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Decline of fish diversity in the anthropogenically polluted Thane creek along the Central West Coast of India

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Abstract

The fish diversity and associated environment of 12 strategically selected intertidal stations along the extremely polluted Thane creek on the west coast of India were studied for a year and compared with past available data to investigate changes in the creek ecology due to various anthropogenic activities like industrial, domestic, and solid waste disposal along with land reclamation. Hydro-sedimentological investigations revealed enhancement of total nitrogen (TN) and organic carbon (C_{org}) load and hypoxic levels of dissolved oxygen (DO) over the years. Silt component of sediment was increasing, with proportionate decrease in clay due to various anthropogenic disturbances. 12 species of fish were recorded along the entire length of the creek with dominance of only 5 species that occurred throughout the year, namely Mugil cephalus, Mystus gulio, Mystus shingala, Tilapia mossambica and Scylla serrata where as the other fishes were rare in their occurrence. A comparison with the past literature for the study area revealed decline in the fish diversity. As per the energy transfer theory, it was observed that the benthos in the study area can support an average fishery yield of at least 256937.2 kg/year (i.e. 21411.433 kg/month). This however is not fully utilized because the fishes were found to feed mostly on phytoplankton and the locals also reported very poor fishery catch in the creek.

Keywords: Hydro-sedimentology, benthos, energy transfer, fish, coastal pollution.

Introduction

The coastal waters within the 30 meters of the continental shelf offer good feeding ground for many crustaceans and fishes, many of which spend a part of their life cycle in the creeks or in estuaries[1]. It is generally thought that the mangrove habitats surrounding these ecosystems are widely utilized by these marine fauna[2]. Studies in various parts of the world have recognized the importance of mangroves and sea grass beds as nurseries for fishes[3].

Several hypotheses have been proposed to explain the high abundance of juvenile fishes in mangroves and sea grass beds. The hypothesis, are based on avoidance of predators, the abundance of food and interception of fish larvae[4], viz., (a) the structural complexity of these biotopes provide excellent shelter against predators[5], (b) these biotopes are often located at a distance from the off shore waters and are therefore less frequented by predators[6], (c) the relatively turbid waters of the bays and estuaries decrease the foraging efficiency of the predators[7] and (d) these biotopes provide a great abundance of food for fishes[8,9]. But, the use of these biotopes as nurseries is not much apparent in the Indo-Pacific region[3].

The distribution and abundance of fish in estuarine and coastal environments is dependent on physical, chemical and biotic factors[10]. Increasing awareness of possible effects of man on the marine environment has led to a search for early warning indicators of any induced changes[11]. The near shore waters of industrialized cities are prone to different types of pollution[1], which get build up from various sources[12]. Further, with increasing development of shorelines and draining of mangrove swamps, it is vital that the importance of mangroves as fishery habitats be accurately defined[13], to provide useful advice for coastal management and alternative land use decisions.

Study area: Thane creek (Long. 72°.55' to 73°.02' E and Lat. 19°.00' to 19°.15' N) is a mangrove fringed tropical coastal ecosystem along the central west coast of India. The creek is 26 km long which extends northwards from the Bombay harbour bay and joins the Ulhas River by a minor connection near Thane city. The creek is narrow and shallow in the north where Ulhas river flows into it through a minor connection and is broader and deeper towards the sea. Due to geomorphic head near Thane city, the creek receives negligible fresh water flow from the Ulhas River. Hence, except during monsoon, it is tidally influenced with dominance of neritic waters. In all, 12 stations were selected with the following criteria: i. Maximum stretch (26 km) of the creek gets represented; ii. Uniform distribution of stations along both the banks; and iii. Sites of known polluting sources and human interference get represented; figure-1. Station 1 was the first station from the Ulhas river side and station 12 was nearest to the sea. Trombay (station 12) had significant fishing activity while other stations received a variety of effluents, sewage discharges, or solid wastes.

Material and Methods

The study stations were sampled monthly from May 1999 to April 2000 during neap high tide for analyzing parameters like dissolved oxygen (DO), dissolved inorganic phosphate ($PO4^{3-}$-P), and nitrate-nitrogen (NO^{3-}-N) using standard methods[14]. Salinity was estimated using the Mohr's argentometry method. Sediment samples for benthic fauna study were collected during low tide from low water level mark (LWLM), mid-water level mark (MWLM) and high water level mark (HWLM). At least five samples were collected from each water level. Each sample was collected up to a depth of 10 cm using quadrants of 0.01 m^2 size and 10% $MgCl_2$ was added to sedate the organisms. Sediment was sieved through a 0.5 mm mesh sieve and animals retained were preserved in 5% buffered formaldehyde. The preserved fauna were sorted into macro benthos and meiobenthos before weighing to finally calculate their density (ind. m^{-2}) and biomass (g m^{-2}; wet wt). The density and biomass values are used to estimate the annual production using the formula suggested by Elmgren[15], and there by evaluate the demersal fishery potential of the creek. Sediment samples, collected separately from the intertidal area, were dried to analyze organic carbon (C_{org})[16], sediment texture[17], total nitrogen (TN)[14], and total phosphorus (TP)[14]. The fish specimens were collected during the entire study period from the fishermen across the creek during their fishing activity and identified for the species[18].

