Mangroves of Nakhon Si Thammarat Province in southern Thailand: Species diversity, community structure and current status

Amarasinghe, M.D.[1], Dulyapurk, V.[2], Taparhudee, W.[2], Yoonpundh, R.[2] and Jumnongsong, S.[2]

1. Network of Aquaculture Centres in Asia-Pacific, email: mala@enaca.org,
2. Faculty of Fisheries, Kasetsart University, Thailand

Mangroves are one among nature's amazing creations, for the reason that these plants are supremely equipped to survive and perform in the harsh inter-tidal zone of the coast where sea meets land. It is reported that 60-75% of the coast-line of the Earth's tropical region is lined with mangroves. Thailand's coastline extends over 2815 km, of which 1878 km are around the Gulf of Thailand. Nakhon Si Thammarat (NST) Province borders part of western shoreline of Gulf of Thailand and it is one of the major areas of mangroves around this shallow sea. Relatively large areas of mangroves still remain along the coasts of Surat Thani, Songkla, Samut Sakorn and Chantaburi Provinces that border Gulf of Thailand. Coastline of NST borders Pak Panang bay which receives the largest volume of freshwater from Pak Panang river and lesser amounts from Bang Chak, the Pak Nakhon, and the Pak Phaya rivers. The flow of water in the Pak Panang river, which is 110 km long and drains an area of approximately 100 km^2 is controlled by a barrage built at the river mouth[1].

Nakhon Si Thammarat receives about 2000 mm of annual rainfall of which 50% is received in less than three months, from November to January with north east monsoon. The mean annual temperature is 27.2°C with 83% relative humidity. A semi diurnal tidal pattern prevails with a range that does not exceed 1 m.

Research on reconciliation of multiple demands on mangrove ecosystems of the EU-Funded MANGROVE project jointly carried out by Universities of Essex, Kasetsart, Wageningen, Mulawarman, Vietnam National, Network of Aquaculture Centres in Asia-Pacific and Stockholm Environmental Institute, is based on three villages, i.e. Ban Kong Khong (close to the largest area of mangrove in the mouth of Pak Panang river), Ban Pak Nam Pak Phaya (area with abandoned shrimp ponds and re-plantation occurs to some extent and Ban Talad Has (area where mangrove planting / afforestation is done on mud-flats).

Structure of mangrove ecosystems at study sites in Nakhon Si Thammarat

The structure of mangrove vegetation is characterised in terms of species richness, diversity, tree/stem density, species and stand basal area, frequency of occurrence of constituent species, plant/stand height, above ground biomass and canopy volume/leaf area index. These parameters can either be measured in sample (representative) areas, i.e. from demarcated plots or using plot-less methods. Qualitative assessment of vegetation structure often uses species richness, plant height and apparent zonation of plants.

Figure 1: Location of study sites and distribution of mangroves in Nakhon Si Thammarat Province, Thailand.

Mangrove plant diversity

Plant species that are exclusive to the inter-tidal mangrove habitats are known as true mangrove species while those that occur in mangrove and other wetland habitats are called the mangrove associated species. A total of 87 true and associated mangrove plant species belonging to 41 families are recorded to occur in Thailand[2]. Five families of mangroves, Rhizophoraceae, Avicenniaceae, Combretaceae, Palmae and Sonneratiaceae, are the dominant around the country.

The true mangrove species, i.e species that are exclusive to inter-tidal areas, that occur in the study area include, *Acanthus ebracteatus*, *A. ilicifolius, Aegiceras corniculatum*, *Avicennia alba*, *A. marina*, *A. officinalis*, *Bruguiera cylindrical*, *B. gymnorrhiza*, *B. hainessi*, *B. parviflora*, *B. sexangula*, *Ceriops decandra*, *C. tagal*, *Heritiera littoralis*, *Kandelia candel*, *Lumnitzera littorea*, *L. racemosa*, *Nypa fruticans*, *Rhizophora apiculata*, *R. mucronata, Scyphiphora hydrophyllaceae*, *Sonneratia alba*, *S. caseolaris*, *S. ovate*, *Xylocarpus granatum* and *X. mollaccensis*. The common mangrove associated species, i.e. species that occur in localities outside the inter-tidal zone, are *Acrostichum aurem*, *A. speciosum* (ferns), *Caesalpinia sp. Clerodendron inerme*, *Derris trifoliate*, *Hibiscus tiliaceus*, *Oncosperma tigillarium*, *Phoenix paludosa*, *Premna integrifolia*, *Rapanae porteriana*, *Scolopia macrocama* and *Thespesia populnea*[3].

