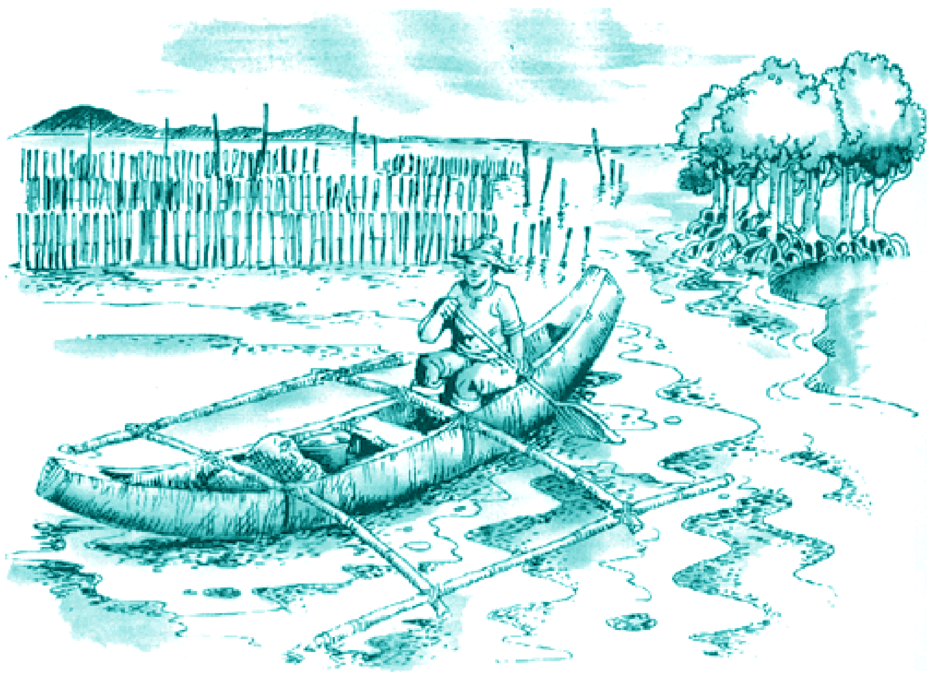
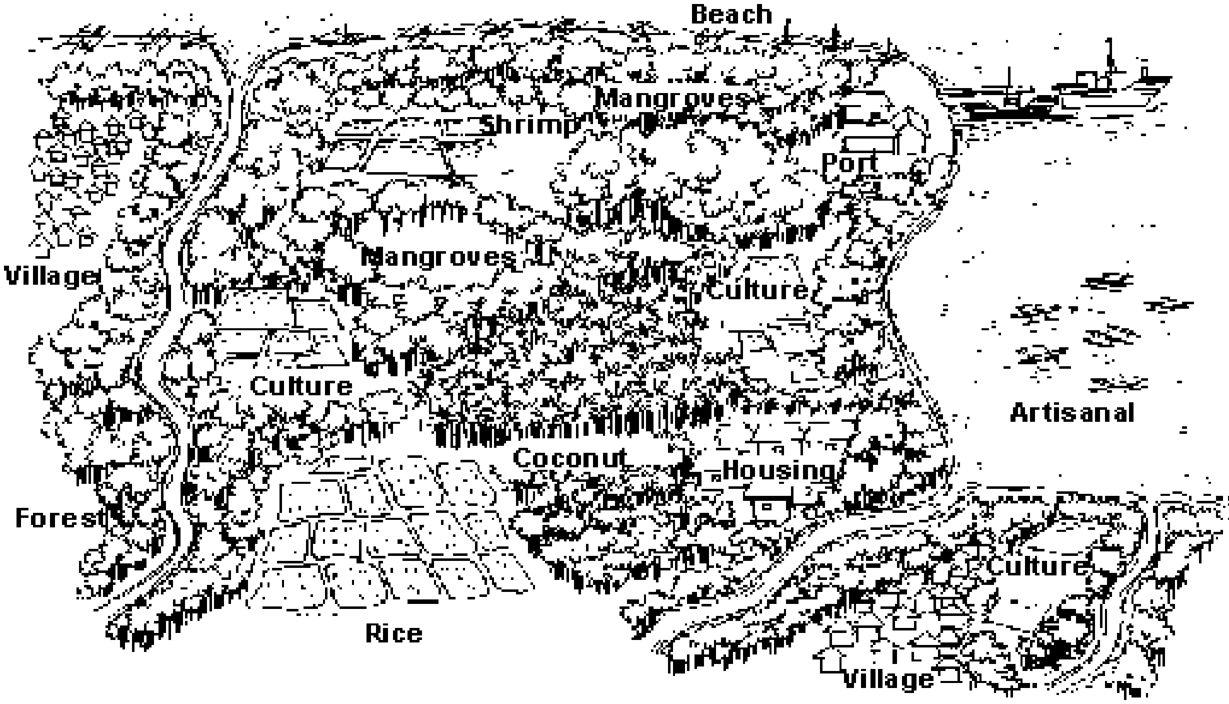
Brackishwater and Marine Systems



Community-Based Rehabilitation of Mangroves



Mangroves are intertidal communities of tropical and subtropical trees and shrubs growing in salt to brackish water and in predominantly muddy or sandy substrates, and protected coastlines. To cope with extreme conditions (of salinity, water saturation and dessication and anoxia), mangroves have evolved a variety of coping mechanisms including prop roots, cable roots and salt glands.

Facts

- Mangrove-associated fish contribute around 30% (1.09 million tons) of annual finfish resources (excluding fish bycatch) in the ASEAN region.

- Mangrove-dependent prawns provide almost 100% (0.4 million tons valued at US$1.4 billion) of total prawn resources in the ASEAN region.