Results and Discussion

Characteristics of water bodies influence the quality of water individually and in combination with various pollutants, thereby, influencing the biota therein[19]. Station-wise average hydro-sedimentological values are given in table 1. The salinity in the creek increased seawards. Though the overall average DO was 2.35 ± 0.79 mg l^{-1}, markedly low values were recorded at stations 2, 3, and 4 with DO falling close to zero in some instances under the influence of sewage point sources in the upstream zone. The average PO_4-P values were noticeably high at upstream stations 1–4, as this region was narrow and shallow and received heavy sewage load. For the same reason, higher levels of NO_3-N were found at stations 1 and 2. Gross pollution of water has its origin mainly in urbanization, industrialization, agriculture and increase in human population observed in past one and a half century[20]. Sediment texture analysis revealed that silt component was more dominant (average 66.74 ± 6.20%) than the clay (average 28.65 ± 3.5%) and sand (2.2 ± 1.21%) fractions. C_{org} and TN in the sediments declined seawards.

Thane creek has apart from mangroves, industries, urban settlements and villages along both its banks. The inhabitants of these villages are mostly fishermen who depend upon the creek. However the heavy industrialization and urbanization along the creek has resulted in release of effluents in quantities far exceeding the assimilating capacity of the creek. Environmental pollution from human activities is a major challenge of civilization[21] high input of waste results in fluctuating trend in catch rate along with low species diversity[1]. Fishes constitute economically very important group of animals[22] which is directly or indirectly related with human health[23] industrial activities which lead the acidification of water bodies, fish communities have suffered significant changes in the community composition during the present study although the fish catch was not estimated, the different species of fish occurring in the creek were collected seasonally from several fishermen in the creek while fishing. It was observed that the fishing activity was mainly restricted to the lower stretches (marine end) of the creek, while at the riverine end fishing was an activity of the monsoon season only when the commercially important fishery would occur. Surface water bodies get polluted due to urban sewage discharge[24]. In the tropical country like India, highly seasonal rainfall and heavy discharge of water during monsoons results in high flushing rate[25]. During the investigation a total of 12 species of fish were recorded, consisting of 11 species of fin fish and 1 crustacean. The 11 fin fishes include *Mugil cephalus, Mystus gulio, Mystus shingala, Tilapia mossambica, Lates calcarifera, Elops saurs, Coilia dussimieri, Trichirus savala, Cleupia toli* and *Johnius spp.*, while the only crustacean was *Scylla serrata*. Among the above fishes only 5 species were dominant and occurred throughout the year, namely *Mugil cephalus, Mystus gulio, Mystus shingala, Tilapia mossambica* and *Scylla serrata* where as the other fishes were rare in their occurrence.

All these 5 species occurred throughout the length of the creek, while the other species were restricted to the marine end of the creek. During the monsoon *Mugil cephalus, Mystus gulio* and *Mystus shingala* were reported in fairly large numbers from the upper stretches of the creek, later in the year their catch reduced significantly with occurrence of only *Tilapia mossambica* and *Scylla serrata*. However, greater abundance and fish species diversity throughout the year in the shallow region of the creek was observed during the monsoon during the 1981-82 and 1991-94 study, attributing the shallow region of the creek as a fairly sustainable nursing ground during the monsoon[26]. Although the present observation corroborates their view, a significant reduction in the diversity is also noted, with the conspicuous absence of prawns from the entire stretch of the creek. The presence of *Metapenaeus monoceros, Macrobrachium rosenbergii and Penaeus indicus* from the shallow region of the creek was reported earlier[26], while during the study in 1983, the presence of *Parapenaeopsis hardwickii, Macrobrachium rude, Metapenaeus brevicornis, Exopalaemon stylifera* and *Penaeus indicus* from the lower stretches of the creek was observed[27]. The absence of these species during the present study can be attributed to the increased pollutant load in the creek, which repelled most of the commercially important fish and crustacean species.

From the benthic faunal biomass, the average annual total production of 988.22 g/m^2/yr was calculated[15] and is presented in table 2. The values generated are used to estimate the

demersal fishery potential of the creek. Assuming that the average width of the mudflats of the creek was 100 m. (including both the banks) and the length as approximately 26 km, the total mudflat area is approximately 2600,000 m^2 using this approximation the total production of the study area amounts to 2569372000 gm/yr i.e. 2569372 kg/yr. The energy transfer from one trophic level to the next is of the order of 10 % (ecological efficiency)[28]. Using this generalization it can be concluded that the benthos in the study area can support an average fishery yield of at least 256937.2 kg/year i.e. 21411.433 kg/month. This however is not fully utilized because the fishes were found to feed mostly on phytoplankton and the locals also reported very poor fishery catch in the creek.

