MANGROVES AND AQUACULTURE IN SOUTHEAST ASIA

JURGENNE H. PRIMAVERA
Aquaculture Department
Southeast Asian Fisheries Development Center
Tigbauan, Iloilo, Philippines

INTRODUCTION

The history of brackishwater pond culture in the Philippines and elsewhere in Southeast Asia has been associated with mangrove loss because in earlier times, the larger society has viewed mangroves and other wetlands as wastelands to be developed. In a proactive move to address environmental concerns over shrimp aquaculture, the SEAFDEC Council in 1999 mandated the development of environment-friendly shrimp culture and the build-up of expertise in mangroves.

This paper reviews the status of mangroves and their conversion to culture ponds in Southeast Asia, and the environmental impacts of aquaculture, aside from habitat loss. To improve the sustainability of brackishwater aquaculture, recommendations include an inventory of mangrove and pond culture areas in the region, zonation of mangrove areas within the context of integrated coastal zone management, aqua-silviculture and environment-friendly aquaculture, rehabilitation of degraded mangroves, and enforcement of existing laws including the buffer zone/mangrove greenbelt requirement.

MANGROVES

Over the centuries, mangrove systems have contributed significantly to the well-being of coastal communities through their provision of a wide array of goods and services. The latter, also referred to as amenities, include coastal protection from typhoons and storm surges, erosion control, sediment trapping, nutrient supply/recycling, wildlife habitat, and nurseries. Mangrove goods or products come from forests and fisheries. Harvests from the former include timber (for dwellings, construction, fences, furniture, boats, fishing poles), firewood, tanbark for dyes, fibers and ropes, corks and floats, mats and paper. Mangrove plants also yield honey, vegetables and alcoholic beverages; mangrove extracts rich in gums, glues, steroids, alkaloids, flavonoids, saponins and tannins are widely used as medicines, e.g., antiseptics, analgesics, for asthma, boils, diabetes, hepatitis, leprosy, malaria, rheumatism, skin diseases, tumors, ulcers and other ailments (Bandaranayake 1998; Primavera et al., 2004).

Among fisheries products are fish, crabs, prawns, mollusks and other invertebrates used mainly for food. A positive relationship between fish/shrimp nearshore catches and mangrove area has been documented for Indonesia, Malaysia and the Philippines (see references in Primavera, 1995). Mangrove-associated fish, crustaceans and molluscs contribute 21% (1.4 million tons) yearly to the inshore capture fisheries in the ASEAN region (Singh et al., 1994). Mangrove-associated fish contribute around 30% (1.09 million tons) of annual finfish resources excluding trash fish, while mangrove-dependent prawns provide almost 100% (0.4 million tons valued at US$1.4 billion) of total prawn resources in ASEAN. Because there is little evidence for the trophic subsidy or 'outwelling' hypothesis that exported mangrove detritus enhances primary productivity offshore (Lee, 1995), the mangrove-fisheries connection may therefore lie in the nursery function through provision of food and shelter from predation (Hatcher et al., 1989) and the lateral trapping or retention of planktonic prawn larvae in mangrove swamps (Chong, 1996).

The latest global estimate of mangroves is 15 million ha as of 2000, of which a third is found in Southeast Asia (Wilkie and Fortuna, 2003; Fig. 1). This drop from 18 million ha in the early to mid-1990s (Spalding et al, 1997) shows a drastic mangrove decline worldwide within the last few decades. The anthropogenic causes of such loss include overexploitation by coastal communities and conversion to settlements, tourist resorts, agriculture such as rice and coconut fields, salt beds, industrial activities and brackishwater aquaculture.

AQUACULTURE

Aquaculture now provides a third of total fisheries production compared to only 16% in 1991. Globally, aquaculture produced a total of 51.4 million mt valued at US$60 billion in 2002 with more than 90% from Asia (FAO, 2002). Freshwater fish contributed 47.7% of volume, followed by mollusks (22.9%), plants (22.6%) and crustaceans (4.2%). land-based ponds and water-based pens, cages, longlines and stakes in brackishwater and marine habitats provided 55.3% of 2002 production; freshwater habitats contributed 44.7%. Table 1 matches commodities to their respective production system (e.g., ponds and pens) and habitat.

But the phenomenal growth of aquaculture in recent years has been associated with ecological problems and social conflicts. Environmental impacts are salinization of soil and water, loss of bycatch in wild seed and broodstock collection; introduction of exotic species, spread of parasites and diseases, interactions with wildlife, displacement of wild populations, genetic effects, use of chemicals and antibiotics, dependence on fishmeal and fish oil, and release of aquaculture wastes and coastal pollution (Naylor et al 2000; Primavera 1998). Foremost among the negative ecological effects is habitat loss or modification when intertidal mangroves are cleared for ponds and cages/pens are installed above subtidal seagrass beds and sediment communities. Early support from external development agencies such as the International Bank for Reconstruction and Development and the Asian Development Bank facilitated mangrove conversion to culture ponds (Siddall et al., 1985; Primavera, 1993).

