creeks that dot the coastline of the state, to assess the extent of alterations that have taken place in these natural ecosystems.

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