Mangroves of Southeast Asia

J. HONCULADA-PRIMAVERA

SEAFDEC Aquaculture Department
5021 Tigbauan, Iloilo, Philippines
<jhprima@aqd.seafdec.org.ph>

Abstract

This paper provides an introduction to Southeast Asian mangroves covering taxonomy, distribution and ecological factors; discusses mangrove goods and services and their valuation; and recommends guidelines for mangrove conservation and management, including mangrove-friendly aquaculture.

Introduction

Thirty-five percent of the total 18 million ha of global mangrove forests (Table 1) are found in the Southeast Asian countries of Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Thailand and Vietnam (Table 2, Figure 1). Indonesia alone has 4.5 million ha of mangroves (Spalding *et al.* 1997). At the same time, the region also leads in brackishwater aquaculture, producing for example, 446,000 mt of shrimp or 60% of 1997 global yields (Rosenberry 1997).

Conversion to shrimp ponds, in addition to settlements, agriculture, salt beds, overexploitation and other factors (Primavera 1995), have led to high rates of mangrove loss over the last three decades ranging from 25% in Malaysia to 50% in Thailand (Low *et al.* 1994). In Vietnam, a total of 102,000 ha of mangroves have been cleared for shrimp farming from 1983 to 1987 (Tuan 1997). By 1988, the increase in shrimp culture area in the Mekong Delta to 123,000 ha means a decrease in mangroves of the same magnitude (Trong 1995). In Thailand, shrimp farms accounted for 32% or 65, 150 ha of the total 203, 600 ha of mangrove area destroyed between 1961 and 1993 (Menasveta 1997). For example, in Ao Ko Nok, Chanthaburi province, most of the prawn ponds which grew from zero in 1975 to 1, 836 ha in 1991 were built in mangrove forests which declined by 1, 428 ha in the same period (Raine 1994).

Taxonomy, distribution and environmental factors

The term mangrove refers to intertidal communities of tropical trees and shrubs or to their constituent plants (Tomlinson 1986). Mangrove plants belong to 20 families, 22-27 genera and around 60 species (Tomlinson 1986; Duke 1992), of which around 40 exclusive species and 65 non-exclusive species are found in Southeast Asia (Japar 1994; Spalding *et al.* 1997) (Table 3). Mangroves are confined between 30°N and S latitude with outliers in Bermuda, Japan, Australia and New Zealand (Figure 2). The Indo-Pacific or Eastern group has 40 species compared to only 8 species for the Western group (Tomlinson 1986).

Table 1. **Global area of mangroves** (Spalding *et al.* 1997)

Region	Mangrove area (x 10^5 ha)
South and Southeast Asia	75.2 (41.5%)
Australasia	18.8 (10.4%)
The Americas	49.1 (27.1%)
West Africa	28.0 (15.5%)
East Africa and the Middle East	10.0 (5.5%)
Total area	181.1

Table 2. **Mangrove area in Southeast Asian countries** (data from Spalding *et al.* 1997)

Country	Area (x 10^5 ha)
Brunei	0.17
Cambodia	0.60
Indonesia	45.4
Malaysia	6.4
Myanmar	3.8
Philippines	1.6
Thailand	2.6
Vietnam	2.5
Total	63.2 (34.9% of world)

Mangroves are found in salt water with water temperatures ≥24°C, substrates that are predominantly muddy but also sandy, and protected coastlines (Tomlinson 1986; Hutchings & Saenger, 1987; Duke 1992). Mechanisms evolved by mangroves to cope with extreme conditions of salinity, desiccation and anoxia, include salt glands, a variety of root structures including prop roots, cable roots and pneumatophores and viviparous propagules (Tomlinson 1986).

Whereas neotropical mangroves have been classified by Lugo & Snedaker (1974) into overwash, fringe, riverine, basin, scrub and hammock forests based on physiography and structure, Old World forests may be river-dominated or tide-dominated, or interior mangroves, according to dominant physical processes (Woodroffe 1992).

Functions of mangroves

Mangrove functions may be classified into information, regulatory or carrier and resource function.