Table-1
Average and standard deviation values of water and sediment parameters at the intertidal stations during 1999-2000

Station	Salinity (ppt)	DO (mg l-1)	PO_4-P (mg l-1)	NO_3-N (mg l-1)	Sand (%)	Silt (%)	Clay (%)	Corg (%)	TN (%)	TP (%)
1	10.98 ± 9.6	2.73 ± 1.5	0.180± 0.092	0.987 ± 0.582	2.67± 2.42	68.33 ± 12.67	30.00 ± 11.28	2.61 ± 0.44	0.176 ± 0.054	0.6 44± 0.275
2	12.35 ± 10.5	1.13 ± 1.0	0.450 ±0.168	0.893 ± 0.640	3.97 ± 3.11	70.83 ± 12.40	21.67 ± 10.30	3.90 ± 0.38	0.281 ± 0.064	0.656 ± 0.300
3	19.29 ± 13.0	1.47 ± 1.5	0.354 ±0.114	0.945 ± 0.370	9.57 ± 3.42	64.17 ± 16.21	26.67 ± 11.55	2.76 ± 0.53	0.206 ± 0.040	0.770 ± 0.392
4	16.21 ± 12.6	2.00 ± 1.0	0.400 ±0.120	0.970 ± 0.581	1.51 ± 2.12	72.50 ± 9.65	25.00 ± 10.00	2.83 ± 0.44	0.205 ± 0.035	0.819 ± 0.374
5	15.83 ± 10.6	2.16 ± 1.0	0.398 ±0.069	0.976 ± 0.790	1.07 ± 1.23	71.67 ± 11.15	24.17 ± 12.40	3.46 ± 0.52	0.257 ± 0.060	0.772 ± 0.377
6	19.35 ± 11.5	2.98 ± 1.0	0.340 ±0.098	1.073 ± 0.491	1.12 ± 1.53	63.33 ± 20.15	33.33 ± 13.71	2.38 ± 0.26	0.164 ± 0.046	0.736± 0.276
7	21.70 ± 12.5	2.52 ± 1.4	0.255 ±0.124	1.029 ± 0.506	0.63 ± 0.80	70.83 ± 15.64	28.33 ± 9.37	2.73 ± 0.30	0.194 ± 0.042	0.708 ± 0.319
8	23.25 ± 12.5	2.21 ± 1.6	0.213 ±0.092	0.863 ± 0.426	0.76 ± 0.66	64.17 ± 14.43	33.33 ± 11.55	2.10 ± 0.38	0.149 ± 0.043	0.675 ± 0.330
9	23.40± 12.1	2.90± 1.7	0.204 ±0.087	0.939 ± 0.397	1.33 ± 2.09	62.50 ± 18.15	33.33 ± 13.03	2.41 ± 0.33	0.164 ± 0.039	0.586 ± 0.298
10	23.38 ± 12.3	2.29 ± 1.3	0.172 ±0.100	1.022 ± 0.337	2.07 ± 3.50	59.17 ± 13.11	36.67 ± 16.14	2.00 ± 0.23	0.141 ± 0.049	0.587 ± 0.280
11	23.83 ± 11.6	2.75 ± 1.4	0.210 ±0.112	1.108 ± 0.643	0.82 ± 1.52	62.50 ± 18.15	29.17 ± 15.64	2.23 ± 0.25	0.162 ± 0.035	0.591 ± 0.326
12	28.60± 11.6	3.11 ± 1.1	0.100 ±0.035	0.836 ± 0.279	0.88 ± 1.12	70.83 ± 15.05	22.08 ± 10.76	2.14 ± 0.39	0.134 ± 0.033	0.619± 0.327

Table-2
Station wise annual production estimates (gm/m2 wet wt.) and percentage contribution of macrofauna and meiofauna