Conventional economic analysis of mangrove goods and services generally cover only products that are traded, and ignore nonmarketed services such as coastal protection (Hamilton and Snedaker, 1984). Reviews of published valuation data reveal a range of US$10-4,000/ha/yr for forestry products (Radstrom, 1998) and US$775-11,282/ha for fishery products (Ronnback, 1999). The economic rent of Philippine mangroves converted into aquaculture ponds has been estimated at US$20-130/ha/yr (~PhP520-3,400) depending on cultured crop, planning horizon and discount rate (Evangelista, 1992). But the fishpond lease agreement fee (FLA) for government-owned ponds has remained at PhP50/ha/yr since the 1950s — such low fees underprice the rights to harvest public forests and induce mangrove conversion to ponds, but do not penalize low pond production (World Bank, 1989). After the Revised Fisheries Code was passed in 1998, the Department of Agriculture-Bureau of Fisheries and Aquatic Resources set graded increases for the FLA fee to reach more commensurate levels of PhP1,000/ha/yr by 2004. The lack of implementation of the new fees due to a complaint filed by the aquaculture industry with the courts reflects a lack of political will.

Elsewhere in the region, Sathirathai (1997) compared the benefits from an area comprising 640 ha shrimp ponds + 400 ha mangroves in Tha Po Village, Surat Thani, Thailand. Considering products from forests and fisheries as well as social benefits of coastal protection, shoreline stabilization and carbon sequestration, he concluded that mangrove conversion to commercial shrimp farms was economically viable only for private persons but not for society as a whole. Analysis revealed that the intact mangrove forest had total economic value ~70% higher than when converted to a shrimp farm (~$60,000/ha vs $16,700/ha).

Calculations showed $3,735/ha maximum Net Present Value for a shrimp farm which is lower than $4,116/ha maximum economic value (including $666/ha fisheries, $2,991/ha coastal protection, $170/ha direct uses but excluding other uses and non-use values) when mangroves were retained.

WHAT CAN BE DONE

To become sustainable, the development of aquaculture must change its sectoral approach to one of integration within the coastal zone. Steps towards attaining sustainability include an inventory of pond and mangrove areas in the region followed by mangrove area zonation, mangrove rehabilitation, environment-friendly aquaculture, and enforcement of existing laws.

Law enforcement

Numerous laws and regulations have been promulgated by countries in the region to protect remaining mangrove areas and mitigate widespread deforestation. In the Philippines, these include criteria for permanent forests (areas for shore/riverbank protection and those bordering islands, game and bird sanctuaries); guidelines for mangrove development into fishponds or rehabilitation or reversion of unutilized/abandoned ponds back to mangrove forest; and legal property instruments such as renewable 25-year Community Forest Management Agreements and Mangrove Stewardship Agreements (Primavera et al, 2004). The latter allow selective harvest of mangrove products for livelihood, thereby encouraging community participation and ensuring local responsibility and sustainability of mangrove rehabilitation. This grant of tenure has been critical in the success of community-based mangrove replanting programs by legitimizing the *de facto* claims of local communities over coastal resources. Mangrove laws also provide for a protective greenbelt or buffer zone along coastlines and riverbanks (see below).

Therefore legislation that conserves, protects and rehabilitates mangroves in the Philippines and in the region has not been wanting — it is their implementation that is absent or generally weak, hampered by lack of manpower and resources, overlapping jurisdiction and corruption (Primavera, 2000a).

Inventory of mangrove areas and aquaculture ponds

Although conversion to salt beds, agriculture, settlements, and overexploitation by coastal dwellers have caused mangrove decline, aquaculture remains the major causative factor at least in Southeast Asia (Primavera, 1995, 1997). .Most of the thousands of hectares of brackishwater ponds in the Philippines (Fig. 2) and Indonesia were mangrove swamps developed for milkfish cultivation — such pond culture dates back to at least 1400 in Java, Indonesia (Herre and Mendoza, 1929). However, the high rates of 25-80% mangrove loss in the region (Table 2) over the last three decades (Low et al., 1994) have coincided with the Shrimp Fever of the 1980s (Primavera, 1997, 1998). In Vietnam, a total of 102,000 ha of mangroves were cleared for shrimp farming from 1983 to 1987 (Tuan, 1997). Shrimp farms in Thailand accounted for 32% or 65,150 ha of the total 203,600 ha of mangrove area destroyed between 1961 and 1993 (Menasveta, 1997).

There is a need to update these figures by means of an inventory of mangrove and culture pond areas in Southeast Asia. Mangroves may be classified according to geomorphological (estuary, delta or lagoon, Fig. 3) and ecological (fringing, overwash or island, riverine, dwarf, basin and hammock) types influenced by hydrology and topography (Lugo and Snedaker, 1974).

Fish/shrimp pond areas also need to be classified according to former land use (pristine or degraded mangrove, agricultural land), tidal level (intertidal or supratidal), status (operational, abandoned/unutilized or undeveloped), etc.

Zonation

Based on their ecological and economic functions, mangroves can be designated into four zones: a) <u>preservation</u> for coastal protection, biodiversity, and ecotourism; b) <u>sustained yield</u> of forestry and fisheries products; c) <u>conversion</u> to aquaculture, agriculture, salt beds and other uses; and d) <u>rehabilitation</u> or reforestation. Mangrove conversion to ponds and other uses may only be applied to countries whose swamps remain luxuriant. Some ecologists have recommended that such conversion should cover no more than 20% of a given mangrove area (Saenger et al., 1983) and target only degraded mangroves that are not ecologically critical. In the Philippines where only a few mangrove forests remain, the solution lies in replanting of degraded areas and reverting abandoned or underutilized ponds back to mangroves.