1. **Information**. This may be aesthetic, religious, cultural, historical and educational in nature. Many Philippine towns and villages are named after mangroves (Table 4) —Matabao

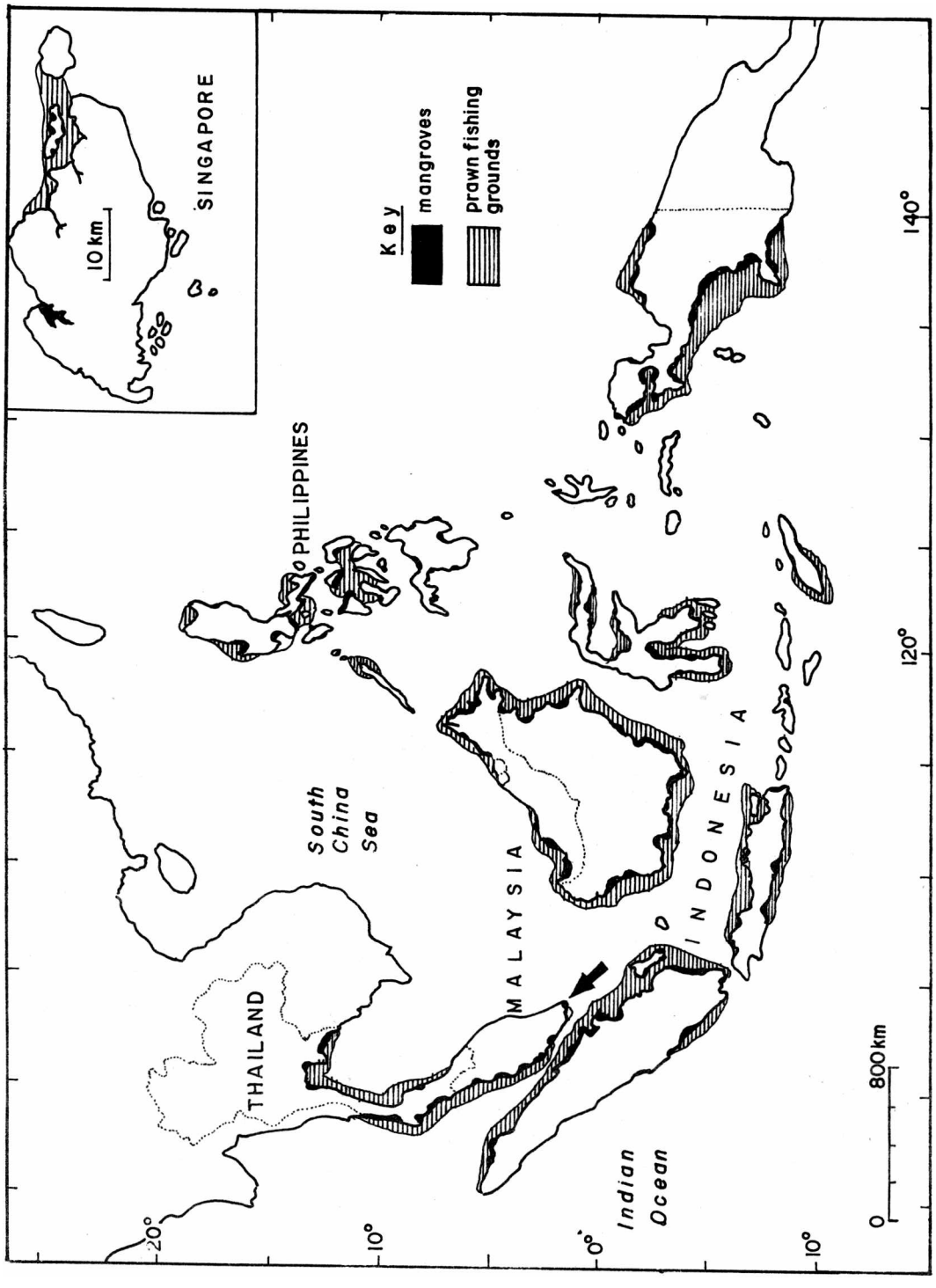

Figure. 1. **Major mangrove areas and prawn fishing grounds in Southeast Asia**. Arrow is Singapore (inset) (Chong *et al.* 1994)