Station	Macrofauna			Meiofauna			Total Annual Production Macro +Meio (gm/m^2)	% Contribution	
	Actual Density no/m^2	Actual Biomass gm/m^2	Annual Production = biomass x 2.5 (gm/m^2)	Actual Density no/m^2	Actual Biomass gm/m^2	Annual Production = biomass x 8 (gm/m^2)		Macro-fauna	Meiofauna
Stn 1	8757	70.900	177.25	598626	25.076	200.608	377.86	46.91	53.09
Stn 2	9655	67.989	169.97	609358	18.144	145.154	315.13	53.94	46.06
Stn 3	7940	126.322	315.80	601894	22.806	182.449	498.25	63.38	36.62
Stn4	33230	252.108	630.27	847240	30.819	246.551	876.82	71.88	28.12
Stn5	2860	17.268	43.17	657988	31.255	250.041	293.21	14.72	85.28
Stn6	60717	576.156	1440.39	967387	47.143	377.145	1817.53	79.25	20.75
Stn7	64455	369.107	922.77	817797	41.208	329.661	1252.43	73.68	26.32
Stn8	39363	319.675	799.19	662971	35.683	285.467	1084.65	73.68	26.32
Stn9	56345	579.408	1448.52	1034740	43.583	348.663	1797.18	80.60	19.40
Stn10	35227	388.225	970.56	701273	45.773	366.181	1336.74	72.61	27.39
Stn11	34485	640.492	1601.23	877944	33.921	271.365	1872.59	85.51	14.49
Stn12	1968	27.597	68.99	752430	33.389	267.111	336.10	20.53	79.47
Average	29584	286.274	715.68	760804	34.067	272.533	988.22	72.42	27.58

Conclusion

During the 1991-93study, 22 species of fish and 68% reduction in the fishery of the shallow region of Thane creek in comparison to the data of 1981 – 82 was recorded[26]. Although a quantitative data was not collected during the present study a comparison of the number of fish species indicated a substantial decline in the fishery of Thane creek. Further the local fishermen communicated an almost 75 % decline in the fishery in comparison to the fish catch obtained in the 1990's. The locals also informed about the gradual changes in occupation of the fishermen due to unsustaining yields, which have resulted with the rising effluent and sewage load. Moreover they complained that fish kill due to sudden release of harmful and toxic chemicals, were now a regular feature in the creek. Urbanization and industrial activities have done much harm to the natural and aquatic environment[29]. Loss of wetland has disastrous effects on wildlife and biodiversity[30]. In addition the perils of non-biodegradable matter loomed large in the creek it had even succeeded in forcing the fishermen to change their fishing gears from the traditional dol nets to gill nets, with infrequent use of wall nets. This is because the dol nets would invariably get clogged with the non-biodegradable waste like thermocol, plastic bags etc., instead of the actual fish catch. With the fishery becoming obscure in Thane creek, commercial fishing in the creek was observed to be a dying occupation.

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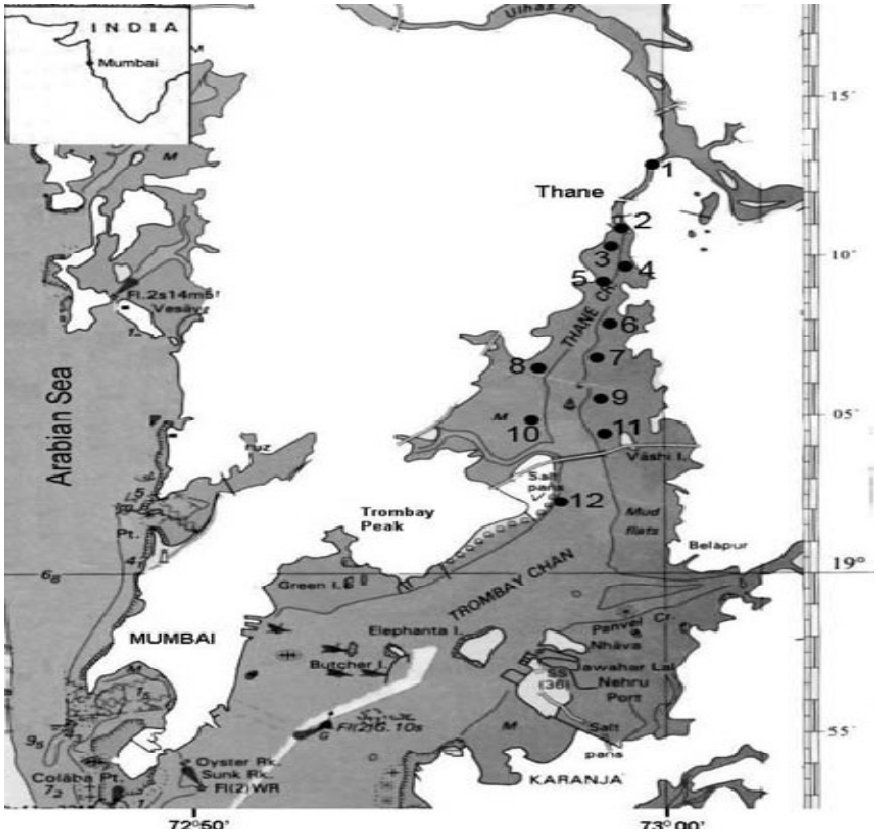

Figure-1
Location of intertidal stations along Thane creek