Areas to be preserved for coastal protection are called mangrove greenbelts or buffer zones (although they also include beach forests which comprise mangrove associates, outside of true mangrove species). Practically all countries in Southeast Asia require a coastal greenbelt with ranges of 20-100 m wide for the Philippines (Table 3), 100 m for Malaysia (recommended by the National Mangrove Committee), and 200-540 m (width = 130 x mean spring tide range) for Indonesia. Forming part of the preservation-conservation zone, such greenbelts and buffer zones should be retained or planted not only along shorelines and riverbanks but also between adjacent uses, e.g., shrimp pond and rice field.

Mangrove Rehabilitation

Many government and NGO initiatives involve the planting of mangroves in existing seagrass beds, and of mangrove monocultures of *bakhaw* or *Rhizophora apiculata, R. mucronata* and *R. stylosa* (although natural monospecific stands of mangroves do occur such as of *R. apiculata* in more protected portions of bays). Therefore mangrove projects should follow biophysical criteria, e.g., suitable species and seasons to avoid high mortality rates. Suitable sites should match the species to corresponding tidal level (Fig. 4) and exclude seagrass beds and mudflats which are habitats in themselves. Locally adapted and existing mangrove species should be planted in a given area, such as *Avicennia marina* and *Sonneratia alba* in seaward zones, and *Rhizophora* species in more sheltered areas. Multispecies mangrove nurseries can be established for the production of planting materials from both seeds and germinated wildlings.

Mangrove-Friendly Aquaculture

For aquaculture to be sustainable, its impacts on mangroves must be reduced or mitigated. Already, the culture of seaweeds, mollusks and fish in cages in subtidal waterways is both compatible with mangroves and amenable to small-scale, family level operations (Primavera, 1993, 1995). But there remains a need for Mangrove-Friendly Aquaculture (MFA) technology in the intertidal forest that does not require clearing of the trees. MFA may be applied on two levels: a) silvofisheries or aquasilviculture where the low-density culture of crabs, shrimp and fish is integrated with mangroves, and b) mangrove filters where mangrove forests are used to absorb effluents from high-density culture ponds (Primavera 2000b).

A review of low-density MFA systems in Asia includes the traditional Hong Kong *gei wai* and Indonesian *tambak* that are decades- to centuries-old technologies, while silvofisheries in Indonesia, mixed shrimp-mangrove systems in Vietnam, and aquasilviculture ponds and mangrove pens in the Philippines and Malaysia are more recent state-initiated projects (Table 4). Unfortunately, ponds which are the predominant MFA system alter mangrove hydrology and ecosystem functions through the construction of gates, dikes and channels (Primavera, 2000b). By contrast, mangrove pens only require net enclosures with minimal impacts on mangrove hydrodynamics and vegetation — mud crab culture in pens is the most financially lucrative and environment-friendly among MFA systems. However, continued dependence of crab culture on fish biomass (popularly called ‘trash‘ fish) and natural seedstock may impact negatively on food supplies of local people and wild crab fisheries, respectively (Williams and Primavera, 1998).

On the other hand, the filtration function of mangroves can be applied in more intensive aquaculture farms. In a study to assess such capacity, effluents from a shrimp <u>Penaeus monodon</u> pond were made to pass through a natural mangrove stand (predominantly <u>*Avicennia rumphiana/A. officinalis/Nypa fruticans)*</u> and water quality was monitored as seawater from a creek was conditioned in a reservoir, used in a shrimp pond and treated in the natural mangrove stand (Primavera et al., unpub. ms.). Twenty-four hour monitoring of solids and nutrient levels showed that retention of effluents in the mangroves for 6 h reduced suspended solid levels by 64.2%, sulfide by 34.0%, NH_3 by 24.8%, and NO_3 by 18.7%. First order estimates of 2.18-6.54 ha of mangroves needed to treat N wastes from one ha of shrimp pond (Table 5) were based on stocking density of 10-30 postlarvae/m^2, 20-30 g harvest size, 4% biomass feeding rate, mean daily removal rate of 0.158 mg NH_3-N/L and 0.483 mg NO_3-N/L, volume of water drained, and area of the mangrove stand. Greater mangrove biomass increase in the natural mangroves receiving effluents vs a control mangrove (with no effluents) provided evidence of nutrient assimilation.

Waste processing is only one of the many ecological services required by shrimp farms aside from food inputs, postlarval nurseries and water supply. The “ecological footprint” or ecosystem area that provides these goods and services to a semi-intensive shrimp farm in Colombia has been calculated as 35-190 times the actual surface area of the farm (Kautsky et al., 1994).

The “mangrove-friendliness” of brackishwater aquaculture systems can be evaluated in terms of how they affect the basic resource and regulatory functions of the mangrove ecosystem. One such evaluation is the Mangrove-Friendly Index for aquaculture systems by J. Higano (SEAFDEC/AQD, 2004) which factors in location of the aquaculture pond within the mangrove zone, production efficiency, nutrient balance inside the pond and outside in the receiving waters, culture intensity and socioeconomic impacts (Table 6).

