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Conservation of biodiversity of the coastal resources of Sundarbans, Northeast India: an integrated approach through environmental education

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Abstract

The Indian Sundarbans, a diversified coastal wetland on the southern fringe of the State of West Bengal, harbors a luxuriant biodiversity and acts as a potential refuge of living marine resources. Girdled with thick mangrove foliage, this estuarine delta system offers an excellent nursery ground for most of the brackishwater finfish and shellfish. Since supply of hatchery-produced tiger prawn seed (*Penaeus monodon*) is highly inadequate in West Bengal, the aquaculture farms of this region largely depend on the supply from natural resources. Being motivated by a regular cash income, the majority of coastal people from Sundarbans have adopted prawn seed collection as their profession almost throughout the year as an important source of earning. The users are neither trained nor guided at any stage from collection to marketing and are fully dependent on traditional methods. They first sort out the tiger prawn seeds (mainly the postlarval stage PL 20) accounting only 0.25–0.27% of the total catch and thereafter the major portion of the haul are thrown away on the beach flats or the tidal mudflats. This wasted by-catch contains the juveniles of economic and uneconomic varieties of finfish and shellfish along with a bulk of holoplankters and meroplankters (non-target species). This practice causes several ecological and occupational consequences, namely, (i) the huge destruction of the pelagic biota that can lead to severe stock depletion as well as hamper the energy transference through the marine ecosystem food webs; (ii) constant dragging of nets along the coast and tidal creeks paves the way for soil erosion, uprooting the mangrove seedlings and saltmarsh vegetation; (iii) the water quality is deteriorating in the catchment areas due to mud erosion and (iv) due to constant contact with the seawater, the collectors are affected with waterborne diseases, skin infections, reproductive tract disease in women and many other contagious diseases.

This paper, in addition to identifying the challenge to environmental quality and resource abundance, emphasizes the need for grass-root public education so that local people come to understand, support and implement sustainable resource conservation and environmental protection activities now and in the future. As a follow-up course of action, the authors have initiated a general awareness program for developing consciousness among the coastal people regarding proper use of natural resources. Initiatives are taken for educating coastal people by holding workshops and seminars with the use of educational resource materials. Exclusive awareness camps and grass root level training for coastal people are also being proposed as a future course of action by means of exhibitions, audiovisuals etc. It is proposed that local government bodies come forward to mitigate this problem with scientific and rational approaches and to take proper actions towards conservation.

Keywords: Conservation; Sustainable development; Coastal zone; *Penaeus monodon*; Sundarbans; India; Environmental education; Public awareness

1. Introduction

Coasts are dynamic interface zones involving the meeting of atmosphere, land and sea. The coastal zone also provides an important buffer zone and filtering system for the coastal ecosystem. All these components are in a fragile balance controlled by physical and biological processes which can be easily upset by natural or human-induced perturbations (Viles and Spencer, 1995). The interaction between human societies and the environment in this zone is very pronounced in the coastal regions of West Bengal, northeast India which belongs to the domain of southeast Asia known as the global environment 'hotspot' (Talaue-McManus, 2001). Hence coastal resource management has become important and imperative for nutritional, economic and environmental reasons (Bergin and Michaelis, 1996).

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The land-based activities proximal to the shore include discharges of sewage, sediments and industrial effluents. Agricultural chemicals together with pollutants from aquaculture farms, oil spills and other human interference also add to the degradation of water quality of the coastal zones. The extraction of raw materials like timber, fuel woods, prawn seeds, sea grass, molluscs and crocodile shells in the coastal zones of Indian Sundarbans has profound impact on the socioeconomy and environmental security for the coastal population.

To assess the degree of deterioration of this coastal zone of West Bengal, a systematic monitoring practice undertaken for a period of 2 years during 1998–2000 revealed certain alarming facts. There has been both an increasing trend of biodiversity loss and a fall in the quality of coastal waters due to severe anthropogenic stress for over the last two decades. This paper has the innate objective to highlight the results and adverse impacts of excessive harvesting practices of the tiger prawn (*Penaeus monodon*) seed together with the by—catches by the coastal inhabitants. Certain remedial measures are suggested to mitigate the environmental hazards.