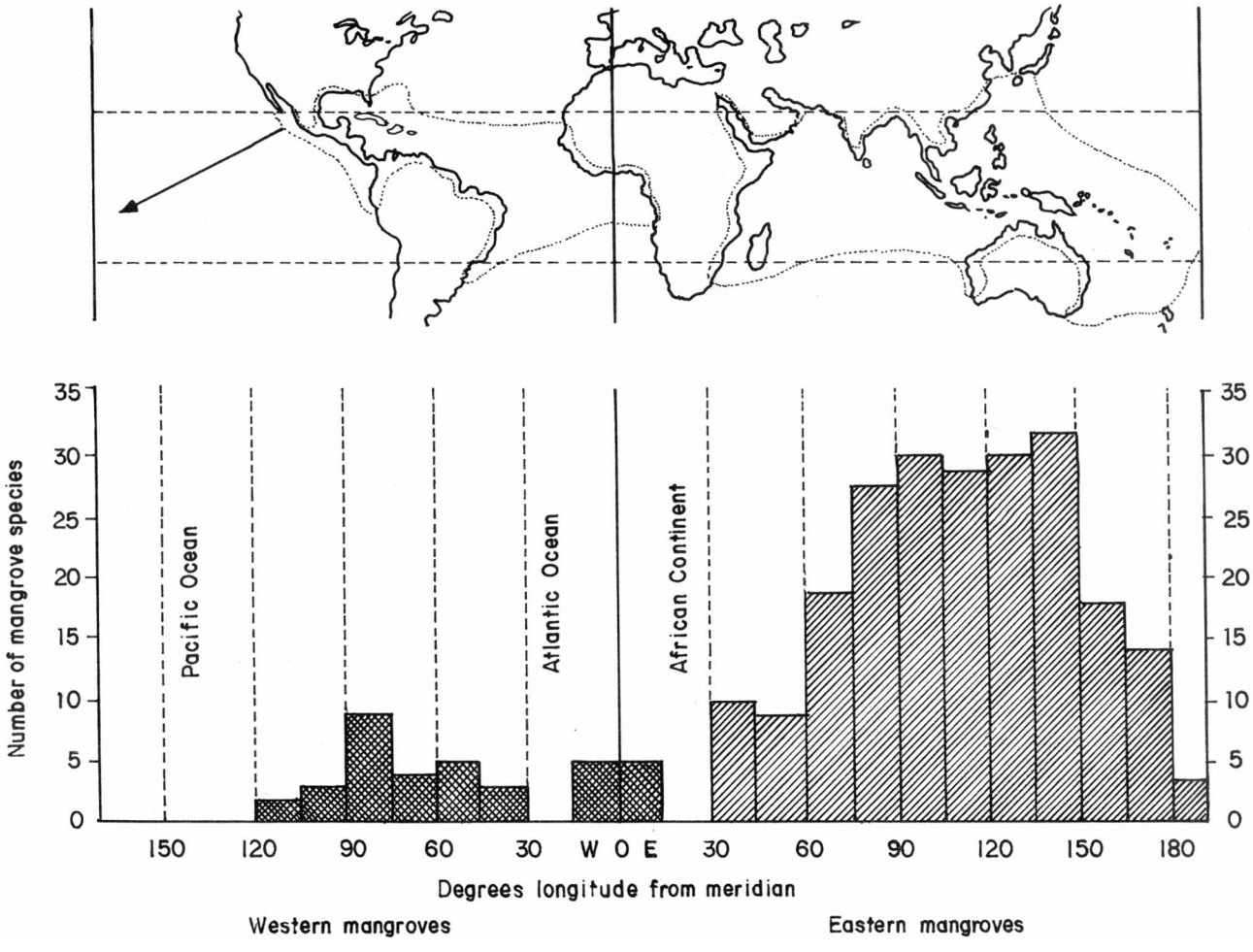

Figure 2. **Generalized distribution of mangroves:** approximate limits for all species; eastern and western groups do not overlap except for possible extension (arrow) in the Western Pacific. Histogram shows approximate number of species per mangroves per 15° of longitude (Tomlinson 1987)

Table 3. **Mangrove species list for South and Southeast Asia** (Spalding *et al.* 1997)