OTHERS

Proper siting and management of farms, ICZM

Integrated coastal zone management coordinates the interests of various stakeholders, e.g., fisheries, aquaculture, forestry, settlements and navigation to ensure the optimal use of resources, maintenance of biodiversity, and conservation of critical habitats. The expansion of brackishwater pond culture in Southeast Asia has been a sectoral rather than holistic exploitation of the coastal zone. As intensive culture farms increase, the processing and disposal of effluents and sediments attain greater importance.

Therefore site selection of pond sites must consider the waste-absorbing or assimilating capacity of the environment, in addition to standard criteria of soil quality and tidal regime. Aside from proper pond siting and design, methods to mitigate the impacts on receiving waters include zero or reduced water exchange in combination with sedimentation and treatment ponds, pond liners, probiotics, sludge collection and storage, and the use of mangroves to process shrimp pond effluents (Primavera, 1998).

Natural resource use fees

The World Bank (1989) has recommended fees for the use of mangroves and other natural resources at levels commensurate to economic rent. Governments can also impose green taxes based on the Polluter Pays principle to mitigate the environmental and socioeconomic damages from brackishwater aquaculture (e.g., correcting water quality problems and rehabilitating mangroves and other degraded landscapes), revoke early policies and withdraw subsidies used to stimulate aquaculture expansion (e.g., declaration of coastal land as public resources, loans and tax breaks for aquaculture), and require environmental planning and performance as preconditions to the approval of pond culture loans, credits and access to resources.

ADDENDUM

The horrific 26 December 2005 tsunamis in the Indian Ocean have highlighted the importance of mangrove-beach forests in protecting coastal communities. We need a paradigm shift on how we view our shorelines, away from beach resorts with tropical palms swaying in the breeze to solid greenbelts of mangroves and associated species that provide critical buffer zones. We need another paradigm shift to redress environmental imbalance by reverting pond and resort areas and settlements along vulnerable coastlines back to lush mangrove-beach forests.

REFERENCES

Bandaranayake, W.M. 1998. Traditional and medicinal uses of mangroves. Mangroves and Salt Marshes 2: 133-148.

Chong, V.C. 1996. The prawn-mangrove connection, pp. 1-17. In: Seminar on Sustainable Utilization of Coastal Ecosystems for Agriculture, Forestry and Fisheries in Developing Regions, Kuala Lumpur, Malaysia, 12 December 1995. Japan International Research Center for Agricultural Sciences.

Evangelista, D.L. 1992. Management of mangrove areas in Calauag Bay, Quezon Province, Philippines. Naga ICLARM Q. 15: 47-49.

FAO. 2002. FishStat+ (version 2.3)

Field, C.D. 1995. Journey amongst mangroves. International Society for Mangrove Ecosystems, Okinawa, Japan

Furukawa, K. and S. Baba. 2002. Short-term environmental variation in mangrove forests and needs of integrated coastal zone management, pp. 20-29. In Proceedings of the Third Meeting of the Project on ASPACO, Okinawa, Japan, 1-6 October 2002

Hamilton, L.S. and S.C. Snedaker (eds). 1984. Handbook for Mangrove Area Management. United Nations Environment Programme, Kenya and Environment and Policy Institute, East-West Center, Honolulu, Hawaii, 123 pp.

Herre, A.C.W.T. and J. Mendoza. 1929. Bangos culture in the Philippine Islands. Phil. J. Sci. 38: 451-509.

Kautsky, N., H. Berg, C. Folke, J. Larsson, and M. Troell. 1997. Ecological footprint for assessment of resource use and development limitations in shrimp and tilapia aquaculture. Aquacult. Res. 28: 753-766.

Low J.K.Y., A. Arshad and K.H. Lim. 1994. Mangroves as a habitat for endangered species and biodiversity conservation, pp. 157-169. In: Wilkinson, C., S. Sudara and C.L. Ming (eds) Proceedings of the Third ASEAN-Australia Symposium on Living Coastal Resources: Status Reviews (vol. 1), Chulalongkorn University, Bangkok, Thailand, 16-20 May 1994. Australian Institute of Marine Science, Townsville.

Lugo, A.E. and S.C. Snedaker. 1974. The ecology of mangroves. Ann. Rev. Ecol. Syst. 5: 39-64.

Menasveta, P. 1997. Mangrove destruction and shrimp culture systems. World Aquacult. 28(4): 36-42

Naylor R.N., R.J. Goldberg, J.H. Primavera, N. Kautsky, M. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney and M. Troell. 2000. Effect of aquaculture on world fish supplies. Nature 405: 1017-1024

Primavera, J.H. 1993. A critical review of shrimp pond culture in the Philippines. Rev. Fish. Sci. 1, 151-201.

Primavera, J.H., 1995. Mangroves and brackishwater pond culture in the Philippines. Hydrobiologia 295, 303-309.

Primavera, J.H., 1997. Socioeconomic impacts of shrimp culture. Aquacult. Res. 28, 815-827.