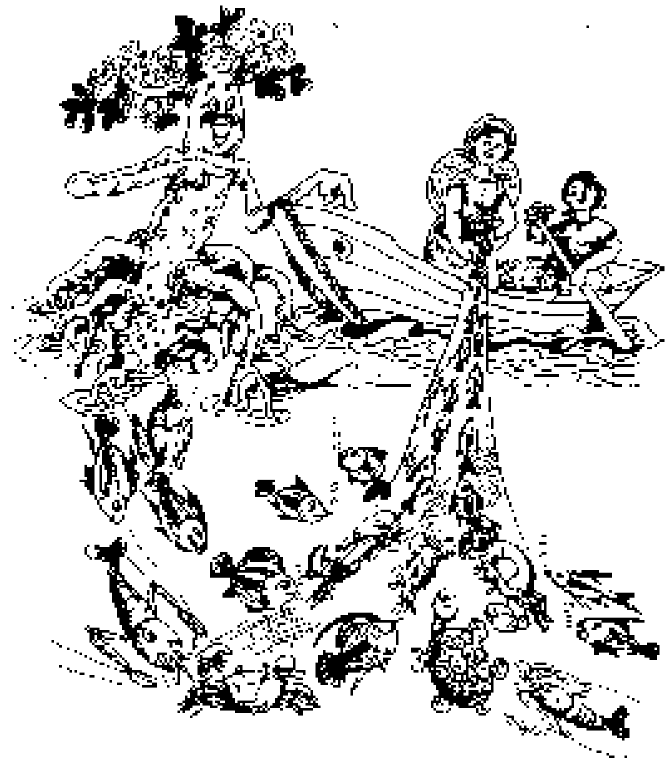
- A review of mangrove fisheries gives estimates of production and value (on a per ha per yr basis) respectively, of 257-900 kg and US$475-5,330 for fish, 13-756 kg and $91-5,292 for penaeid shrimp, 13-64 kg and $39-352 for mud crab, and 500-979 kg and $140-274 for mollusks.

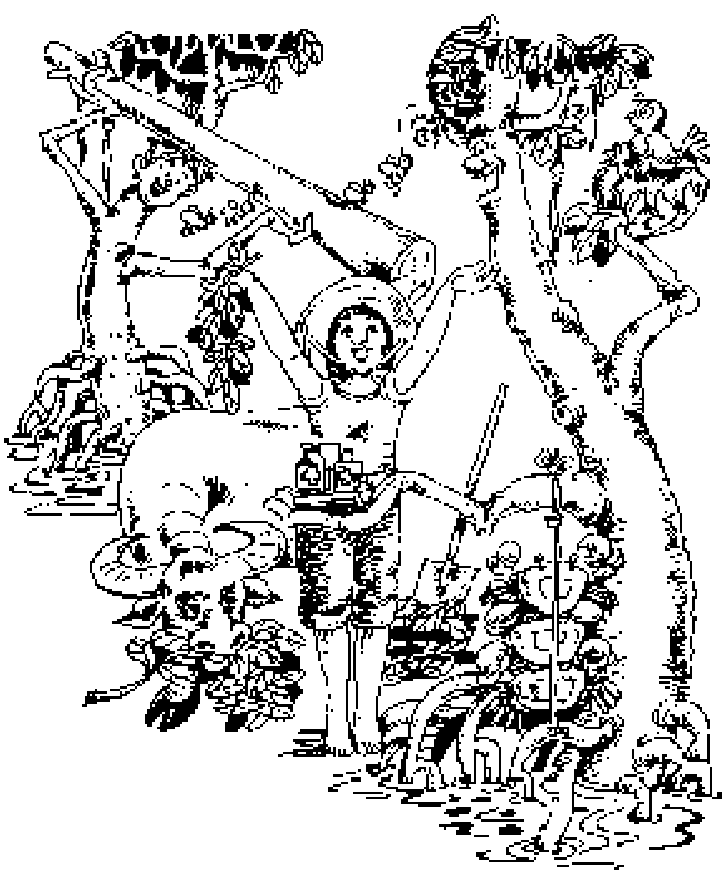
- Conversion to shrimp/fish ponds, in addition to settlements, agriculture, salt beds, overexploitation and other factors, have led to high rates of mangrove loss ranging from 25% in Malaysia to 50% in Thailand over the last three decades.

- Shrimp pond construction in mangroves totaled 102,000 ha in Vietnam in 1983-1987 and 65,200 ha in Thailand 1961-1993; many of these farms have collapsed due to diseases. The ponds were subsequently abandoned.

Mangroves produce both forest and fisheries resources and goods. Fisheries products include fish, shrimp, crabs, bivalve and gastropod mollusks, other invertebrates and seaweeds.

A positive correlation between nearshore fish and shrimp catches and mangrove area has been documented in many countries. Declining municipal fisheries yields parallel the reduction of Philippine mangrove areas, while brackish water pond hectarage and aquaculture production are increasing. Although total fisheries production may remain the same, municipal fisheries provides equity by supporting many more people than pond culture.





Several other products can be obtained from mangroves

Aside from the products it provides, the regulatory function of the mangroves or the provision of amenities or services are equally important. These services include coastal protection, erosion control, sediment stabilization and trapping of terrestrial run-off, flood regulation, nutrient supply and regeneration, treatment of dissolved and particulate wastes, and habitat for wildlife. Total values as high as US$10,000/ha/yr have been estimated for all these mangrove goods and services.

Mangrove rehabilitation

Rehabilitation is the restoration of a degraded system to a more stable ecological status, which may or may not be its previous condition (Lewis, 1999).

The guiding principle in mangrove rehabilitation is the restoration of normal hydrological patterns. The community can draw on local knowledge of past hydrodynamics. Once the correct tidal elevation is restored, colonization by waterborne seedlings from adjacent stands can proceed. Planting should be undertaken only if natural mangrove recruitment does not occur, or if there is an overriding need by the local community for specific products, e.g., fishing poles from *Rhizophora*. Degraded areas with sparse mangrove cover can also benefit from enrichment planting of suitable species.

