

Aquaculture Practices and the Coastal Marine Environment

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Abstract

Aquaculture has the potential for causing environmental harm as well as for improving livelihood and nutrition. Aquaculture development, therefore requires to be seen in the wider context of aquatic resource use, land use development and its environmental consequences.

As a consequence of the scientific and technical progress during the recent decades, during which time large scale operations have been introduced, aquaculture has become the main local water consumer and polluter in many coastal areas. The size of the industry which is now beginning to emerge, the scale of its individual production units, raise questions concerning the high input rate of feed and chemical and a correspondingly high production of wastes. In intensive aquaculture system uncollected dead fish, non-consumed and undigested feed, metabolic excretory products, residue of biocids and biostats are continuously released from the rearing units, thus causing environmental problem in the coastal areas.

The damage caused by aquaculture to other activities, and to the environment in the whole area, may be irreversible and inhibit other forms of sustainable exploitation of natural resources. It is therefore essential that the potential negative effects of intensive aquaculture development, particularly in the developing countries, be appraised thoroughly and to be included in the planning process.

* The present paper reviews the development of

aquaculture and its possible impact on the coastal marine environment in the developed and developing countries.

Introduction

Aquaculture is a fast growing industry in the south east Asia. This region alone contribute about 85% to the total world aquaculture fish production. The relative importance of aquaculture in future seafood production can be assessed from the amount of aquaculture production and the present estimates for capture fishery. The mangroves are the basic source of nutrients for the larvae of commercially important fishes and prawns and the capture fishery indicate a positive relationship with the available mangrove areas. However, as indicated in recent FAO report, aquaculture has the potential for causing environmental harm and up to certain extent, it has already done the damage to the mangrove environment in the South-East Asian countries (Arbhabhirama *et al.*, 1988; Chua *et al.*, 1989; Beveridge and Phillips, 1993).

Aquaculture practices have become an environmental concern as a result of expansion and intensification of culture operations. The small-scale aquaculture practices may have little significant impact on the ecosystems, and the traditional shrimp ponds operating within mangrove swamps using enclosed muds and sluice gates are the best examples. However, intensive and/or extensive aquaculture practice may give rise to environmental problems, if unabated.

Table 1: World shrimp production through aquaculture.

Country	Production (tonnes)	Area (ha)	Production (kg/ha)
China	1,45,000 (21.0)	1,40,000 (41.4)	1,036
Indonesia	1,40,000 (20.3)	2,00,000 (20.1)	0700
Thailand	1,10,000 (15.9)	80,000 (8.0)	1,375
India	35,000 (5.1)	65,000 (6.5)	0538
Philippines	30,000 (4.3)	50,000 (5.0)	0600
Vietnam	30,000 (4.3)	1,60,000 (16.1)	0188
Taiwan	30,000 (4.3)	8,000 (0.8)	3,750
Bangladesh	25,000 (3.6)	1,00,000 (10.1)	0250
Japan	3,500 (0.5)	500 (0.05)	7,000
World	6,90,100	9,93,750	694

Source: Srivastava, 1993.

Table 2: State-wise details of shrimp farming in India (1992-93)

State	Estimated Brackishwater Area (ha)	Area under culture (ha)	Estimated production (tonnes)
West Bengal	4,05,000	34,050	16,300
Orissa	31,600	7,760	4,300
Andhra Pradesh	1,50,000	9,500	12,800
Tamil Nadu	56,000	530	1,100
Pondicherry	800	Negligible	Negligible
Kerala	65,000	13,400	9,750
Karnataka	8,000	2,570	1,150

Goa	18,500	550	350
Maharashtra	80,000	1,980	1,050
Gujarat	3,76,000	360	200
Total	11,90,000	70,700	47,000

Source: Aquaculture drops for farmers, MPDA publication (1993), Vol. VI No. 8, 1-4 pp.

Table 3: Average aquaculture production in India through different type of systems.

System	Production (tonnes) per ha per year		
	B.W. Prawn	F.W. Prawn	F.W. Carp
Extensive	2.0	0.5	2.0
Semi-intensive	5.0 6.0	2.0	5.0
Intensive	>10.0	>4.0	<10.0

B.W. : Brackish water, F.W.: Fresh water.

Aquaculture Methods

- a: Fish/prawn farming in ponds.
- b: Cage culture, pen culture.
- c: Mussels, oysters and clams culture on floating rafts, long line and stake.
- d: Hatchery operations.

