

Significance of Mangrove Swamps for Aquaculture

SAYEEDA WAFAR & A.G. UNTAWALE

National Institute of Oceanography, Goa

Abstract

Mangrove ecosystems are specialised environment. They are unique in many ways and include terrestrial plants growing in swamps containing saline water with a dense root system and a network of aerial roots. Trees produce a considerable amount of organic matter which flows in different pathways as food for marine organisms. Mangroves serve as nursery grounds for marine fishes and shrimps. There is a flourishing capture fishery in mangroves in many Asian countries. Since ancient times, portions of swamps are being converted into ponds and these are used for aquaculture of fish and prawns. In many countries including India thousands of hectares of mangrove swamps have been converted into brackish water farms. Along the east coast of India about 26% reduction has occurred in the mangrove cover between 1975 and 1991. Long-term use of aquaculture in ponds degrades the environment and hence it is suggested that a number of precautions become necessary before they are used for aquaculture. It is also important to protect and conserve the mangrove forests with their swamps and several alternatives have been suggested so that both aquaculture and this unique ecosystem could coexist. These are based on management principles.

Ecological features

Mangrove ecosystems, also known as mangals or mangrove swamps are notable for their unique ecological features and for the levels of biological productivity which are quite often higher than those of the adjacent coastal or estuarine waters. In terms of ecological features, the most prominent in this ecosystem is the terrestrial vegetation consisting of trees and shrubs belonging to several families. These have many characteristics and adaptations that enable them to grow and thrive in saline and occasionally anaerobic conditions. This vegetation has two major ecological roles to play: (i) their dense root system and the network of aerial roots trap freshwater borne sediments and detritus, thus reducing erosion and providing shelter for a number of organisms, and (ii) the terrestrial vegetation produces much more organic matter (primary production) than the aquatic autotrophs (tree production is generally 2-3 orders of magnitude higher than that of phytoplankton) and sustains the aquatic food chain. This transfer occurs *via* litter-fall and the litter is initially passed through a decomposition

stage. After that, the material may undergo either of the following three pathways: (a) may serve as food for the secondary producers during all stages of its decomposition, (b) may get ultimately broken down completely resulting in inorganic compounds, or (c) may at any stage of its decay go out of the system. The nutrients released would support phytoplankton production thus re-entering the food chain. The litter-fall in any mature mangrove is of the order of 1000 g dry wt/m²/yr and the carbon and nitrogen flux from this source would be of the order of 1400 mg C and 27 mg N/m²/d (Wafar *et al.*, 1997).

Nursery Ground for Young Hatchlings

Such a high productivity and its utilisation promoted by mangroves are because of two reasons: (i) this ecosystem is often called nursery ground for the young ones of many marine fishes and shrimps. The fishes lay their eggs in the entangled roots of the trees and later they hatch and grow on the the needed food available, and (ii) the root system provides shelter to juvenile fishes and prawns. Other groups of aquatic organisms depend on plankton or benthic organisms. These are also available within the ecosystem. A large amount of detritus is used as food for the deposit feeders, especially shrimps. Because of these reasons, the mangrove swamps have been widely acknowledged to play a significant role in sustaining coastal marine fisheries in the tropical world.

Fishery of Mangroves

The importance of mangroves to local fishery can be judged from the diversity of finfish existing in the swamp and the relationship between the fish catch and the mangrove area. Jeyaseelan (1998) has described 77 species of finfish from the mangroves of Indian Ocean and Western Central Pacific. A strong linear relationship has often been demonstrated between the capture fisheries and the mangrove cover in the coastal zone of tropical waters. An analysis of marine fisheries data of 1981 for the peninsular Malaysia shows that 32% of the capture fishery is associated with mangroves (Anon, 1976). On the west coast of peninsular Malaysia, 42% of the landings are associated with mangroves, whereas the east coast of the country has shown only 12% of fish landing (Jothy, 1984). Statistical correlations have also been obtained between the mangroves and shrimp landings in peninsular Malaysia, suggesting that mangrove waters in Malaysia support a diversity of fish and prawns (Gidney *et al.*, 1982). Similar observations have been made in Australia (Blabber *et al.*, 1989), and in the deltas of Sundarbans, both in India and Bangladesh (Ahmed, 1966). Moreover, the influence of mangroves on the fisheries extends far into the coastal waters, well beyond the limits of the ecosystem. Turner (1977) correlated the landings of penaeid shrimps and the areas of intertidal vegetation at 27 locations around the world and obtained linear relationships between these two variables indicating that the shrimp production increases with the size of mangrove vegetation. A correlation between shrimp landings and