General principles in mangrove rehabilitation

- Restore normal hydrology
- Observe natural recruitment of seedlings
- Plant seedlings only if no recruitment occurs or if the community needs specific products
- Avoid *Rhizophora* monocultures

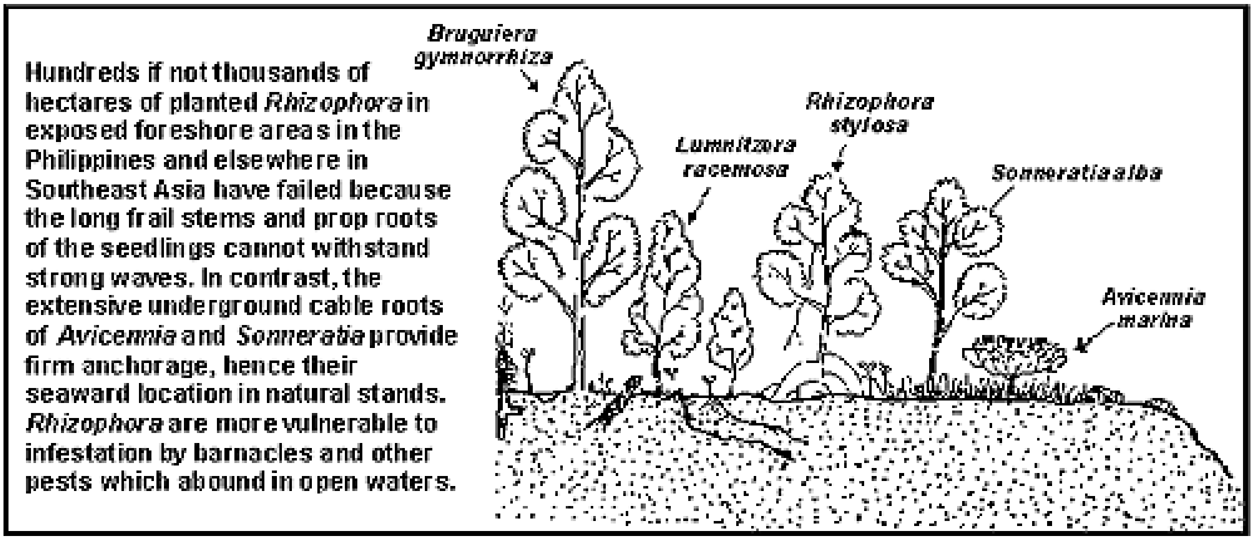
Mangrove plantations

At the outset, the stakeholders or local villagers should have a consensus on their goal in rehabilitating a given area.

- Shoreline protection (pioneers *Avicennia marina* and *Sonneratia alba*/*Sonneratia caseolaris*)
- Forestry products: *Rhizophora* for firewood, posts and piles; *Ceriops tagal* for tanbark; *Xylocarpus granatum* and *Heritiera littoralis* for furniture; and, *Nypa fruticans* for thatch (housing material)
- Improvement of fisheries catches (by restoring habitat)

Active mangrove planting of small areas – by villagers, local officials and schoolchildren as well – for educational purposes has greater importance than the total number of hectares planted. Nevertheless, tenure over the planted area will motivate planters to regularly monitor and protect the young seedlings.

Seedlings should not be planted near strong water currents, on tidal flats that serve as feeding grounds of migratory birds and seagrass beds. Planting should coincide with the availability of propagules (in case of direct planting) and the season of least wave action and typhoons. Mangrove species to be planted will depend on biophysical conditions of substrate (*A. marina*, *S. caseolaris* in sand, *Rhizophora* in mud), wave action (*A. marina* in seaward locations, *R. mucronata*/*R. stylosa*/*R. apiculata* along rivers), salinity and tidal elevation. Species of *Rhizophora* have been favored by past and ongoing mangrove planting programs throughout Asia because of their large propagules that are available year-round. Such monocultures have often failed.



Planting density or spacing will also depend on the objective - closely spaced clumps of three seedlings for coastal protection, higher densities of *Rhizophora* for firewood and charcoal, and lower densities for timber. Maintenance and monitoring by the community in the first months require daily check-up for barnacles, filamentous algae as well as the replacement of dead plants. As the plants become established, visits can be less frequent .

Mangrove seeds can be planted directly (e.g., the viviparous or germinated propagules of *Rhizophora*) or sowed (*Sonneratia*). Nursery-grown potted plants and hardened wildlings can also be outplanted in the field.

Mangrove nurseries

- Factors to consider in selecting a mangrove nursery site:

  – brackishwater (inundated by spring tides) and freshwater supply;
  – location close to mangrove seed sources, area for planting and village; and
  – accessibility preferably by land.

- The nursery should be built on a cleared and level area that drains well.
- Components include:

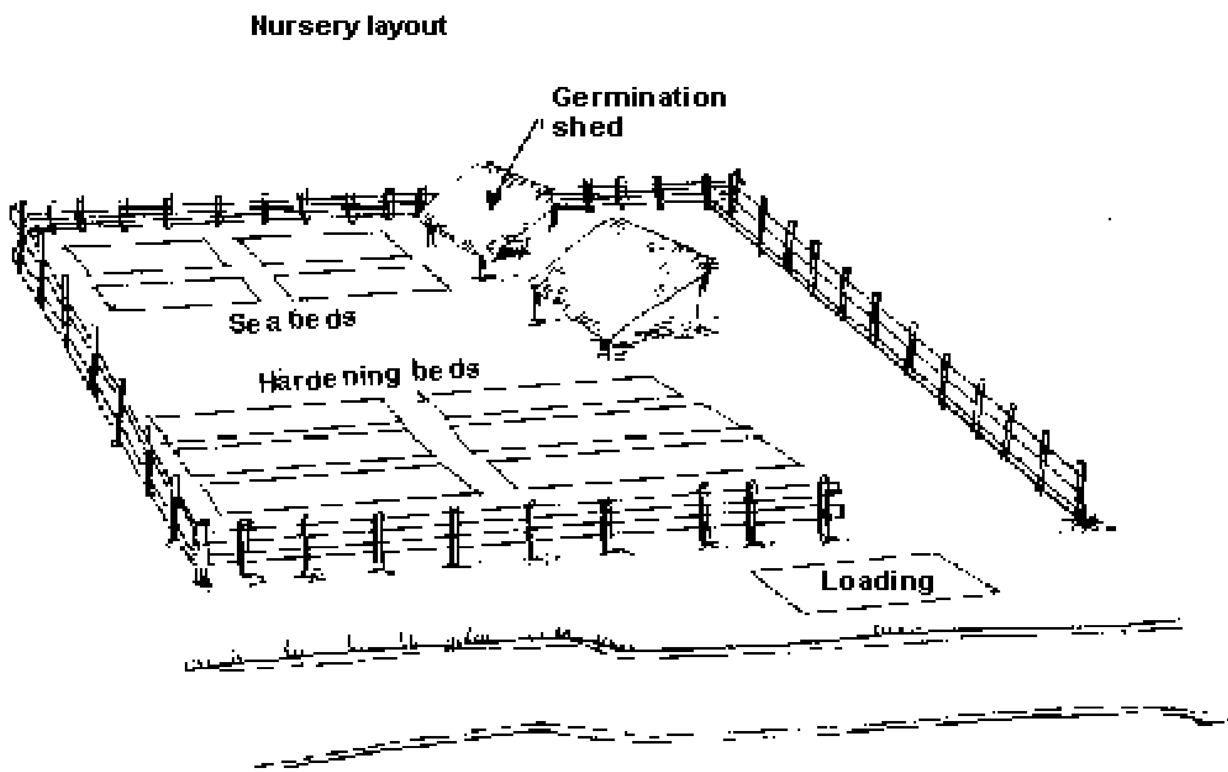
  – seed boxes (for small seeds like *Sonneratia*);
  – elevated germination beds;
  – beds for hardening of seedlings;
  – potting shed;
  – bagging shed; and

– storage shed.

- Shading by means of coconut leaves or netting material is advisable to reduce sunlight.
- The size of the nursery will depend on the number of seedlings required.

Peak fruiting seasons

- Undamaged mature seeds may be collected from the tree or on the ground when they have just fallen.
- The growing tips of propagules should be protect during transport.
- Mature seeds of each species have their own characteristics.
- Propagules must be planted within a week after collection.
- If seeds and propagules are not sufficient, wildlings or young saplings less than 30 cm tall from mature stands may be used. Plants in newly-colonized mangroves should not be used.



Community participation and ICZM

Since the local residents are the users, the management of coastal resources (including mangroves, sea grasses and coral reefs) should be community-based. Community involvement in the planning and implementation of coastal resource management (CRM) projects and sharing in the benefits of the interventions will contribute to the success of CRM. This may require organizing community organizations in coastal villages and leadership training under the initiative of local government bodies or non-government organizations (NGOs). Rehabilitation and other mangrove management projects shall be in the context of a wider integrated coastal zone/area management (ICZM or ICAM) that coordinates the needs of various sectors: fisheries, aquaculture, forestry, industry, among others.

Socio-economic considerations in mangrove rehabilitation programs

- Local knowledge and skills
- Social organization and institutions
- Land use and tenure

Tenure over mangrove areas In many countries, mangrove areas are open access public lands owned by the government. It is important that mangrove planters (individual families or groups) obtain tenure over their respective areas whether in the form of management/stewardship contract or lease from the government. Such mechanism ensures that they will reap the benefits of what they sow.
The successful conservation of the 300-ha Talabong Mangrove Reserve and decrease in illegal pond expansion and illegal fishing in Bais Bay, Negros, Philippines were due to the personal commitment of the mayor and local officials, community empowerment and provision of tenurial instruments. In turn, populations of various whales and dolphins that have subsequently returned to Tanon Strait outside the Bay provide opportunities for ecotourism along with mangroves, seagrasses and coral reefs in the Bay. The successful mangrove replanting projects of Yad Fon, a local NGO, in Trang Province, southern Thailand emphasize education and community involvement in the protection, monitoring and evaluation of rehabilitated sites.

Co-management of CRM with local government units is essential because local officials are responsible for the enactment of ordinances pertaining to marine conservation and rehabilitation and their implementation. Effective enforcement of such regulations is hampered by lack of manpower and facilities, and corruption at various national and local government levels. However, the successful co-management of Bais Bay, central Philippines illustrates political will at work. Local governments also have a role to play in conflict resolution - within the community and between neighboring communities.

Aside from local government support, property rights and community involvement, other factors important in mangrove rehabilitation and CRM initiatives are effective information dissemination/educational programs, and external technical expertise and funding, and alternative livelihood options.

Alternative short-term sources of income may be:

- cottage industries such as weaving and basket making; and
- sale of nipa thatch, seaweeds, mollusks, crabs and fish from mangrove fisheries/small-scale aquaculture.

Mangrove-friendly aquaculture includes the growing of seaweeds (*Gracilaria*), bivalve molluscs (oyster, mussel and cockle) and fish in cages/pens in mangrove waterways and tidal flats. Mudcrabs, fish and shrimp can also be cultured in pens and ponds integrated with mangrove trees inside the forest itself (called aquasilviculture or silvofisheries).

It is particularly important that the planters, i.e., the villagers (or even landless poor from neighboring areas) are allowed to harvest fish, invertebrates and other products from rehabilitated sites. Gleaning of molluscs and other invertebrates for domestic consumption in tidal flats adjoining mangroves is often done by women and children. Moreover, such small-scale fishing and gleaning in inshore areas are more species-selective, less fuel- and time-consuming, and safer than deep-water fishing.

Successful mangrove rehabilitation depends on both sound ecological principles and participation of local communities and government officials.