Primavera, J.H. 1998. Tropical shrimp farming and its sustainability, pp. 257-289. In: S. de Silva (ed), Tropical Mariculture. Academic Press, London

Primavera, J.H. 2000a. Development and conservation of Philippine mangroves: institutional issues. Ecol. Econ. 35: 91-106

Primavera, J.H. 2000b. Integrated mangrove-aquaculture systems in Asia. Integrated Coastal Zone Management. Autumn edition: pp. 121-130

Primavera, J.H., A. delos Reyes, J. Altamirano, C.L. Torres and J. Lebata. Processing of shrimp pond effluents in a natural mangrove wetland. Unpub ms.

Primavera, J.H., R.B. Sadaba, M.J.H.L. Lebata and J.P. Altamirano. 2004. Handbook of Mangroves in the Philippines – Panay. SEAFDEC Aquaculture Department (Philippines) and UNESCO Man and the Biosphere ASPACO Project, 106 pp.

Radstrom A. 1998. Economic evaluations of mangrove ecosystems—a review. Department of Systems Ecology, Stockholm University, Stockholm, Sweden.

Ronnback P. The ecological basis for economic value of seafood production supported by mangrove ecosystems. Ecol. Econ. 1999: 29: 235-252.

Saenger, P., E.J. Hegerl and J.D.S. Davie. 1983. Global Status of Mangrove Ecosystems. IUCN Commission on Ecology Papers No. 3. Gland, 88 p.

Sasekumar, A. and K.H. Lim. 1994. Compatible activities and mangrove forest, pp. 101-104. In C. Wilkinson, S. Sudara and C.L. Ming (eds) Proceedings of the Third ASEAN-Australia Symposium on Living Coastal Resources: Status Reviews. Australian Institute of Marine Science, Townsville, Australia

Sathirathai, S. 1997. Economic valuation of mangroves and the roles of local communities in the conservation of the resources: case study of Surat Thani, south of Thailand. Economy and Environment Program for Southeast Asia (EEPSEA), Bangkok

SEAFDEC/AQD. 2004. Promotion of Mangrove-Friendly Shrimp Aquaculture in Southeast Asia, Report on the Regional Seminar-Workshop on Mangrove-Friendly Shrimp Aquaculture, Bangkok, Thailand, 24-27 June 2003

Siddall, S.E., J.A. Atchue III, P.L. Murray, Jr. 1985. Mariculture development in mangroves: a case study of the Philippines, Panama and Ecuador. In: Clark, J.R. (ed) Coastal Resources Management: Development Case Studies, Renewable Resources Information Series, Coastal Management Pub. No. 3. Prepared for the National Park Service, U.S. Dept. of the Interior, and the U.S. Agency for International Development. Research Planning Institute, Inc., Columbia, South Carolina.

Singh, H.R., V.C. Chong, A. Sasekumar and K.H. Lim. 1994. Value of mangroves as nursery and feeding grounds, pp. 105-122. In: Wilkinson, C., S. Sudara, C.L. Ming (eds) Proceedings of the Third ASEAN-Australia Symposium on Living Coastal Resources: Status Reviews vol. 1, Chulalongkorn University, Bangkok, Thailand, 16-20 May 1994. Australian Institute of Marine Science, Townsville

Spalding, M., F. Blasco, and C. Field (eds). 1997. World Mangrove Atlas. The International Society for Mangrove Ecosystems, Okinawa, Japan, 178 pp.

Tuan, M.S. 1997. Building up the strategy for mangrove management in Vietnam, pp. 244-255. In: Hong, P.N., N. Ishwaran, H.T. San, N.H. Tri and M.S. Tuan (eds) Proceedings of Ecotone V, Community Participation in Conservation, Sustainable Use and Rehabilitation of Mangroves in Southeast Asia. UNESCO, Japanese Man and the Biosphere National Committee and Mangrove Ecosystem Research Centre, Vietnam

Tuan, M.S. 1997. Building up the strategy for mangrove management in Vietnam, pp. 244-255. In Hong, P.N., N. Ishwaran, H.T. San, N.H. Tri and M.S. Tuan (eds)Proceedings of Ecotone V, Community Participation in Conservation, Sustainable Use and Rehabilitation of Mangroves in Southeast Asia, UNESCO, Japanese Man and the Biosphere National Committee and Mangrove Ecosystem Research Centre, Vietnam

Valiela, I., J.L. Bowen and J.K. York. 2001. Mangrove forests: one of the world's threatened major tropical environments. Bioscience 51 (10): 807-815.

White, A.T. and R.O.D. de Leon. 1996. Mangrove resource decline in the Philippines: government and community look for new solutions. Tambuli 1: 7-11.

Wilkie, M.L. and S. Fortuna. 2003. Status and trends in mangrove area extent worldwide. Forestry Department Working Paper FRA 63, FAO, Rome.

Williams, M.J. and J.H. Primavera. 2001. Choosing tropical portunid species for culture, domestication and stock enhancement in the Indo-Pacific. Asian Fish. Sci. 14: 121-142

World Bank. 1989. Country Report: Philippines. Environmental and Natural Resources Management Study. The World Bank, Washington, D.C., U.S.A., 173 pp.