World Aquaculture Production Trends

In 1990, the total world aquaculture production had reached just over 15 million tonnes (Table 1), valued at about US \$ 26.5 billion (Josupeit, 1992). Predictions indicate that future production will reach 19.6 million tonnes by 2000, 37.5 million tonnes by 2010, and 62.4 million tonnes by 2025. On the contrary, world fisheries production from capture fishery will remain stable at about 100 million tonnes (Hempel, 1993). Therefore, all future production increase in seafood supplies is expected to come from aquaculture (Fig. 1).

Indian Scenario

Traditionally in India, aquaculture and fisheries had been associated with the poor, illiterate and undernourished fishermen who belonged to economically weaker sections of the society. However, considering the vast potentially suitable brackish water area, at present (Table 2), it is an industrial activity and more than 32 large companies have entered the fray. Our export have also increased from Rs. 680/ crores in 1986 to Rs. 2,500, crores in 1993. Now Ministries of Science and Technology, Agriculture, Commerce and Rural Development are extending support to the development of aquaculture. Present level of production from different type of aquaculture in india is given in Table 3. The average production is around 1800 kg/ha for fish and less than 550 kg/ha for brackish water prawns.

However, free of regulations and boosted by its inherent profitability, this 100 per cent export industry has grown unabated. The pains of the boom are suddenly becoming apparent.

Environmental Impact

In the global perspective, aquaculture in the past has been a marginal activity. However, the size of the industry which is now beginning to emerge, and the scale of its individual production unit, start to raise questions concerning physical and economical development, resource utilization and environmental protection. This has necessitated us to see aquaculture in a much wider contexts of resource use, land-use development, rural, regional and general economic development. It has frequently been claimed that aquaculture is a complementary activity, profitably utilising the resources which are otherwise unused. Closer inspection, however, suggests this rarely is the case and that the use of resources by aquaculture represent a removal for use elsewhere. Environmental considerations are becoming an important issue (Table 4), and is seen as a major constraint for future aquaculture development.

Physical Environmental Changes

Mangroves occur throughout the tropics and in sub-tropical areas on sheltered shores bearing soft intertidal sediments (Macintosh, 1982). The total global mangrove resource has been estimated to cover an area of 160,000 km². Of these less than 1% occurs along the Indian coast. As seen in figure 2, large areas of pristine tropical wetlands, predominantly mangrove swamps have been cleared and converted to brackishwater fish pond or shrimp farm.

In India, presently there is a boom of the shrimp farming and it is attributed to rapid and unregulated cleaning of coastal wetlands. Best example is of Nellore, where prawn farmers pose a direct threat to the rich mangrove forests (India Today, Oct. 31, 1994). According to the recent survey, India has lost almost 35% of the mangrove in less than 15 years, substantial portion of it has been for the shrimp culture. As the shrimp farming in India is expanding fast, more areas of mangrove swamps are likely to come under cultivation. In Brazil, mangrove cutting to develop shrimp ponds, had to be terminated.

Increased Nutrient Load and Eutrophication

Coastal aquaculture contribute to the enrichment of the coastal waters where farms are located. Uneaten food and residue organic or inorganic fertilizers are constantly added to the marine environment. For achieving the high yield ca. 670 kg of feed per ha. per day is added to the farm. Out of which 10-20% goes as waste. The total load of phosphorus and nitrogen from a typical cage fish farm has been estimated to be about 20% kg and 90 kg, respectively, per tonne of fish produced per season with a feed coefficient of 1.3 (Ackefors & Enell, 1990). The nutrients released consist of dissolved and particulate fraction. High input of nutrient salt in coastal water may lead to phytoplankton bloom and eutrophications.

Table 4: Environmental impact from different type of aquaculture systems.

System	Type Impact
Fish/prawn culture in Ponds	Destruction of ecosystem, salinization, acidification of soil. Health risks to farm workers from water borne diseases.
Raft culture	Public, health risks microbial disease, red tides, Industrial pollution, wood consumption.
Cage/Pen culture	Exclusion of local fish fauna, navigational hazards, social disruption, wood consumption.
Hatcheries	Accumulation of wastes, nutrients and organic enrichment, impoverishment of biodiversity, microbial diseases.

In intensive and semi-intensive shrimp farm, 10-30% of the water is exchanged every day either through tidal energy or pumping. During the process, aquaculture effluents are drained into the marine ecosystem (Brown *et al.*, 1987; Enell & Ackefors, 1991). One of the first effects of enrichment is an increase in oxygen consumption by heterotrophic organisms within the sediment. When the demand for oxygen exceeds the supply, the sediment becomes anoxic and at this point there are major changes taking place in sediment chemistry and ecology of benthic organisms (Baden *et al.*, 1990).