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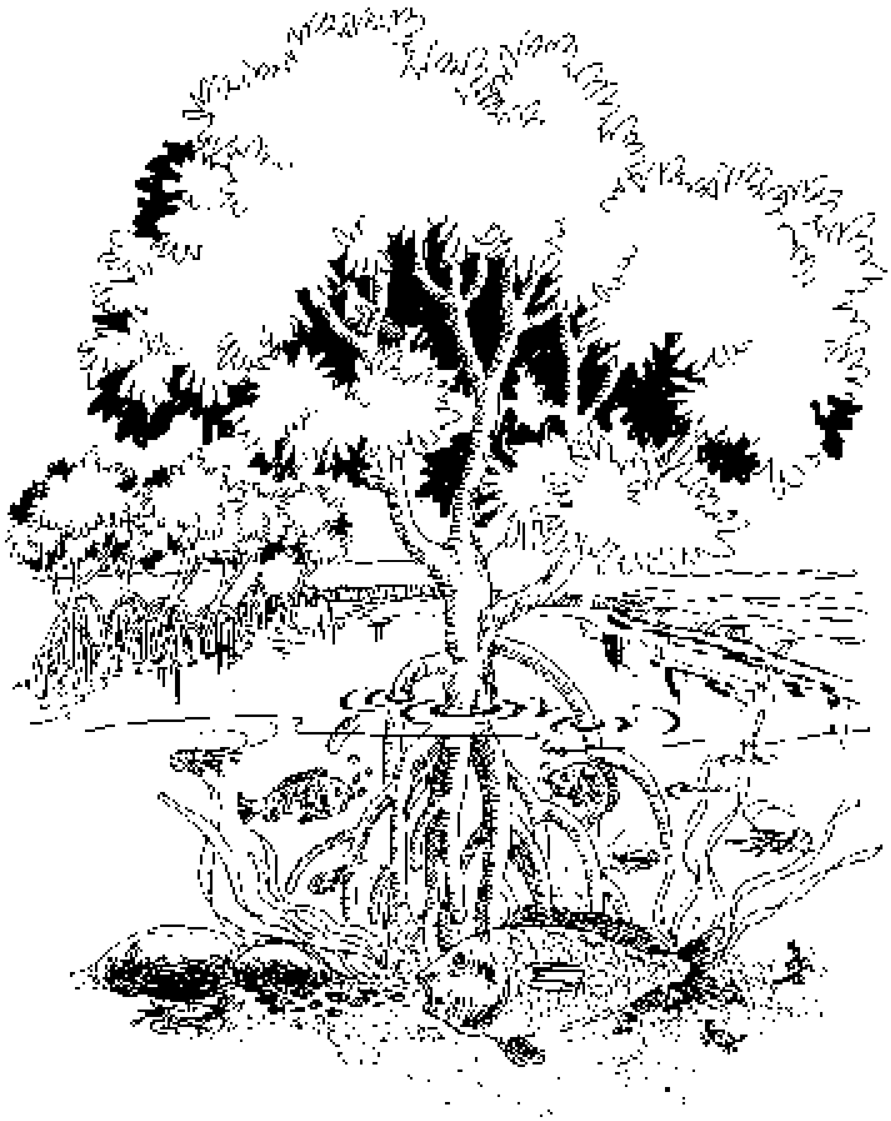
Mangrove-Based Small-Scale Shrimp Aquaculture



Mangrove-based small scale aquaculture can take many forms. Some examples are:

- culture of blood cockles and other shellfish on mudflats to the seaward of mangroves;
- cage or rack culture of oysters, other shellfish and fish in mangrove estuaries;
- culture of mud crabs within mangrove areas; and
- pond culture of shrimp and fish within or adjacent to mangroves.

Mangroves are not the best site for aquaculture ponds, especially for shrimp culture, as they have potentially acidic soil. Shrimp ponds may have problems with low pH, which is bad for the health and survival of shrimp. Also, when mangroves are converted into aquaculture ponds, valuable environmental benefits are lost. In general, it is better to set up aquaculture ponds on higher land behind mangroves.

The putting up of new aquaculture ponds within mangrove areas should be discouraged. However, brackishwater shrimp ponds have already been built in many areas.

Some environmental and economic benefits of mangroves

- Help protect coasts and river banks from erosion
- Help protect coastal dwellers from storms and storm surges
- Help reduce peaks of nutrient and sediment discharges from coastal rivers
- Help trap sediment and build new land
- Help reduce atmospheric CO2 levels by fixing and storing carbon
- Produce leaf litter and other detritus that support coastal food chains
- Provide nursery and feeding ground for fauna, including commercially valuable fish, shrimp, crab, gastropods and bivalve species
- Provide timber and fuelwood for coastal dwellers
- Provide other products like honey and medicinal drugs
- Enhance biodiversity
- Provide aesthetic and recreational values
- Provide scientific, educational and cultural values

In 1986, the Provincial Government of Ca Mau, the southernmost province of Vietnam, established 22 mixed shrimp farming-mangrove forestry enterprises (SFFEs) in the brackish water, coastal lowlands of Ngoc Hien and Dam Doi districts where Vietnam's largest remaining mangroves are found. It aims to provide income for small-scale landholders while managing the remaining mangrove resources for timber/fuelwood production and for environmental reasons.

Under the SFFEs, farming households are allocated 6-10 ha of land on a 20-year lease. At least 70% of the land is for mangrove forestry and the rest for aquaculture and domestic use. Shrimp culture is the primary livelihood for most households, although income from extensive wild shrimp culture remains low. This is partly due to unreliable wild seed stocks, particularly of species with high commercial value like *P. merguiensis* and *P. indicus* (low value *Metapenaeids* now represent about 80% of the harvest). Extensive culture of hatchery-reared seed of black tiger prawn *(P. monodon)* is also practiced widely, but yields and economic benefits have been highly variable because of low survival (commonly less than 1%) due to poor pond design and water and seed quality; bad farm management practices, farmer inexperience and disease outbreaks.