Distribution of mangrove species within a mangrove area depends largely on availability and distribution of seeds/ seedlings, tolerance of species for inundation as well as soil

salinity and thus resulting zonation of species. Three distinct zones can be identified in mangrove areas of Nakhon Si Thammarat, i.e.

- Water-front zone that consists of *Avicennia marina*, *A. alba* and *A officinalis*[4]. Stature varies from a few meters to 10 m in height.
- Rhizophora zone - *Rhizophora mucronata* and *R. apiculata* dominated zone occurs hinterland to the *Avicennia* zone and along rivers and creeks with a mean height about 8 m.
- Mixed species zone - These mangrove forests mostly consist of mixed species including *Bruguiera cylindrica*, *Ceriops tagal*, *Excoecaria agallocha*, *Ficus sp.*, *Heritiera littoralis, Hibiscus tiliaceus*, *Intsia bijuga*, *Xylocarpus granatum*, and *X. moluccensis* situated behind the water-front zones.

Figure 2: Mangroves of Pak Panang estuary in Nakhon Si Thammarat Province.

Mangrove areas around Ban Pak Nam Pak Phaya in Ta Sak Sub-district of Mueang District were converted to shrimp ponds during the height of the shrimp farming industry in the 80s and early 90s, most of which are now being abandoned due to rising production costs and declining demand for the commodity. Mangroves occur as a thin belt of less than 10 m in width along the small rivers that drain this area and they are composed mainly of *Rhizophora apiculata*, *R. mucronata*, and *Avicennia alba* which are 7-10 m tall. Mangroves in the periphery of the abandoned ponds were found to be consisted of trees with low stature (3-4 m) and dominated by pioneer species such as *Avicennia marina*, *A. alba*, *Rhizophora apiculata* and *R. mucronata* mixed to a lesser extent with species such as *Bruguiera gymnorrhiza*, *Excoecaria agallocha*, *Heritiera littoralis*, *Aegiceras corniculatum* and associated species such as *Thespesia populnea*, *Premna integrifolia* that occupy the area interior to the water-front zones. Tidal circulation in these areas does not occur uninterrupted due to the presence of sluice gates of the abandoned shrimp ponds.

Least disturbed mangroves occur in Pak Panang estuary and Ban Kong Khong village is situated in the proximity of this mangrove area (Figure 2).

Mangrove fauna

A total of 607 species of fish belonging to 87 families have been recorded from estuarine waters of Thailand. These include 30 elasmobranch species and 577 teleost species among which gobies (Eleotridae and Gobiidae) are the most diverse groups of fish in Thai estuaries. The Ariidae, Plotosidae, Mugilidae, Sciaenidae, and the Polynemidae mainly inhabit the estuaries, but the nurseryfish (Kurtidae) are restricted to mangrove canals. More than 90 species are commercially important for small-scale coastal fisheries and in the local economy. Around 40 species are well known in the global aquarium trade. In the past decade, species diversity has drastically decreased owing to loss of habitats (over 55% of mangrove areas have been claimed by deforestation, shrimp ponds and settlements), overfishing and pollution. There are 75 threatened species, (8 endangered; 67 vulnerable and near threatened). Two alien species introduced for aquaculture, *Oreochromis mossambicus* and *Poecilia sphenops*, flourish mainly in the inner Gulf of Thailand[5].

Trajectory of change in mangrove extent

The extent of mangroves estimated for NST in 1975 has been 155 km^2 (15,500 ha)[6] and it has reduced to 13,000 ha in 2005[7]. The major reason for dwindling mangrove extent in the province is attributed to their conversion to shrimp farms. Between 1961 and 1996, Thailand lost around 20,500 km^2 of mangrove forests, or about 56% of the original area, mainly because of shrimp aquaculture and other coastal developments[4].