		Bangladesh	Brunei Darussalam	Cambodia	China and Taiwan	Hong Kong	India (west)	India (east)	Indonesia	Japan	Malaysia	Myanmar	Pakistan	Philippines	Singapore	Sri Lanka	Thailand	Vietnam
1	*Acanthus ebracteatus*		•		•			•	•		•			•	•		•	•
2	*Acanthus ilicifolius*	•	•		•	•	•	•	•		•			•	•	•	•	•
3	*Acrostichum aureum*	•	•		•		•	•	•	•	•	•		•	•	•	•	•
4	*Acrostichum speciosum*		•		•				•		•				•		•	
5	*Aegialitis annulata*								•									
6	*Aegialitis rotundifolia*	•						•				•					•	
7	*Aegiceras corniculatum*	•	•		•	•	•	•	•		•	•	•	•	•	•	•	•
8	*Aegiceras floridum*								•					•				•
9	*Avicennia alba*	•	•				•	•	•		•	•		•	•		•	•
10	*Avicennia marina*	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•
11	*Avicennia officinalis*	•	•				•	•	•		•	•		•	•	•	•	•
12	*Avicennia rumphiana*								•		•			•				
13	*Bruguiera cylindrica*		•		•		•	•	•		•	•		•	•	•	•	•
14	*Bruguiera exaristata*								•									
15	*Bruguiera gymnorrhiza*		•	•	•	•	•	•	•	•	•	•		•	•	•	•	•
16	*Bruguiera hainesii*								•		•						•	
17	*Bruguiera parviflora*		•				•	•	•		•	•		•	•		•	•
18	*Bruguiera sexangula*	•	•		•				•		•	•		•	•	•	•	•
19	*Camptostemon philippinense*								•					•				
20	*Camptostemon schultzii*								•									
21	*Ceriops decandra*	•					•	•	•		•	•		•		•	•	•
22	*Ceriops tagal*	•	•		•		•	•	•		•	•	•	•	•	•	•	•
23	*Cynometra iripa*																•	
24	*Dolichandrone spathacea*		•						•		•			•	•	•	•	•
25	*Excoecaria agallocha*	•	•		•	•	•	•	•	•	•	•		•	•	•	•	•
26	*Excoecaria indica*	•							•		•	•			•			
27	*Heritiera fomes*	•						•				•					•	
28	*Heritiera globosa*		•						•									
29	*Heritiera littoralis*	Ex	•		•			•	•	•	•			•	•	•	•	•
30	*Kandelia candel*	•	•		•	•	•	•	•	•	•	•			•		•	•
31	*Lumnitzera littorea*		•		•			•	•		•				•		•	•
32	*Lumnitzera racemosa*		•		•		•	•	•	•	•			•	•	•	•	•
33	*Lumnitzera rosea*													•				
34	*Nypa fruticans*	•	•	•	•			•	•	•	•	•			•	•	•	•
35	*Osbornia octodonta*								•		•			•				
36	*Pemphis acidula*								•	•				•	•	•	•	
37	*Rhizophora apiculata*	•	•	•			•	•	•		•	•		•	•	•	•	•
38	*Rhizophora mucronata*	•	•	•	•		•	•	•		•	•	•	•	•	•	•	•
39	*Rhizophora stylosa*				•				•	•				•	•			•
40	*Rhizophora lamarckii*							•	•		•							
41	*Scyphiphora hydrophyllacea*		•		•				•		•			•	•	•	•	•
42	*Sonneratia alba*		•		•		•	•	•	•	•			•	•	•	•	•
43	*Sonneratia apetala*	•					•	•				•				•		
44	*Sonneratia caseolaris*	•	•	•	•		•	•	•		•	•		•	•	•	•	•
45	*Sonneratia griffithii*							•			•	•					•	
46	*Sonneratia lanceolata*								•									
47	*Sonneratia ovata*		•		•				•		•				•		•	•
48	*Sonneratia gulngai*		•						•		•							
49	*Sonneratia urama*								•		•							
50	*Xylocarpus granatum*	•	•		•		•	•	•		•	•		•	•	•	•	•
51	*Xylocarpus mekongensis*	•							•			•			•		•	

Ex - extinct in that country

(*Lumnitzera*), Pagatpatan (*Sonneratia*) and Tangalan (*Ceriops tagal*). The premiere city of Manila or Maynila owes its name to the species *Scyphiphora hydrophyllacea* locally called nilad, which grew abundantly along Manila Bay in pre-Hispanic times (Merrill 1918).

2. **Regulatory.** The carrier function of mangroves, also called services or amenities, are geomorphic and hydrologic (coastal protection, erosion control and sediment trapping) and ecological (nutrient, supply/regeneration, storage and recycling of pollutants).