2. Study area

The Indian Sundarbans (4267 sq. km), with rich floral and faunal diversity, forms a productive and protective margin for coastal West Bengal (Fig. 1). This is a part of the largest prograding Ganges delta formed at the estuarine phase of the Hugli-Matla river systems. It has been acclaimed as the World Heritage tropical forest site in Asia, and also designated as a global biodiversity 'hotspot' (Sarat Babu, 1999; Sayer et al., 2000). The present study area includes the coastal belts of Indian Sunderbans with special emphasis on an area, known as Lot no. 8 by the side of the Baratala river, adjacent to Kakdwip, South Twenty Four Parganas, West Bengal. A large discharge of freshwater from the Hugli estuary especially during southwest monsoon and run off of precipitated water from the catchment areas provides the brackishwater condition for the coastal waters of Bay of Bengal. This water washes in and out along many tidal inlets and creeks like Saptamukhi, Jamira, Matla, Gosaba and Raimangal with the ebb and flood tidal currents. These coastal waters are enriched with nutrients recycled from the mangrove forest of Sundarbans.

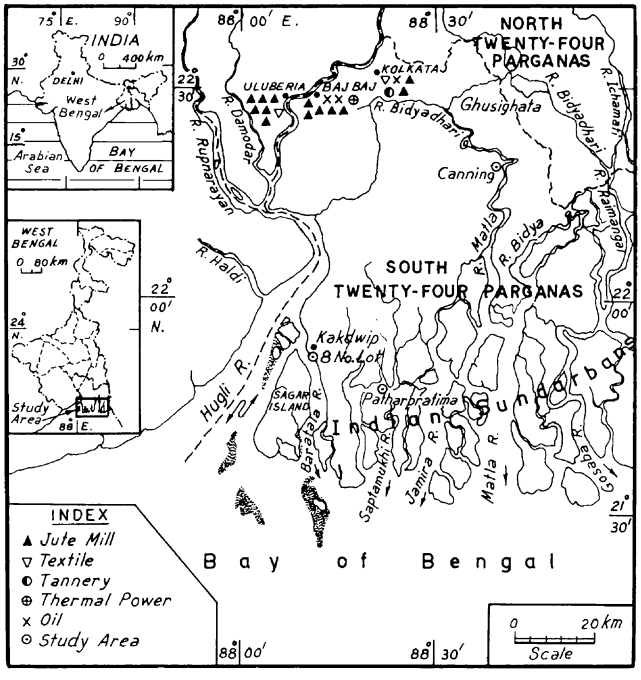

Fig. 1. Map of Indian Sundarbans showing the study area and network of important streams and creeks.

The 'extensive' aquaculture farms are increasingly mushrooming along this coastal zone taking advantage of the nutrient-rich brackishwater situation which is often supplemented by artificial feed for the establishment of 'semi-intensive' and 'intensive' aquaculture. The tiger prawn *P. monodon*, the largest Indian marine penaeid prawn (Kurian and Sebastian, 1982), is the most preferred species for shrimp farming. This species is the principal crop of such brackishwater aquaculture while mullets (*Liza parsia* and *L. tade)*, bhetki (*Lates calcarifer*) and many other species of other groups are produced as secondary crops from these waters (Guhathakurta and Kaviraj, 2000). These traditional farms yield tiger prawns at the rate of 500–600 kg per ha, measuring about 15–18 cm and their market price ranges from 7–10 US$ per kg. Due to lack of physicochemical factors (especially the requisite salinity of 30–32 ‰), artificial hatching of *P. monodon* is uncommon in the fish farms of West Bengal. On the other hand, procurement of tiger prawn seed stock from other states of India is not feasible because (i) the supply is seasonal and does not fulfil the demand for traditional fish farming, (ii) risk of contamination by microorganisms, (iii) high rate of mortality of the fetched prawn seed, (iv) the physicochemical conditions greatly differ in the different coastal states of India and (v) of a high cost involvement. Thus, the ever increasing demand of tiger prawn seed by the mushrooming fish farms along the coast of West Bengal (e.g., Sagar Island, Patharpratima, Canning) attracted the poor coastal people towards collection of prawn seeds from the seawater for selling them to the transporters to earn their livelihoods.

3. Field and laboratory data collection procedure and analyses

The data was collected twice a season during March 1998–February 2000 on the number of prawn seed catch by the professional seed collectors. The by-catch as left

over on the beach and mudflat during this process was collected and preserved in 4% buffer formalin and taken in the laboratory for identification up to species level whenever possible. The authors interviewed the seed collectors and transporters to obtain an elaborate account of the quantum of catch, rate of mortality of seeds and income incurred in the process. Hydrological parameters were estimated by standard methods (Strickland and Parsons, 1968).

4. Results and discussion

4.1. Exploitation of prawn seed

4.1.1. Collection and marketing of prawn seed

The estuarine system of Sundarbans with its intricate network of streams, rivulets, creeks and channels associated with mangrove vegetation serves as a nursery ground for many prawn and fish species as it provides physiologically suitable environment with respect to temperature, salinity and other physiochemical parameters. Millions of tiny larvae, post-larvae, fish larvae and juveniles enter into the ecosystem along with the tides for feeding and growth. The collection of prawn seeds by the coastal people continues round the year and the availability of seed in the lower zone of the Hugli estuarine system shows considerable fluctuations. Different types of nets and gears can be used for collection of the tiger prawn seeds (Basu and Pakrasi, 1979).