Some general characteristics of shrimp farming forestry enterprises (SFFEs)

- Flat with an elevation of less than 1 m above highest tide.
- Much of the area is tidally flooded from 150 to 365 days per year.
- Pronounced wet (May to November) and dry (December to April) monsoonal climate.

Small-scale improved extensive and semi-intensive shrimp culture

Increasing the stocking density (up to, but not more than, 10 per meter) and the survival rate of *P. monodon* in the pond can improve the contribution of shrimp farming to the livelihood of small-scale farmers in coastal areas. This can be achieved through modest intensification, together with better pond design, good quality seed and improved farm management practices. A range of options for improvement require different levels of investment. It is necessary to show farmers a sequence of steps they could take to increase their income. These steps depend on the condition of the farm, individual financial circumstances and experience.

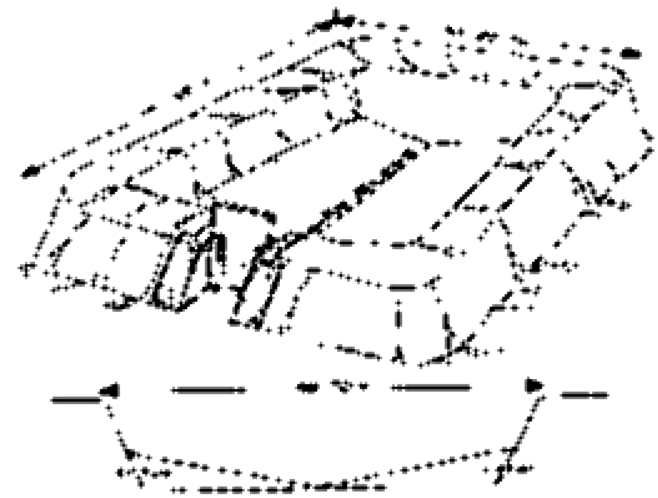
The three main requirements

1. A good pond
2. Strong, high quality and disease-free seed
3. Good nursery care during the first 20-25 days of stocking

Two types of farming systems commonly used in Ca Mau Province

1. Separate farms where shrimps are cultured in ponds without mangroves. Mangroves are grown in a separate area of the farm, sometimes in combination with shrimp culture, like mixed farms.
2. Mixed farms where mangroves are grown entirely within the pond, much like the tambac aquaculture system used in Indonesia for centuries.

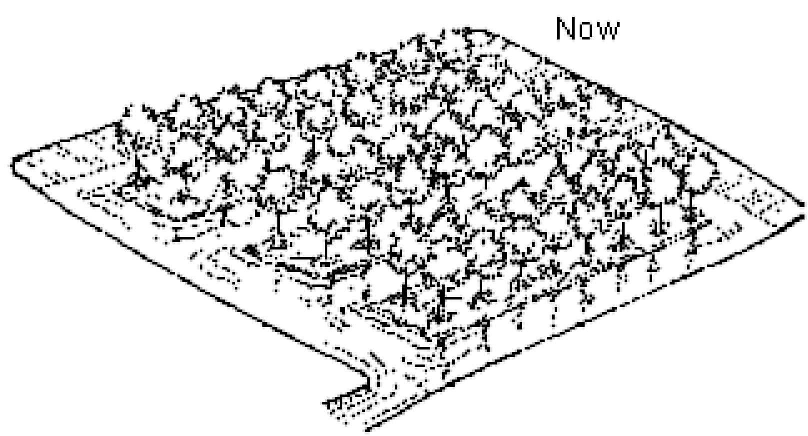
Some general suggestions on farm layout



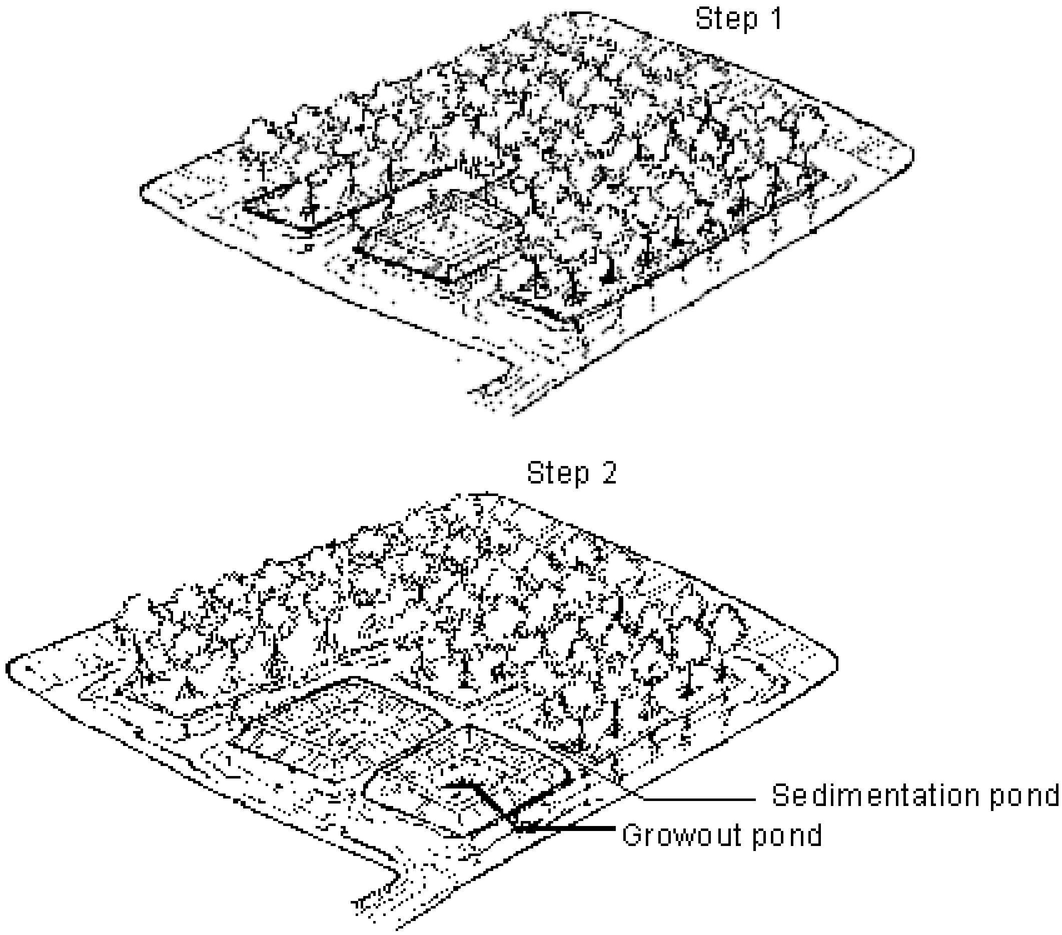
Pond specifications
Area: 2000 sq m (40 m x 40 m) to 2500 sq m (40 m x 50 m)
Depth: 1 m average water depth
Bottom: Slope bottom towards the center of the pond (a slope of 10 cm in 20 m is sufficient); also slope the bottom from the rear of the pond to the water gate (a 20 cm slope in 40-50 m is good).