mangrove areas has been found in Indonesia by Martosubroto & Nameen (1977). This has been given in Table I. MacNae (1974) reviewed the situation around the Indian Ocean. He compared the mangrove areas with shrimp landings and concluded that *P. indicus*, *P. monodon* and *P. merguensis* depend on mangroves for the shelter during their juvenile stages. Though this ecosystem sustains both directly and indirectly a rich fishery, it is still not possible to generalize the statement, "no mangroves — no prawns". In many regions the correlation between prawn landings and mangrove areas is good but, this is not always true. A probable cause for this could be incomplete and inaccurate fishery data from some regions.

Table I
Mangrove areas and shrimps landing for some countries

| Country | Mangrove area (in hectares) | <i>Penaeus</i> spp (in tonnes) | Total shrimp (in tonnes) |
|-------------|--------------------------------|-----------------------------------|-----------------------------|
| India | 355,500 | --- | 24,769 |
| Thailand | 317,700 | 14,164 | 116,403 |
| E. Malaysia | 539,134 | -- | 15,633 |
| W. Malaysia | 149,500 | — | 54,584 |
| Indonesia | 3,000,000 | 41,080 | 117,311 |
| Philippines | 251,577 | 19,026 | 24,984 |
| Vietnam | 300,000 | — | 62,000 |
| PNG | 250,000 | 653 | 1,490 |
| Australia | 1,161,700 | — | 21,565 |
| Total | 6,325,111 | 74,923 | 438,739 |

The annual marine fish production in India is about 2.27 million tonnes including 62,000 tonnes of shrimps. Among the shrimps, *Penaeus monodon*, *Penaeus indicus* and among the fishes *Etroplus*, mullets, etc. are common in the mangroves of India. It has been reported that the migration of larvae of penaeid prawns to the mangrove swamps is regulated by salinity — they prefer lower salinity and *P. merguensis* depends on mangroves for shelter during its juvenile stages. Thus, the early life of penaeid prawns is spent in the mangrove swamps using them as nursery grounds but their residence period differs from species to species. About 195 species of juvenile fishes belonging to 127 genera of 68 families have been listed from the mangrove ecosystem of Pichavaram along the east coast of India (Jeyaseelan & Krishnamurthy, 1981). According to the studies of Mohan *et al.* (1997), species like *Penaeus monodon*, *P. indicus*, *P. semisulcatus*, *Metapaenus monoceros*, *M. dobsoni*, *M. affinis*, *M. brevicornis* form commercial fisheries from the mangrove swamps of Godavari delta.

It is not only the capture fishery that benefits from the presence of mangrove swamps but also the culture fishery derives advantage from the mangrove swamps.

The high production rate along with the high preference of fish larvae and juvenile shrimps to mangrove environment render them ideal sites for aquaculture.

Aquaculture in Mangroves

The impoundment of mangrove swamps into aquaculture ponds is not a new activity — since the time immemorial man has been utilising mangrove swamps for aquaculture purposes. During the construction of the aquaculture ponds, the mangrove trees are cleared, land is levelled and then the pond area is flooded, drained and dried. Subsequently, small dikes are built and sluice gates are installed to retain water irrespective of the tidal conditions. The pond is then seeded. Over the past few decades tidal area under conversion to fish ponds has been increasing continuously. The total estimated mangrove area of Asia and the Pacific regions was around 7.6 million hectares in the year 1982. From this, about 1.2 million hectares of mangrove forests in the Indo-Pacific region has been estimated to be converted into aquaculture farms in the year 1977. The individual pond generally ranges from 0.1 - 1.0 ha to hundreds or thousands of hectares in size. Conversion of mangroves into brackish water farms is very extensive in the Philippines, where 1.25 million hectares representing over 45% of the original mangrove swamps, have reportedly been reclaimed for shrimp and milkfish farming between 1967 and 1977 (Liberto, 1984). About 0.5 million hectares of mangrove areas have been reclaimed for aquaculture purposes in Thailand (De la Cruz, 1984). In India, more and more mangrove areas are being acquired for this purpose especially in Tamil Nadu, Orissa, Sundarbans and Andhra Pradesh. The total annual fish and shrimp production from mangrove areas is about 2.3 tonnes per hectare. The shrimp production in India has grown at the rate of 15% annually, bringing the country to the position of 4th largest shrimp producer in the world. Along the east coast, where there is an active shrimp production industry, 26% reduction has been observed in the mangrove cover between 1975 and 1991. Similarly, shrimp farming is one of the fastest export-oriented industries in Bangladesh, which is again at the cost of mangrove vegetation (Brown, 1997).