It is evident that considerable amount of waste is produced by fish farm. The consequences of any hypernutrification in terms of enhanced primary production and phytoplankton standing crop are complex. Sometimes the phytoplankton production is stimulated by eutrophication while in other cases it is not affected. There are a number of toxic dinoflagellates stimulated by the addition of ammonia. Red tides have become a synonym with eutrophication and mass killing of the fish.

Impoverishment of Biodiversity

In addition to the ecological effects of the

wastes released from the fish farms, the presence of high biomasses of fish/prawn and human activity can dramatically alter the local ecology. Routine farms operations may disturb the breeding of some species. There have been a number of accusations that fish farm development has a negative impact on wildlife, in particular predatory birds and mammals (Annon, 1988; Whilde, 1990). The best example is of the Pulicat bird sanctuary, where prawn farmers, in gross violation of the Wildlife Act, have begun to encroach on the bird sanctuary.

Socioeconomical and Health Implications

While aquaculture creates employment, the skills of farmers, fishermen and occasionally scientifically trained staff can be harnessed. Farmed fish can pose a health risk. Bacterial and viral numbers in waste-fed ponds tend to be higher than in non waste-fed ponds. Because fishes are not susceptible to the same pathogen as human, they can safely harbour these microorganisms and, unless depuration is used, muscle may become contaminated during processing.

The impact of mangrove clearance is difficult to quantify, but there is no doubt that removal of

mangroves has a significant ecological, economic and social impact. The loss of shrimp nursery grounds from mangrove areas may also adversely affect the shrimp culture and capture fishery. Mangroves are also important in coastal protection and their removal may cause coastal erosion. The loss of mangrove habitats can bring associated losses of wildlife, from insects, such as fireflies, to proboscis monkeys. Aquaculture is a net consumer of water and therefore, in areas, where water is scarce, conflicts can arise.

Excessive use of ground water to dilute seawater for shrimp culture may lower the ground water table, land subsidence and intrusion of salt water into the freshwater aquifer. For example in Nellore District, the Kurrupattapupalam village has no drinking water. All the wells and other fresh water sources in the village turned saline, because salt water from the ponds where the prawns are cultivated seeped into the ground water sources.

Ameliorating the Effects of Aquaculture

The primary focus is to reduce levels and/or consequences of impact, but the implied benefit is that these should, if properly applied, permit the restoration and rehabilitation of damaged areas by reducing impacts to within the carrying capacity of the system involved. The use of specific management techniques can also contribute to amelioration, and hence restoration. These would include measures such as feed quality and distribution control, selection of non-competing stocks and/or genetic pools, reducing conflict with potential predators, control of waste use and/or regulation in better conjunction with seasonal changes.

Routine water conservation is practised in many aquaculture systems and can be implemented in many ways. Losses can be minimised by increasing the pond depth. Timing of intermittent waste discharges - e.g., tank or pond cleaning, pond harvesting, can be controlled to ensure maximum

dilution/dispersion, least localized effect.

Today, little attention is paid to sediment recovery and processing from aquaculture solid collection and/or biological treatment processes, though figures indicate there may be substantial quantities involved. Aquaculture wastes can effectively be used for hydroponic water which in turn can be used to grow crops in arid and semi-arid regions. A restricted nutrient load from fish farming is desirable, especially in coastal areas. The use of the husbandry techniques in fish culture is important to minimize feed cost.

Conclusion and Suggestions

Aquaculture is one of the activities within the coastal environment, which has direct or indirect effect on the marine ecosystem and other resource-based economic sectors operating in the area. However, since aquaculture gives employment, income and foreign exchange as well as improved nutrition, it should be developed in the context of wise resource use and the environment. In view of the vast potential offered by this sector, the pace of development has also been fairly rapid over the last few years in India.

Following suggestions are recommended for the effective and sustainable development of aquaculture in India.

1. Development of aquaculture should be taken up within the framework of coastal area planning and management.
2. Master plan is needed to be prepared in all the maritime States so that such projects can be established throughout the coastline.
3. Judicious stocking of seeds to be done and overstocking to be avoided.
4. Effective drainage system should form an integral part of any brackish water farm with provisions to remove harmful pollutants from the water before it is released into the nearby environment.
5. Priorities for aquaculture development should be indicated in national policy. It should allo-