Table 1. Philippine Brackishwater Aquaculture

Group		System	Method
Plants:	*Gracilaria*	stakes, rafts	extensive
	Eucheuma	longlines, beds (subtidal)	
Mollusc:	oyster, mussel	rafts, longlines, Stakes	extensive
		(subtidal)	
Marine/Brackishwater fish:	milkfish, grouper,	ponds, pens/cages	extensive, semi-
	snapper	(intertidal, subtidal)	intensive, intensive
Crustaceans:	prawns/shrimps	ponds	extensive, semi-
	Crabs	(intertidal)	intensive, intensive)

Table 2. Mangrove and shrimp culture pond area in Southeas Asia

Country	Shrimp ponds (ha)[a]	Mangroves	
	(ha)[b]	% Mangrove loss	(30 yr)[c,d]
Brunei Darus.	—	17,100	—
Cambodia	—	60,100	—
Indonesia	350,000	4,542,100	32 – 45
Malaysia	4,000	642,40	25 – 32
Myanmar	—	378,600	—
Philippines	60,000	160,700	40 – 80
Thailand	200,000	264,100	50 – 70
Vietnam	200,000	252,400	—
Total	814,000	6,317,500	
% world total	65	35	

[a] *Rosenberry 1999,* [b] *Spalding et al 1997,* [c]*Low et al (1994), d Sasekumar et al (1994)*

Table 1. Philippine Mangrove Greenbelt/Other Laws (*Primavera et al., 2004*)

P.D. 705 (1975)	Revised Forestry Code: mangrove strips in islands providing protection from high winds, typhoons shall not be alienated
P.D. 953 (1976)	Fishpond/mangrove lease holders required to retain or replant 20-m mangrove strip along rivers, creeks
BFD A.O. 2 (1979)	Min. 25% of total mangrove forest in given area completely protected as Mangrove Wilderness Areas
P.P. 2151 & 2152 (1981)	Declaration of 4,326 ha mangroves as wilderness areas, 74,767 ha as forest reserves
MNR A.O. 42 (1986)	Expansion of mangrove belt in storm surge, typhoon areas: 100 m along shorelines, 50 m along riverbanks
DENR A.O. 76 (1987)	Establishment of buffer zone: 50 m fronting seas/oceans and 20 m along riverbanks; lessees of FLA ponds required to plant 20-50 m-mangrove strip
DENR A.O. 77 (1988)	Integrated Social Forestry Program (provision of legal tenure incentives for co-management of forest resources)
DENR A.O. 123 (1990)	Award of 25-yr Community Forestry Management Agreement for small scale mangrove use, *Rhizophora* and *Nypa* plantations, aquasilviculture
DENR A.O. 15 (1990)	Policies on communal forests, plantations, tenure through Mangrove Stewardship Contracts; revert abandoned ponds to forest; ban cutting of trees in FLA areas; prohibit conversion of thickly vegetated areas
DENR A.O. 3 (1991)	Policies and guidelines for Mangrove Stewardship Agreement
DENR A.O. 23 (1993)	Combined 3-yr Mangrove Reforestation Contract and 25-yr Forest Land Management Agreement into 25-yr FLMA for families (1-10 ha) and communities (10-1,000 ha)

Table 4. Comparison of mangrove-friendly aquaculture systems in Southeast Asia (Primavera, 2000b)

	Hong Kong	Indonesia		Vietnam	Philippines	Malaysia
		Traditional ponds	Silvofisheries			
Technology and source, year started	traditional gei wai;mid-1940s	traditional *tambak*; circa 1400s	silvofisheries; State Forestry Corp; 1976(but trials in 1950s)	mixed shrimp-mangrove systems; State Forestry & Fishery Enterprises;	aquasilviculture; Fisheries Bureau and Environment Dept. (Forestry); 1987 mid-1980s	mud crab pens; Inland Fisheries Division; 1992
Objectives	shrimp, fish production mangrove, wildlife conservation	for food, fuel, fodder, fertilizer, soil stabilization	to solve forestry-fisheries conflict; mangrove rehabilitation, conservation	to relieve land use conflict; mangrove rehabilitation	mangrove management & conservation; fish production	increased incomes of artisanal fishermen
Area covered, present status	~250 ha, Ramsar Wetland Site	wide area	wide area (e.g., Cikiong: 6,600 ha, Balanak: 5,300 ha in West Java)	widespread	~ 10 experimental/ verification projects,	130 pens in Sematan, Sarawak
Pond/pen size	~10 ha ponds	1- 4 ha ponds	0.1 – 1 ha ponds	750 – 3,200 m^2 ponds	pens: 200 m^2 – 1 ha ponds: 0.13 – 2.6 ha	18 m x 9 m pens
Mangroves	natural *Avicennia Kandelia candel*	natural & planted *Avicennia*, *Rhizophora*	planted *Rhizophora*	planted *Rhizophora*	natural, planted	logged over, planted*Rhizophora*
Aquaculture	wild shrimp, fish, natural food	stocked milkfish, wild fish, shrimp; natural food	stocked milkfish, wild fish, shrimp; natural food, supplem. feeding	wild shrimp; natural food	stocked milkfish, mud crab; wild fish, shrimp; natural food, supplem. feeding	stocked mud crab raw (trash) fish feed
Problems	declining shrimp yields; industrial pollution; wildlife vs. aquaculture management	pond intensification	difficult management; conflict in choice of mangrove species	declining shrimp production; illegal mangrove conversion	mangrove tree mortality; raw (trash) fish substitutes	seed supply, feeds

Table 5. Mangrove: Shrimp Pond area ratios for nutrient removal in pond effluents