- Remember that coastal mangrove systems are highly dynamic and their characteristics often change. What is seen now may not be the same in 10-20 years time. Try to anticipate future changes and make plans with these in mind. This will help avoid future problems that might be costly to fix.
- Try to keep a 20-30 m wide belt of mangroves along the waterfront to reduce erosion and provide a nursery for wild aquatic species.
- Try to maximize the benefit of mangroves by arranging the location to allow incoming or outgoing water to pass through the trees.

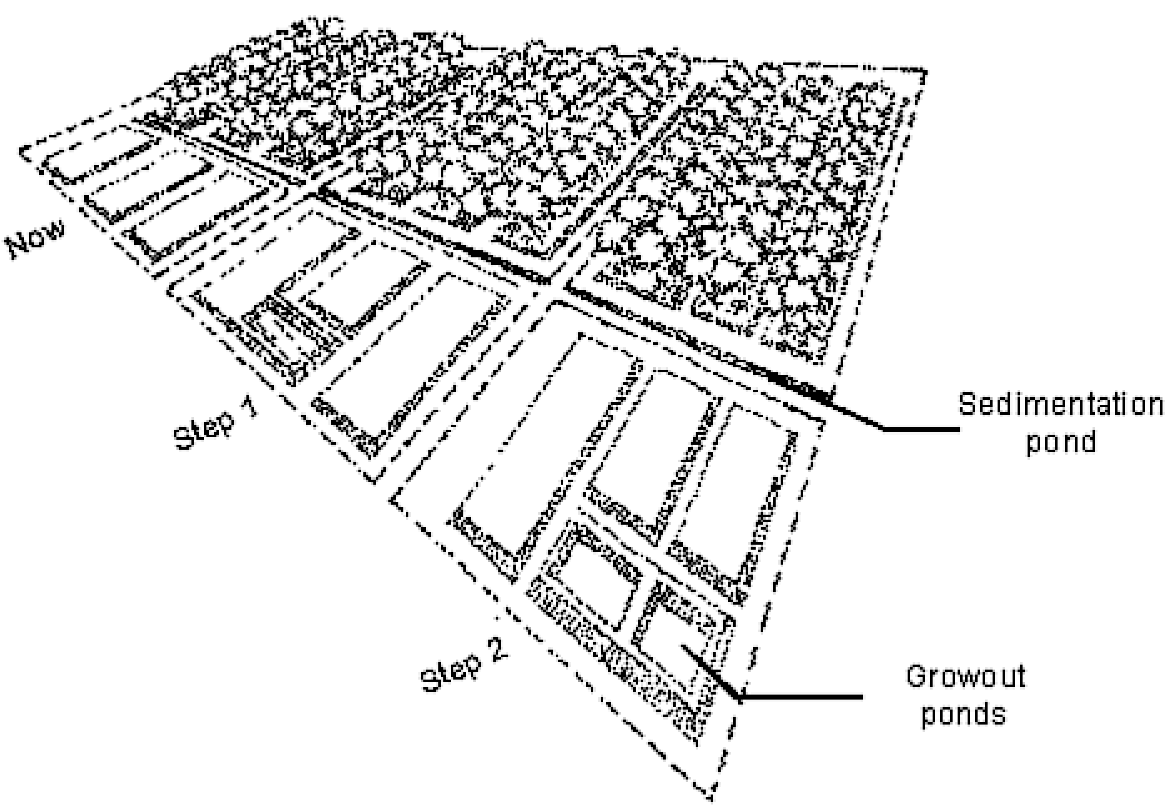
Pond design



A small pond with a water area of about 2000 or 2500 sq m is better than a much larger pond. Big ponds are more difficult to manage. Start with one pond, then add another as capital becomes available. This will help reduce the risk of losing shrimp through disease. No more than three ponds of this design should be built. See suggested sequence for the two main farming systems in the illustrations.