3. **Resource** (Table 5). Utilization of mangrove products may be traditional, small-scale extraction for domestic needs (e.g. fish, crustaceans and molluscs for food; plants for housing, firewood, fodder, medicines and dyes) or commercial scale (charcoal, logs, timber, wood chips, shrimps, molluscs and fish).

   A positive correlation between fish and shrimp nearshore catches and mangrove area (Figure 3) has been documented for Indonesia (Martosobroto & Naamin 1977), Malaysia (Gedney *et al.* 1982; Sasekumar & Chong 1987) and the Philippines (Camacho & Bagarinao 1987). 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. The nursery function of mangroves, particularly for shrimp (Primavera 1998) may be traced to the provision of shelter and food (Primavera 1996, 1997).

Valuation

Mangrove goods and services may be produced on-site or off-site and marketed or non-marketed (Hamilton & Snedaker 1984). Conventional financial analysis generally covers only traded goods ignoring non-marketed products and services like medicines and coastal protection. Nevertheless, high values of US$1,000-11,000/ha/yr place mangroves at par with intensive shrimp culture systems with net profits of $ll,600/ha/yr (Chamberlain 1991) when complete ecosystems are considered (Table 6).

Conservation and management

Mangrove conservation and development can only be meaningful within an integrated coastal zone management (ICZM) framework. Such ICZM programs need to be community-based in order to harmonize the varying interests and needs of various stakeholders in the coastal zones, e.g., fisheries, aquaculture, settlements and navigation.

The mangrove forest itself can have designated zones for protection, production, recovery and development. The protected forest or preservation-conservation zone provides coastal protection, biodiversity, maintenance, ecotourism and scientific research. The productive or sustained yield zone is mainly for the harvest of forestry and fisheries goods for domestic or commercial use. The conversion zone (marginal and landward portions) can be developed into culture ponds, salt beds, agriculture, etc., and the recovery zone is for mangrove rehabilitation by replanting seedlings or

Table 4. **Philippine towns and villages named after mangroves**

Town/village	Mangrove species
Manila (Maynilad)	*Scyphiphora hydrophyllacea*
Bakhaw, Jaro, Iloilo	*Rhizophora* spp.
Bakawan, Concepcion, Iloilo	*Rhizophora* spp.
Alipata, Aklan	*Excoecaria agallocha*
Tangalan, Aklan	*Ceriops tagal*
Matabao, Siquijor	*Lumnitzera littorea*
Pagatpatan, Misamis Oriental	*Sonneratia* sp.

Table 5. **Products of mangrove ecosystem** (Saenger *et al.* 1983)

FOREST PRODUCTS

Fuel
Firewood (cooking, heating)
Charcoal
Alcohol

Construction
Timber, scaffolds
Heavy construction (e.g., bridges)
Railroad ties
Mining pit props
Boat building
Dock pilings
Beams and poles for buildings
Flooring, panelling
Thatch or matting
Fence posts, water pipes, chipboards, glues

Fishing
Poles for fish traps
Fishing floats
Wood for smoking fish
Fish poison
Tannins for net and line preservation
Fish attracting shelters

Textiles, leather
Synthetic fibers (e.g., rayon)
Dye for cloth
Tannins for leather preservation

Food, drugs, and beverages
Sugar
Tea substitute
Alcohol
Fermented drinks
Cooking oil
Dessert topping
Vinegar
Condiments from bark
Sweetmeats from propagules
Vegetables from propagules, fruit, or leaves
Cigar substitute

Household items
Furniture
Glue
Hairdressing oil
Tool handles
Rice mortar
Toys
Matchsticks
Incense

Agriculture
Fodder, green manure

Paper products
Paper of various kind

Other products
Packing boxes
Wood for smoking sheet rubber and for burning bricks
Medicines from bark, leaves, and fruits

OTHER NATURAL PRODUCTS
Fish
Birds
Crustaceans
Mammals
Shellfish
Reptiles and reptile skin
Other fauna (amphibians, insects)
Honey
Wax