Reference	System	Mangrove: Pond Ratio (area)	
		N	P
Boonsong &	Intensive	8.96	7.82
Eiumnoh,1995			
Robertson &	Intensive	7.21	21.7
Phillips, 1995	Semi-int.	2.4	2.8
Kautsky et al.,	Semi-int.	6.4	6.4
1997			
This study	Intensive	2.91-6.54	
	Semi-int.	2.18	

Table 6. Index to express the impact against mangrove (Higano, 2003)

Mangrove friendly Index (MFI)

MFI = f (x1, x2, x3, ….) pond by pond, area by area?

x_1: location of culture area in mangrove zonation
x_2: coverage of shrimp culture in mangrove
x_2: production efficiency
x_3: effluent (nutrient balance outside the area)
x_4: sludge (nutrient balance inside the area)
x_5: water resources
x_6: intensity of shrimp culture
x_7: socio-economical impact

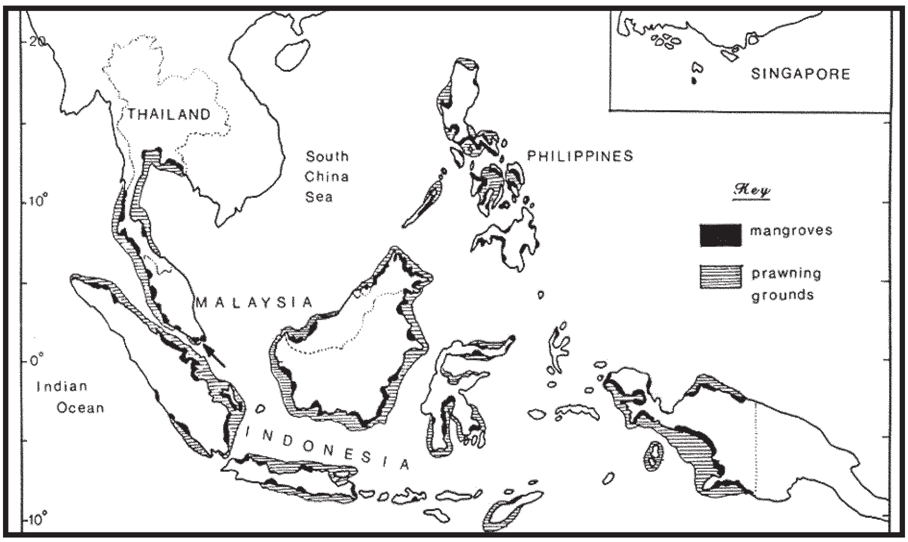


Fig. 1. Map of mangrove (and prawn) areas in Southeast Asia, excluding Vietnam.

Fig. 2. Change in area of mangroves and brackishwater culture ponds(ha) in geographical regions of the Philippines, 1951-1990 (from Primavera, 1997).