Although mangroves have been used for centuries for fish and shrimp culture on a small, sustenance level by the local population, with a minimal damage to the ecosystem, in recent years it has become a commercial industry leading to serious environmental impacts. Removal of mangroves for aquaculture significantly affects the shore-line configuration, generation and cycling of nutrients in coastal seas besides accelerating coastal erosion and destruction of natural habitats of many commercially important species which use the intertidal ecosystem as breeding, nursery and feeding grounds (Primavera, 1991). Risks, associated with the expansion of areas, have already been demonstrated in countries like Thailand, Malaysia and Indonesia. In Pakistan, environmental constraints due to extensive development of shrimp farms are extremes of temperature, salinity, fluctuations in creeks and degradation of estuarine water due

to artificially reduced river flow (Brown, 1997). While the small-scale pond construction would not have significant adverse effects on the mangrove ecosystem, construction of large scale aquaculture farms will require large-scale felling and clearing of mangrove trees. Thus, conversion of large mangrove areas will result in open, degraded mudflats and this in turn will reduce the capture fishery yields from the adjacent waters. Once an area is converted into the aquaculture ponds, it is no longer a natural ecosystem and will cease to contribute to the productivity of the nearshore environment.

Degradation of Environment

A variety of chemicals are also used in coastal aquaculture such as hormones and growth promoters to accelerate the growth whereas products such as disinfectants, narcotisers and biocides are used to weed out the predators and parasites. Such chemicals have a long life in the aquatic environment and if allowed to escape into the adjacent natural waters, as it happens with every renewal or exchange of water, can affect other organisms as well. Moreover, several marine organisms are capable of concentrating some of these toxic products in their tissues and passing them on to higher trophic levels, including man.

Construction of aquaculture ponds on mangrove swamps can lead to other problems. The exposure of sediment to air, results in the formation of highly acidic conditions, thus leading to the acid-sulphate soil problems. Besides aquaculture, mangroves are also reclaimed for agriculture, urban and industrial development. These will automatically result in a reduction of total organic input affecting the productivity of the aquaculture operations themselves. It will naturally have a direct impact on capture fisheries, which will in turn have a bearing on the socio-economic well being of the rural population. In fact, in Latin American and Asian countries, there is a concern that large scale mangrove conversion for shrimp and fish farming has affected widely the rural communities which depend on mangrove resources for their livelihood (Roy, 1984). Development of aquaculture ponds in mangrove areas should therefore be carried out with caution, and prior to any such conversion, a detailed survey of the soil and other conditions should be conducted (Singh, 1980).

It is not our intention here to undermine the economic importance of aquaculture but rather to indicate how far it remains sustainable, i.e. how much of the mangrove swamps can be allowed to be converted into aquaculture ponds without affecting the balance of mangrove ecosystem as well as fishery from the adjacent regions. Aquaculture production is increasing worldwide with Asia accounting for nearly 80% of it. It is expected that it will expand further significantly in the near future. With improvements in techniques, diversification will include many more candidate species. The Mangrove Aquaculture Workshop which was held at Iloilo City of the Philippines during 1986 recommended that:

- (1) Utilisation practices which can be economically productive but are destructive from the ecological point of view need to be discouraged.
- (2) Aquaculture in reclaimed mangrove areas should be intensive rather than extensive in order to lessen the pressure on the remaining mangrove areas.
- (3) In case where conversion of mangrove areas is inevitable, the criteria to be considered are: (a) Underutilised mangrove areas should be given first preference for aquaculture development, (b) Proper site selection survey with chemical, biological and hydrological studies should be conducted, (c) Short-term and long-term cost-benefit ratio should be studied, (d) Impacts of reclamation on the socio-economic fabric of the people residing in the areas must be given serious consideration, and (e) Appropriate technologies should be introduced to minimise adverse impacts.
- (4) More importance should be given to research on ecophysiology of plants, animals and microorganisms in the mangrove ecosystem, development of technologies that would increase seed production of various species used in aquaculture and more knowledge on the role of mangroves on the life stages of various species of fishes and shrimps should be given a high priority.
- (5) Government policies and regulations, consistent with the workshop recommendations, should be formulated and these should be strictly enforced. GESAMP (1991) recommended that the use of mangrove along the shore front or fringing river banks for aquaculture should be discouraged. Burbridge *et al.*, (1988) suggested the following criteria for the construction of shrimp pond in mangroves: (a) The pond should be constructed in areas away from the mangroves and (b) Rehabilitation of the abandoned ponds and improved management of the existing ponds should be considered before clearing additional mangrove areas. The following guidelines have been suggested in the areas where there are no alternatives to the conversion of mangroves: (a) avoid high acid-sulphate soils, (b) ensure exchange of at least 25% of pond water daily by either tidal inlets influx or by pumping, (c) if not possible, lime should be used to neutralise acid or non-acid soils to be used for the bunds, (d) avoid constructing ponds over the tidal so that tidal incursion is not blocked, (e) avoid diversion of freshwater runoff away from the mangroves and (f) implement the plans given by the National Mangrove Committees for awareness and information.

Measures for Conservation of Mangroves

Keeping in mind the importance of mangroves, we need to think seriously about an alternate proposal by which neither mangrove ecosystem should be harmed nor the prawn farming be affected. The best alternative will be to select some flat-lands along the estuaries having sparse or no mangroves with direct opening into the estuary rather

than the mangrove area, especially in the upper reaches of the estuaries which will require minimum conversion. To save the mangroves from reclamation, it is necessary that future aquaculture programmes should be planned with care and with the full support of the people living in the neighbourhood. An assessment of the environmental damage caused by aquaculture in mangroves on the socio-economic conditions of the coastal inhabitants should be given maximum consideration. Also people should be made aware of the importance of mangrove ecosystem and the dangerous consequences leading to its destruction. People should also be made aware about the possibility of regenerating mangroves and the techniques employed for this purpose. In most countries such as India, Pakistan, Bangladesh where mangroves have been seriously degraded, afforestation has become a tool for the recovery of vegetation.

There is a need for protecting the coastal areas and for ensuring that the use and activities in the coastal areas are consistent with the principles and requirements of environmental conservation. According to the Gazette notification of the Ministry of Environment and Forests, Govt. of India, some of the prohibited activities in the coastal regulations are:

1. Setting up of industries except those directly related to sea front
2. Disposal of hazardous substances
3. Setting up of mechanisms for the disposal of wastes
4. Dumping of wastes
5. Bunding or disturbing the natural coast except those required for the control of coastal erosion
6. Land reclamation
7. Construction activities in ecologically sensitive areas

Notwithstanding all these regulations, a simple question we need to answer is: can we allow mangroves to be used for other gainful activities and where do we draw a line? Let us get back to the basic concept of biodiversity — knowing what we have (as species resources) and sustainably using it. The same concept holds valid with the ecosystems as well. We go for total conservation, then we deny others the benefit of its resources or we go for uncontrolled use, then we decrease its sustainability.

It would still be possible to satisfy aquaculture needs and the conservation lobby, if some ground rules are laid down and adhered to. Some of these are:

1. Define the percentage of mangrove cover that can be permitted for other uses and delimit them geographically.
2. Minimise the loss of mangrove vegetation and include as much open space as possible in conversion.

3. Opt for optimal culture practices rather than extensive ones
4. Maintain a rural/community base rather than a commercial base
5. Develop pond structures in such a way that water exchange in the adjacent or the remaining mangroves is not cut off.
6. Bring equivalent area of open denuded mudflats under afforestation to compensate for the loss of mangroves under conversion.
7. Maintain water quality so that there are no negative impacts of water exchange on the adjacent mangroves.