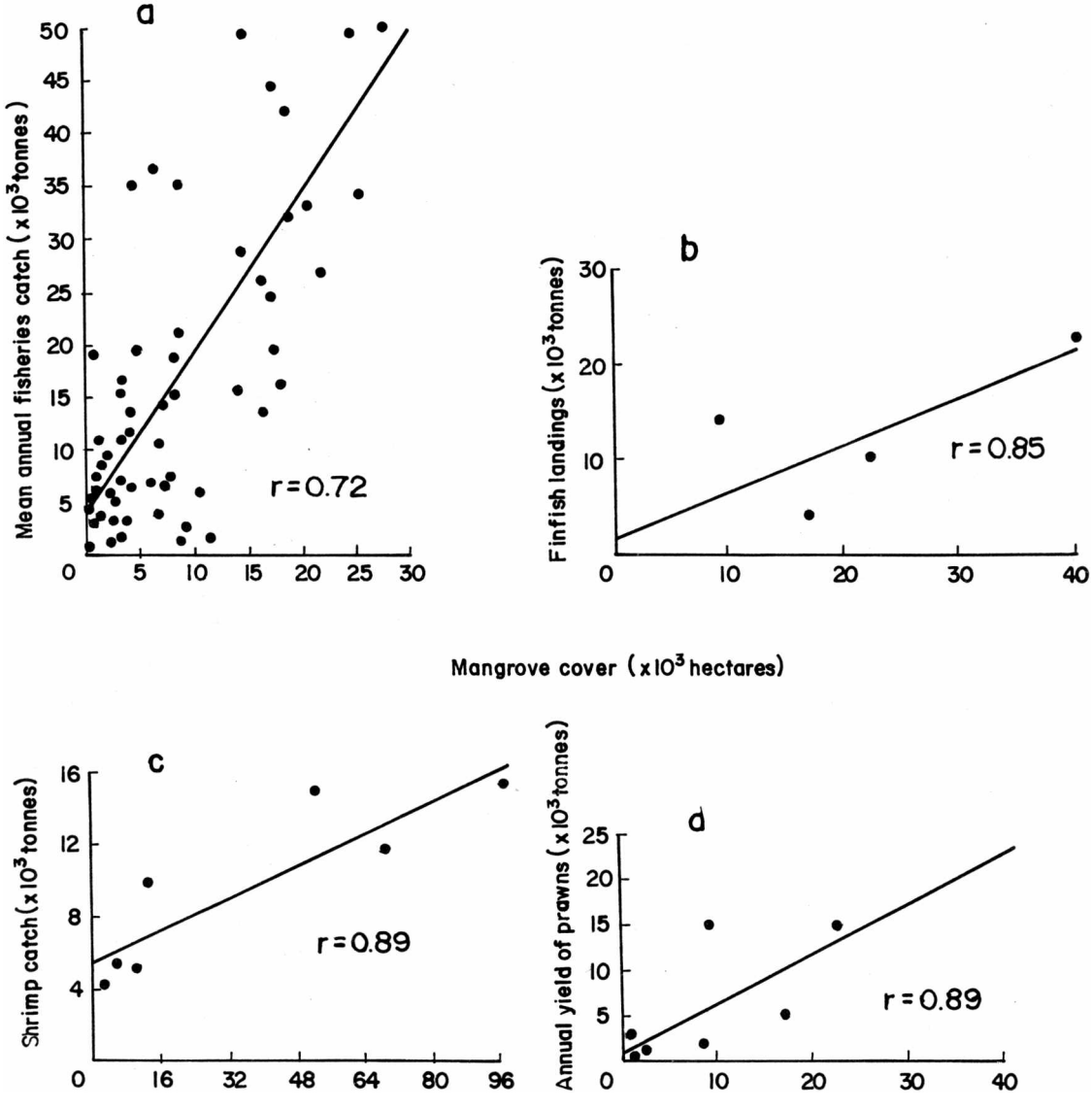

Figure 3. **The relationship between fisheries landings and mangrove areal cover in the ASEAN region:**

a) *Philippines.* Annual fisheries catch by province (Camacho & Bagarinao 1987)

b) *Malaysia.* Mangrove-dependent fish landings on the west coast of Peninsular Malaysia (State Fisheries Statistics 1990)

c) *Indonesia.* Shrimp landings (Martosubroto & Naamin 1977)

d) *Malaysia.* Annual yield of prawns (Sasekumar & Chong 1987)

Table 6. **Economic values placed on products and services of mangroves systems** (After Primavera 1993)