But due to financial constraints the poor inhabitants of the coastal areas collect the prawn seeds with the help of shooting nets of length 320 cm, width 310 cm, height 60 cm at the mouth and mesh size 3.18 mm with 1.15 mm meshed cotton tail piece. They set the nets at the outer convex erosional banks of the water courses at depths of 1 to 1.5 m with the help of bamboo poles. The peak months of collection of prawn seeds are September and October when the number goes up to 2000–3000 prawn seeds catch per person per day. Due to their large availability in this season, the price of 1000 seeds goes down as low as 1 US$. In contrast, a very high price is fetched during the months of January and February when the catch abruptly falls to 200–300 per person per day and the rate goes up to 7–8 US$ for 1000 seeds (Table 1). The fisherfolk engaged in this work efficiently segregate the seeds of the tiger prawn (post-larval stage PL 20, 9–14 mm) by identifying a distinct red streak along the ventral side of their abdomen. They simply use a piece of valve of a large dead bivalve shell and quickly isolate the prawn seed from the haul. They can also guess, by virtue of their experience, the probability of getting prawn seeds in a particular day of a season controlled by the lunar cycles (full moon and new moon), wind velocities and wave amplitudes.

4.1.2. Destruction of other pelagic resources

The crude and unscientific practice of seed collection involves an admixture of several species of shellfish, finfish and other pelagic biota. Due to market demand the seed collectors only prefer to retain the seed of tiger prawn which fetches the maximum price in the trade. After segregation of the larvae and postlarvae of the chosen target species, the rest of the collection is left aside on the beach flats or tidal mud flats as they have no market value. This crude screening practice causes indiscriminate killings of a huge number of pelagic living resources consisting of juvenile finfish, shellfish (Das and Bhattacharya, 1999) and macrozooplankters of immense ecological, commercial and biomedical values. Table 2 depicts an overall list of the encountered species of this region, many of which are endemic in nature. The present study reveals that 70–75% of other shrimp larvae and 20–25% of finfish larvae and rest 4% of macrozooplankters are destroyed during the collection of a mere 0.25–0.27% of tiger prawn seed. A substantial biomass of meroplankters consisting of megalopa, alima, anomuran larvae and polychaete larvae are also wasted in this process. Continuous process of destruction of valuable pelagic biota could, in the long run, lead to severe stock depletion in this fragile environment (Brown, 1997). Such intensive prawn seed collection has resulted in many fold decrease in the catch/net/hour.

Table 1
Seasonal variations of collected prawn seeds, mortality rate and their cost (mean values) from the collection site during 1998–2000

Season and year	No. of seeds captured per person per day	Mortality rate of prawn seeds (%) for 1000	Cost for 1000 prawn seeds (Rs.)
1998–1999			
Premonsoon	755	95	250
Monsoon	2200	255	60
Postmonsoon	380	64	400
1999–2000			
Premonsoon	810	72	240
Monsoon	2800	310	75
Postmonsoon	290	28	450

1 US $= Indian Rupees 50 (≈).

Table 2
List of the encountered by-catch species destructed during the process of collection of tiger prawn seed *P. monodon* during the study period 1998–2000

Finfish	Shellfish
Scatophagus argus	Prawn
Etroplus suratensis	*Parapeneopsis stylifera*
Mystio gulio	*P. sculptilis*
Reconda resseliana	*Palaemon tenuipes*
Cynoglossus arel	*Acetes indicus*
Leiognathus daura	*Penaeus indicus*
Setipinna phasa	*Metapenaeus monoceros*
Liza tade	*M. dobsoni*
L. parsia	*M. affinis*
Corica soborna	*Alphaeus* sp.,
Opisthopterus tardoore	
Chanda sp.,	Crab
Anguilla bengalensis	*Scylla serrata*
Pellonaditchela sp.,	*Varuna litterata*
Pama pama	*Charybdis cruciata*
Neenchelys buitendijki	
Strongylura strongylura	Zooplankton
Coilia dussumieri	Copepod
Polynemus paradiseus	*Eucalanus subcrassus*
Eleutheronema tetradactylus	*E. elongatus*
Chanos chanos	*Labidocera euchaeta*
	Pontella andersoni
	Mysid
	Mesopodopsis orientalis
	Chaetognath
	Sagitta bedoti
	S. enflata

Of the discarded biomass, approximately prawns constitute 70%, zooplankters 4%, crabs 5% and finfishes 20%. The table is, however, not exhaustive of all species.