We can add to this list many more measures so that we could probably satisfy both the needs if we are careful about our management principles. We need a long-term policy and a carefully laid out strategy for its implementation. Both these are within our reach and our management expertise.

References

- Ahmed, N., 1966, Fish and fisheries of Sundarban. In: UNESCO, Scientific problems of humid tropical zone deltas and their implications, *Proceedings of the Dacca Symposium, Paris*, pp. 271-276.
- Anon, 1982, Report of the workshop on the fishery of the Malacca Straits: Part II. Jakarta, Indonesia, 29 March-2 April 1976. Manila FAO South China Sea-Fisheries Development Coordinating Programme SCS/GEN/76/6, 122 pp.
- Blabber, S.J.M., Brewer, D. T. & Salini, J.P., 1989, Species composition and biomass of fishes in different habitats of tropical Northern Australian Estuary: Their occurrence in adjoining sea and estuarine dependence. *Estuarine Coastal Shelf and Science, Vol. 29*, pp. 509-531.
- Brown, B.E., 1997, The conversion of mangroves for shrimp aquaculture development. In: *Integrated Coastal Management: South Asia*. Department of Marine Sciences and Coastal Management, University of New Castle, New Castle Upon Tyne, United Kingdom.
- Burbridge, P.R., Nargaard, R.B. & Hartshorn, G.S., 1988, Environmental guidelines for resettlement projects in the humid tropics. *FAO Environ. Energy Pap.*, 67 pp.
- De la Cruz, A.A., 1984, A realistic approach to the use and management of mangrove areas in southern Asia. In: *Physiology and Management of Mangroves*, edited by H. J. Teas (W. Jhenk Publishers), pp. 65-68.
- Gidney, R.H., Kapetsky, J.M. & Kunhold, W., 1982, Training on assessment of coastal aquaculture potentials in Malaysia — South China Sea fisheries development and coordinating programmes SCS/GEN/42/35.
- Jeyaseelan M. J. P., 1998, Manual of fish eggs and larvae from Asian mangrove waters. Editorial advisor: M. Vannucci, published by UNESCO. ISME, 193 pp.
- Jeyaseelan, M.J. P. & Krishnamurthy, K., 1981, Role of Mangrove forests of Pichavaram as fish Nursery, *Proc. Indian Nat. Sci. Acad, Vol. B 46*, pp. 48-51.
- Jothy, A. A., 1984, Capture fisheries and the mangrove ecosystem. In: *Productivity of the Mangrove Ecosystem: Management Implications*, pp. 129-149.
- Librero, A.R. 1984, Mangrove management in the Philippines. In: *Proc Physiology and Management of Mangroves*, edited by H.J. Teas (W. Jhenk Publishers), pp. 79-87.
- MacNae, W., 1974, Mangrove forests and fisheries. Indian Ocean Programme, *Indian Ocean Fisheries Commission*, 35 pp.

- Martosubroto, P. & Nameen, N., 1977, Relationship between tidal forests (Mangroves) and commercial fish production in Indonesia, *Marine Research in Indonesia*, Vol. 18, pp. 81-96.
- Mohan, P. C., Rao, R. G. & Dehairs, F., 1997, Role of Godavari mangroves (India) in the production and survival of prawn larvae. *Hydrobiologia*, Vol. 358, pp. 317-320.
- Primavera, J. H., 1991, Intensive prawn farming in the Philippines. Ecological, social and economic impacts. *Ambio*, Vol. 20, pp. 28-33.
- Roy R. N., 1984, Consultation on social feasibility of coastal aquaculture: held on 26th Nov. - 1st Dec. 1984 in Madras, India. Organised by National Swedish Board of Fisheries and Bay of Bengal Programme (FAO/SIDA), *Estuarine Coastal Shelf and Science*, Vol. 29, pp. 509-531.
- Singh V.P., 1980, Management of fish ponds with acid sulphate soils. *Asian Aquaculture*, Vol. 3, pp. 46.
- Turner, R. E., 1977, Intertidal vegetation and commercial yield of Penaeid shrimp. *Trans. Amer. Fish. Soc.*, Vol. 106, pp. 411-416.
- Wafar, S., Untawale, A.G. & Wafar, M., 1977, Litter fall and energy flux in a mangrove ecosystem. *Estuarine, Coastal and Shelf Science*, Vol. 44, pp. 111-124.