Country	Year	Product or service	Value (US$/ha/yr/)	Reference
Puerto Rico	1973	Complete mangrove ecosystem	1,550	Hamilton & Snedaker 1984
Trinidad	1974	Complete mangrove system	600	Hamilton & Snedaker 1984
		Fishery products	125	
		Forestry products	70	
Fiji	1976	Complete mangrove system	950-1,250	Hamilton & Snedaker 1984
		Fishery products	640	
Indonesia	1978	Fishery products	50	Hamilton & Snedaker 1984
Indonesia	1978	Forestry (charcoal, woodchips)	10-20	Hamilton & Snedaker 1984
Thailand	n.d.	Charcoal production	4,000	McNeely & Dobias 1991
Thailand	1982	Fish & shrimp	30-2,000	Hamilton & Snedaker 1984
		Forestry products	30-400	
Brazil	1981-1982	Fish (based on extent of open water)	769	Kapetsky 1987
Malaysia	n.d.	Fishery products	750	Ong 1982
		Forestry products	225	
Malaysia	n.d.	Managed forest (sustained harvest)	11,561	Salleh & Chan 1986
India	1985	Complete system (including fishery products)		
		Maintenance of fauna, air and water purification	11,314	Untawale 1986

n.d. - no data

wildlings or natural regeneration. A good rule of thumb is to develop not more than 30% of a given mangrove area. An equally important guideline is the retention (or planting) of greenbelts or buffer zones between aquaculture ponds and adjoining waterways (shoreline, riverbank, etc.) or between adjacent uses (e.g. shrimp pond and rice field) of the coastal zone.

Not all aquaculture requires clearcutting of mangroves. Examples of mangrove-friendly aquaculture exist either in waterways (seaweeds; bivalves such as mussel, oyster and cockles; and cages for crab and fish) or land-based (ponds and pens for crabs, shrimps and fish). These technologies, particularly mangrove ponds and pens (also called aquasilviculture or silvofisheries) integrate the utilization of mangroves for both forestry and aquaculture production (Primavera and Agbayani, 1997).

References

Camacho AS and Bagarinao T. 1987. Impact of fishpond development on the mangrove ecosystem in the Philippines. In: Mangroves of Asia and the Pacific: Status and Management, pp. 383-405. Tech. Rep. UNDP/UNESCO Research and Training Pilot Programme on Mangrove Ecosystems in Asia and the

Pacific (RAS/79/002). Natural Resources Management Center and National Mangrove Committee, Ministry of Natural Resources, Philippines

Chamberlain GW. 1991. Shrimp farming in Indonesia. I. Growout techniques. World Aquacult. 22 (2), 13-27

Chong VC, Sasekumar A and Lim KH. 1994. Distribution and abundance of prawns in a Malaysian mangrove system. In: Proceedings of the Third ASEAN-Australia Symposium on Living Coastal Resources: Research Papers 2: 437-445 (Sudara S, Wilkinson C and Chou LM, eds). Chulalongkorn University, Bangkok, Thailand, 16-20 May 1994. Australian Institute of Marine Science, Townsville

Chong VC, Sasekumar A, Atmadja WS and Low JKY. 1994. Status of mangrove prawn fisheries in the ASEAN countries. In: Proceedings of the Third ASEAN-Australia Symposium on Living Coastal Resources: Status Reviews 1: 147-154 (Wilkinson C, Sudara S and Ming CL, eds). Chulalongkorn University, Bangkok, Thailand, 16-20 May 1994. Australian Institute of Marine Science, Townsville

Duke NC. 1992. Mangrove floristics and biogeography. In: Tropical Mangrove Ecosystems, Coastal and Estuarine Studies 41: 63-100 (Robertson AI and Alongi DM, eds). American Geophysical Union, District of Columbia

Gedney RH, Kapetsky JM and Kuhnhold WW. 1982. Training on assessment of coastal aquaculture potential, Malaysia, Manila, South China Sea Fisheries Development and Coordinating Programme, SCS/GEN/82/35: 62 p

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

Hutchings P and Saenger P. 1987. Ecology of Mangroves, University of Queensland Press, Australia, 388 p

Japar SB. 1994. Mangrove plant resources in the ASEAN region. In: Proceedings of the Third ASEAN-Australia Symposium on Living Coastal Resources: Status Reviews 1: 123-1___(Wilkinson C, Sudara S and Ming CL, eds). Chulalongkorn University, Bangkok, Thailand, 16-20 May 1994. Australian Institute of Marine Science, Townsville, Australia