According to Ongsomwang et al.[7], 1,594.48 ha mangrove areas of NST were converted to shrimp farms, while 662.17 ha were turned into agricultural land during the period 1990-2005.

Moreover, 3,223.21 ha of agricultural land too have been converted to shrimp ponds and 484.94 ha into human settlements. Approximately 14,500 ha of land have been converted to shrimp ponds and it is more than the total area of mangroves lost during the same period (Table 1). This is simply due to the fact that Thai shrimp farmers prefer to

Table 1: Extent of land-use types in Nakhon Si Thammarat in 1990 and 2005 (Ongsomwang et al, 2007)

Land use	Extent in 1990	Extent in 2005	Change
Settlement area	2,096.96	2,477.65	380.70
Terrestrial forest	8, 303.38	7,800.82	-502.56
Mangrove forests	14,078.13	12,999.19	-1,078.94
Agricultural land	35,699.71	34,079.28	-1,620.43
Shrimp farms	11,802.26	26,235.65	14,433.40
Water body	109,602.85	109,377.40	-225.45
Abandoned land	29,986.13	18,718.10	-11,268.02
Miscellaneous area	245.41	126.72	-118.69
Total	211,814.82	211,814.82	

locate their ponds away from inter-tidal zone of mangroves and in the supra-tidal areas where drying the pond and cleaning the bottom is less cumbersome, a practice that is effective in preventing diseases, the main cause of income loss from the enterprise. Approximately 30% of the shrimp production in Thailand comes from the freshwater areas, some of which are located 200 km from the sea[8] and culture technology is expected to improve in order to accommodate intensive culture in relatively a small extent of land.[7]

Organic shrimp farming is the latest spinoff of shrimp industry where shrimps are cultured extensively without any inputs such as artificial feed, antibiotics etc. which demand larger tracts of land to maintain organic shrimp farms. Currently it is restricted to one locality in Chanthaburi Province, nevertheless if the demand escalates this culture will be expanded to other areas and the easily acquired mangrove lands could be the target.

Barbier and Cox[9] report that mangrove conversion is determined by the returns to shrimp farmers, (i.e. the price of shrimp), the input costs to farming shrimp (e.g. feed price and wages) and the "accessibility" to mangrove areas. In addition, exogenous influences, such as income per capita, population growth, and in-migration (i.e. the number of shrimp farms) also are important factors in this context. Kongkeo[8] however, substantiates that Thai shrimp industry, dominated by small-scale farmers has managed to maintain high annual production due to the fact that Thai farmers readily move away from mangrove areas and adopt intensive farming methods with closed or less water-exchange systems in the supra-tidal areas, through which they have managed to substantially reduce the incidence of diseases. Use of concentrated seawater or freshwater as the culture medium too has contributed to lower the incidence of viral infections on cultured shrimps.

Although statistics are not available, substantial extent of inter-tidal land exists as abandoned shrimp ponds. The "Green Carpet" project, supported by KEIDANREN Conservation Fund (KNCF) and Japan Fund for Environmental Conservation (JEC) in collaboration with the Thai Union for Mangrove Rehabilitation and Conservation has planned to replant about 1000 ha of abandoned shrimp ponds in Nakhon Si Thammarat Province within 5 years. *Rhizophora mucronata*, *Rhizophora apiculata*,*Ceriops tagal* and *Bruguira cylindrical* have been used in the plantations and the former two species have shown the best growth rate and 75-90% survival rate[10]. Also they have shown that general soil conditions, i.e. organic matter and total nitrogen contents, pH, cation exchange capacity (CEC) and phosphorous content have improved over a period of three years after planting.

Thai shrimp farmers thus provide a mangrove-friendly paradigm of shrimp culture and it is timely that Southeast Asian Nations, particularly Indonesia, that harbours the largest extent of mangroves in the region, deliberate adequately and adopt policy measures to promote intensive shrimp farming in supra-tidal areas which requires relatively low extent of land than extensive farming in mangrove areas that is encouraged at present.

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