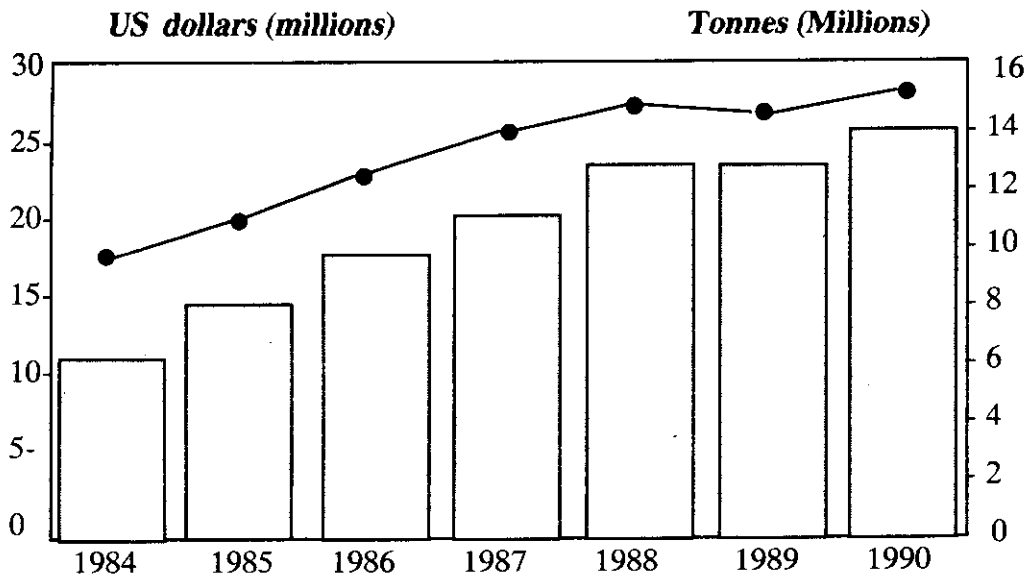


Fig. 1 Increase in world aquaculture production, 1984 - 1990, in terms of both weight curve and value (columns)

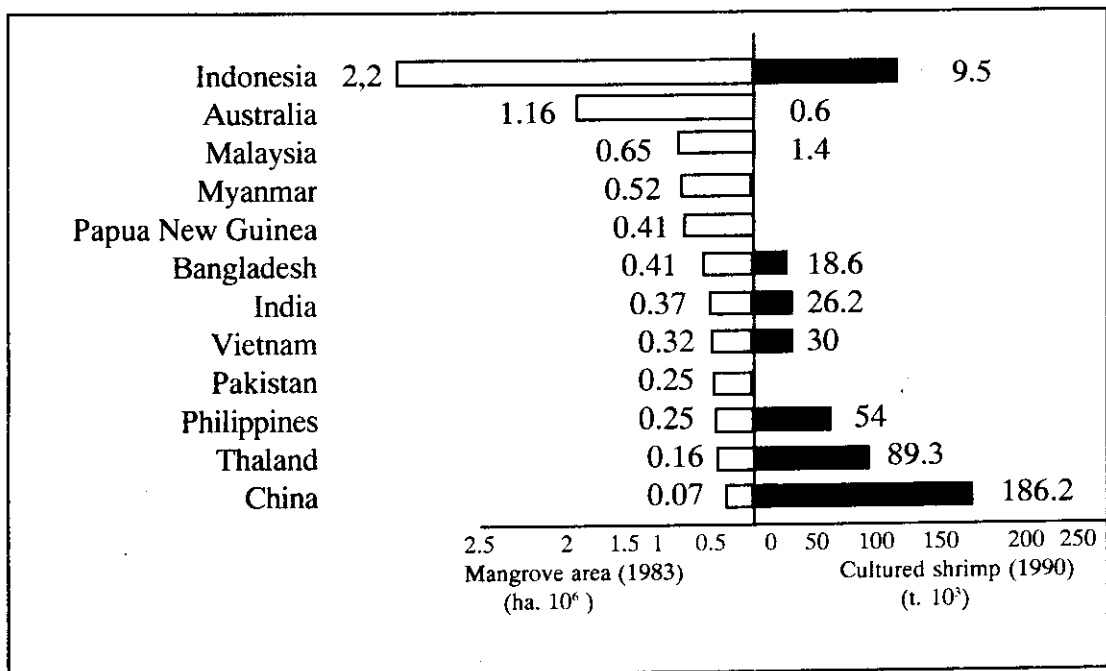


Fig. 2 Relationship between mangrove resources and cultured shrimp production. Sources: Saenger et al. 1983

cate specific areas or zones for aquaculture development, considering the socioeconomic status and environmental sustainability and possible measures for environmental impact.

6. The use of mangrove wetlands for brackish water finfish and shrimp culture should be regulated. (for example; in Malaysia only 20% of the wetland including mangroves) can be converted to shrimp/fish farming.
7. Use of chemicals should be minimum.
8. Species transfers for aquaculture should not change the biodiversity of the area.
9. Monitoring of the aquaculture systems by expert groups should be made mandatory to the aqua-farmers.

The ultimate goal should be development of natural resource in a manner that ensures a sustainable increase in the level of social and individual welfare.

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