Kapetsky JM. 1987. Conversion of mangroves for pond aquaculture: some short-term and long-term remedies. FAO Fish. Rep. Suppl. 370-129-141

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

Lugo AE and Snedaker SC. 1974. The ecology of mangroves. Ann. Rev. Ecol. Syst. 5: 39-64

Martosubroto P and Naamin M. 1977. Relationship between tidal forests (mangroves) and commercial shrimp production in Indonesia. Mar. Res. Indonesia 18: 81-86

McNeely JA and Dobias RJ. 1991. Economic incentives for conserving biological diversity in Thailand. Ambio 20 (2): 86-90

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

Merrill ED. 1918. Species Blancoanae. A critical revision of the Philippine species of plants described by Blanco and Llanos. Bureau of Science Pub. 12. Bureau of Printing, Manila, 423 p

Ong JE. 1982. Mangroves and aquaculture in Malaysia. Ambio 11: 252-257

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

Primavera JH. 1995. Mangroves and brackishwater pond culture in the Philippines. Hydrobiologia 295: 303-309

Primavera JH. 1996. Stable carbon and nitrogen isotope ratios of penaeid juveniles and primary producers in a riverine mangrove in Guimaras, Philippines. Bull. Mar. Sci. 58 (3): 675-683

Primavera JH. 1997. Fish predation on mangrove-associated penaeids: The role of structures and substrates. J. Expt. Mar. Biol. Ecol. 215: 205-216

Primavera JH. 1998. Mangroves as nurseries: shrimp populations in mangrove and non-mangrove habitats. Estuar. Coast. Shelf Sci. 46: 457-464

Primavera JH and Agbayani RF. 1997. Comparative strategies in community-based mangrove rehabilitation programmes in the Philippines. In: Proceedings of Ecotone V, Community Participation in Conservation, Sustainable Use and Rehabilitation of Mangroves in Southeast Asia, pp 229-243 (Hong PN, Ishwaran N, San HT, Tri NH and Tuan MS, eds). UNESCO, Japanese Man and the Biosphere National Committee and Mangrove Ecosystem Research Centre, Vietnam

Raine RM. 1994. Current land use and changes in land use over time in the coastal zone of Chanthaburi province, Thailand. Biol. Conserv. 67: 201-204

Rosenberry B. 1997. World Shrimp Farming 1997. Shrimp News International, San Diego, California

Saenger P, Hegerl EJ and Davie JDS. 1983. Global status of mangrove ecosystems. IUCN Commission on Ecology Papers No. 3. Gland, Switzerland. 88 p

Salleh MN and Chan HT. 1986. Sustained yield forest management of the Matang mangrove. In: Mangroves of Asia and the Pacific: Status and Management, p 319-324. Tech. Rep. UNDP/UNESCO Research and Training Pilot Programme on Mangrove Ecosystems in Asia and the Pacific (RAS/79/002). Natural Resources Management Center and National Mangrove Committee, Ministry of Natural Resources, Philippines

Sasekumar A and Chong VC. 1987. Mangroves and prawns: further perspectives. In: Proceedings of the Tenth Annual Seminar of the Malaysian Society of Marine Sciences, pp 10-22 (Sasekumar A *et al,* eds). University of Malaya, Kuala Lumpur

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

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

Tomlinson PB. 1986. The botany of mangroves. Cambridge University Press, 413 p

Trong NV. 1995. Some issues on environment and fishery resources in the Mekong Delta. National Workshop on Environment and Aquaculture Development, Hai Phong, Vietnam, 17-19 May 1994. NACA, Ministry of Fisheries, Vietnam and EU International Programme

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

Untawale AG. 1986. Asia country reports: India. In: Mangroves of Asia and the Pacific: Status and Management, p 51-87. Tech. Rep. UNDP/UNESCO Research and Training Pilot Programme on Mangrove Ecosystems in Asia and the Pacific (RAS/79/002). Natural Resources Management Center and National Mangrove Committee, Ministry of Natural Resources, Philippines

Woodroffe C. 1992. Mangrove sediments and geomorphology. In: Tropical Mangrove Ecosystems, Coastal and Estuarine Studies 41: 63-100 (Robertson AI and Alongi DM, eds). American Geophysical Union, District of Columbia