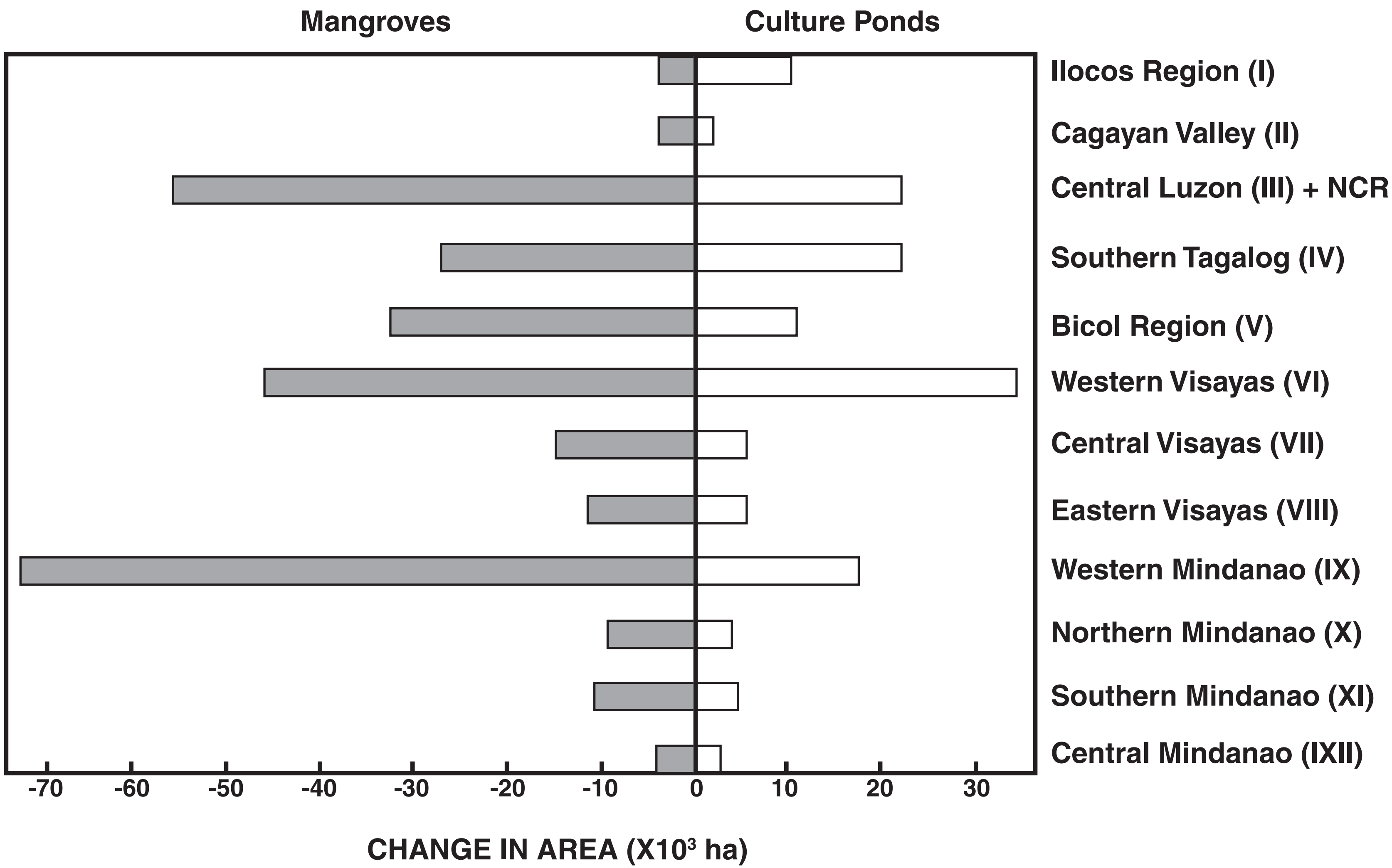
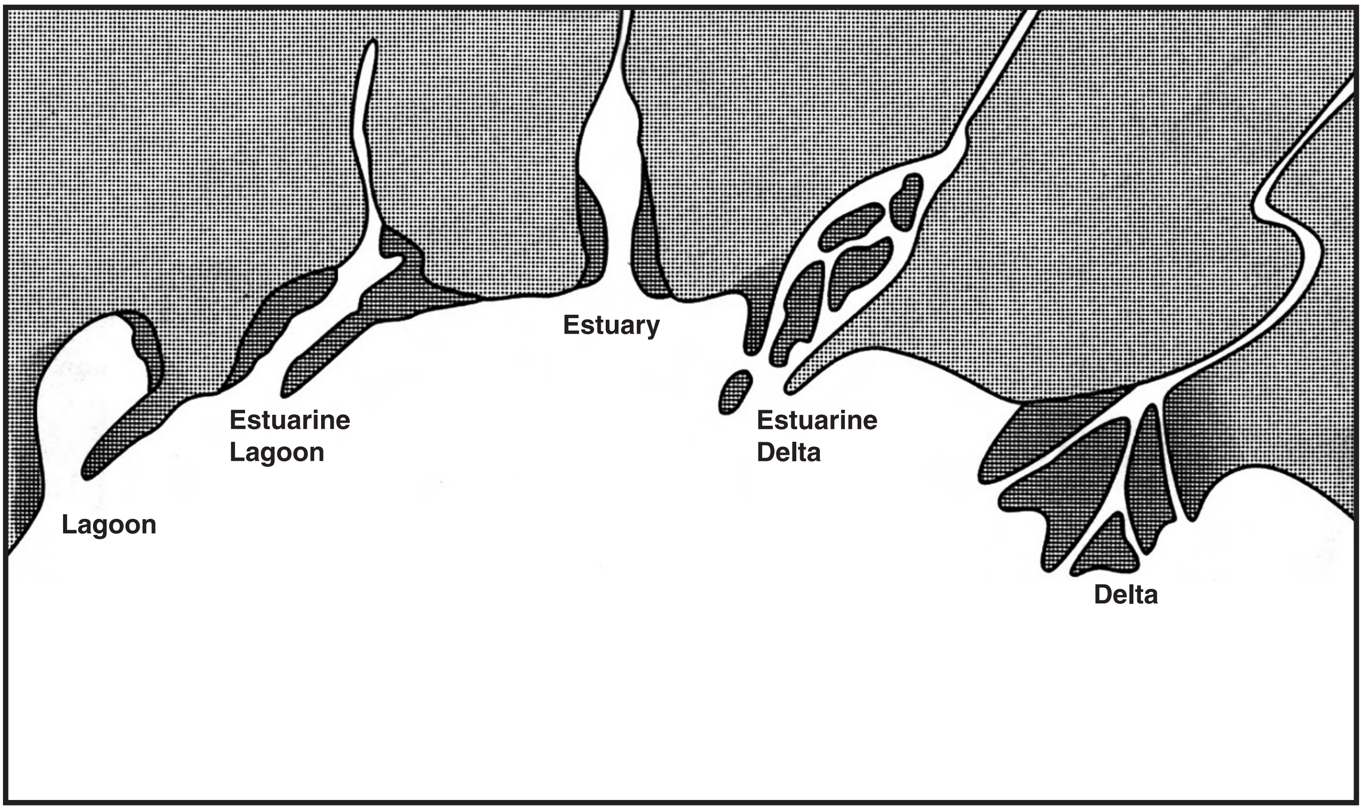


Fig. 3 Variety of mangrove settings based on geomorphology (from Kjerfve, 1990 in Field, 1995)



Variety of tropical settings in which mangroves are found

From Kjerfive, Davies 1973

Fig. 4 (from Furukawa and Baba, 2002).