4.1.3. Mortality of prawn seed

The poverty-stricken users, out of their illiteracy and ignorance, are neither trained properly nor guided at any stage from collection of seed to marketing. As these people depend on very old and traditional method for collection and transportation of seed resources, a mortality rate of about 15–20% has been recorded during the study period (Table 1). Sometimes they use to mix common salt (sodium chloride) to maintain the optimum saline condition to overcome the mortality rate of the collected seeds.

4.1.4. Additional possible concerns

(i) Constant dragging of nets along the shallow water coast paves the way for soil erosion, uprooting the mangrove seedlings and other macrophytic herbs (*e.g., Sueda maritima* Dunort, *Ipomaea biloba* Sweet, *Salicornia branchiata* Roxb).

(ii) Under this condition of indiscriminate and rampant exploitation, the prawn seed population can be reduced to a point where it cannot reproduce enough to sustain itself leading to the so called 'recruitment overfishing'. Besides, this may have unforeseen consequences for the rest of the community (Wells and Alcala, 1987).

(iii) Depletion of pelagic biota would have potential negative impact on demersal fishery of the offshore region.

(iv) Due to direct and prolonged contact with the seawater, the seed collectors (both male and female) are affected with some occupational hazards like waterborne diseases, skin infections, reproductive tract disease in females and many other contagious diseases. Injuries due to shark bites are also associated with this profession.

(v) Water quality is rapidly deteriorating due to high turbidity values as well as low dissolved oxygen content in coastal waters. The seasonal variations of physicochemical parameters of coastal waters also reflects the referred condition (Table 3). Decomposition of discarded biomass during the process of seed collection, destruction of mangrove plants and sea grasses as well as intensive fishing activities throughout the year are some of the important causative agents for the water quality degradation. The impacts of effluents emanating from the multifarious industries situated on both banks of Hugli river, North twenty-four Parganas (Fig. 1) are also of serious concern.

4.2. Remedial measures

Considering the magnitude of the problem, the authors have initiated mass awareness program with the following objectives: (i) recognition of environmental

Table 3
Seasonal variations of physicochemical parameters of water at 8 No. Lot, Sundarbans during 1998–2000

	Water temperature (°C)	D.O. (ml/l)	Salinity (‰)	pH	Turbidity (cm)
1998–1999					
Premonsoon	32.3	4.4	12.82	5.6	2.5
Monsoon	29.6	5.2	5.50	5.2	1.2
Postmonsoon	21.8	5.4	9.58	5.8	2.8
1999–2000					
Premonsoon	30.5	4.8	14.88	6.0	1.0
Monsoon	28.2	5.5	4.54	5.4	1.7
Postmonsoon	22.5	5.2	11.44	5.7	2.4

components in a more precise way applicable for this dynamic ecosystem; (ii) establishment of relationship between the changing environmental components with the changing stock patterns; (iii) establishment of eco-friendly programme without affecting the socioeconomic standard of the generally poor inhabitants of Sunderbans; (iv) motivate the users towards understanding the importance of nature conservation; (v) identification of potential breeding grounds for tiger prawns and enacting laws to prohibit fishing of prawn broods and (vi) monitoring program to take care of the 'health' of coastal waters.

The authors suggest that the seed collectors may more conveniently be motivated to divert their attention to culture fisheries and other non-conventional uses of this coastal zone. This may include mushroom cultivation, apiculture, cash crop production etc., as means of livelihood for coastal inhabitants (Sarkar, 1999; Mukherjee, 1999). This would not only help conservation of this ecosystem but also will allow sufficient time for replenishment of the coastal waters. To encourage these non-conventional cultures, proper demonstrations and training programs are to be organized both in the private and federal levels to highlight the profitability of these practices. Special educational programs for all types of ecotourism involving participation of government officials and native population are to be oriented without any further delay. Publications such as leaflets, books, and posters in regional language on the identification of marine biota and campaigning through video cassettes on coastal zone management are to be brought out as part of environmental studies.

5. Conclusion

This study reveals that it is high time to realize the fact that natural abundance of tiger prawn seeds is fast reaching the threshold limit. It calls for immediate attention to bring back a balance between the quality and quantity of seeds produced in natural environment and the quality and quantity harvested. The study also points out that due to increasing demand of prawn seeds by the brackish water farms, the number of seed collectors have increased over the past five years. Hence it would be wise to find out substitute employment opportunities and then motivate the fisher folks to take up some eco-friendly and non-conventional occupations.

It is recommended to undertake a detailed bio-ecological survey of endangered and commercially important species along with a community- based socio-economic survey of the user groups. Thereafter, an integrated data base is required to be prepared for formulating an effective conservation and management plan of this region.

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