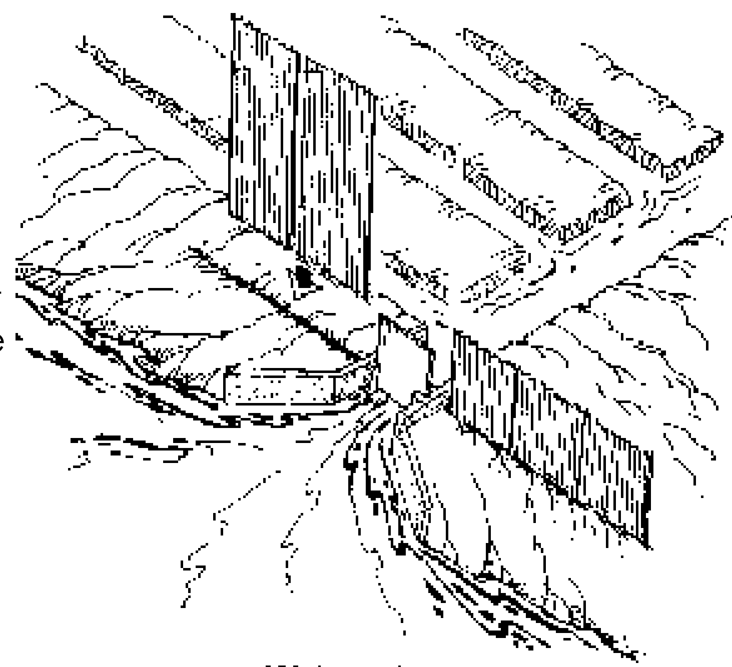
Suggested sequence for improving mixed farming system



Suggested sequence for improving the separate farming system

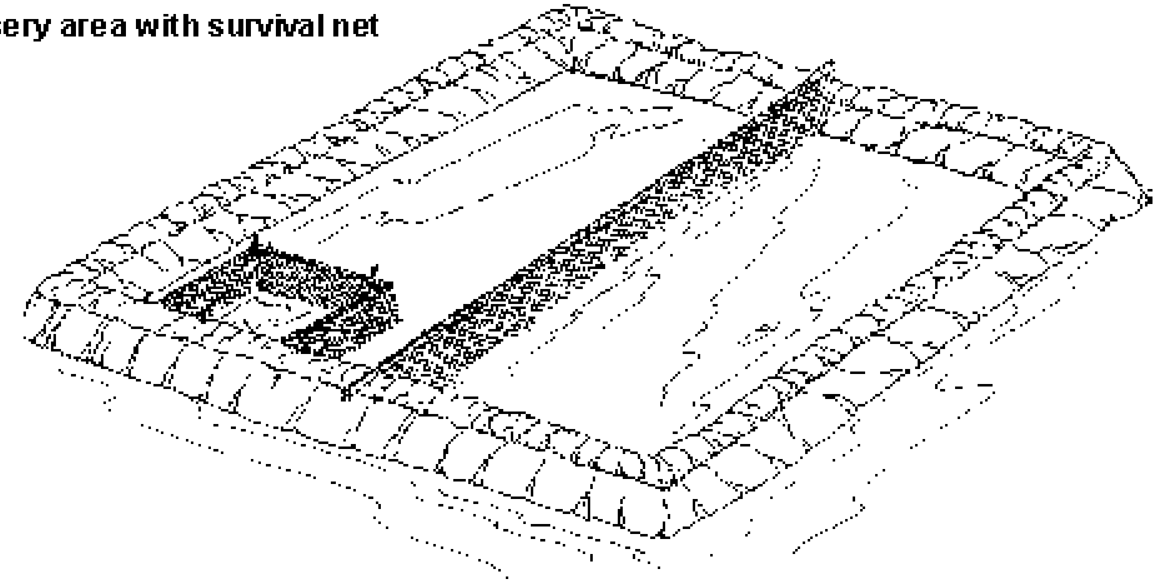
Some useful tips on pond preparation

- Use a sedimentation pond to improve water quality if the intake water has low transparency, is polluted or otherwise of low quality. Generally the water surface area of the sedimentation pond should be at least equal to the water surface area of the growout ponds. The sedimentation pond can be stocked with *P. monodon* at a density of 1-3 per sq m or it can be used for wild shrimp culture.
- Do not dump the excavated material into the river or in mangrove areas. Use it to build an area above the tidal limit, which can be used for terrestrial crops or livestock production. Diversification can help reduce the risk to the household and provide a more stable income.
- Make sure the average pond water depth is 1 m.
- Use a cement water gate that is at least 1 m wide. If necessary, use plastic sheets or fibro-cement roofing material to prevent water leakage through crab burrows along the sides of the water gate (refer to the diagram on the right).
- Outer levees (or dikes) should be at least 4-6 m wide to reduce leakage (10 m is preferable). The levee (dike) around the pond should be at least 0.5 m higher than the highest tide to reduce the risk of shrimp being washed out of the pond by unusually high tides or storm surges.



Watergate

- After constructing or after cleaning the pond, open the watergate and allow the tide to free flush the pond for at least a week. Put a net at the water gate to prevent entry of predators (e.g., fish). Avoid using chemicals to kill predators. If absolutely necessary, use only sparingly. Use Derris root or teaseed powder, both natural products, if piscicides are needed. In some areas with acidic soils, it may be necessary to apply lime (for recommendations, see paper on *Management Practices to Improve Extensive Shrimp Aquaculture*).
- Prepare a nursery area at least 1 week prior to stocking, using fine net (=< 1 mm mesh size) to cordon off the nursery from the rest of the pond. The size of the nursery area should be calculated for a stocking density of about 35-50 per sq m.



- Construct a survival net (mesh size =<1 mm) within the nursery area to estimate survival after the 20-25 day nursery phase. A survival net is simply a small area (10-20 sq m) set aside inside the nursery pond. But it is important because it provides an estimate of the initial stocking rate at the beginning of grow-out period and to estimate how much feed is needed during this phase (if supplementary feeding is employed). A survival estimate is also useful to assess early mortality. If survival is low, then more post-larvae (PL) should be purchased to restock, paying greater attention to nursery practices to ensure better a survival rate next time around.

Stocking and nursery care

The maximum stocking density (at the beginning of grow-out) should be no more than 5 per sq m without supplementary feeding during grow-out. For semi-intensive culture with feeding of *P. monodon*, stock at between 5 and 10 per sq m. Do not overstock. Stocking densities higher than 10 per sq m is not recommended.

Stocking tips

- Select good quality seed (PL10 to PL15). Look for even-sized, actively swimming PL. If a microscope or magnifying glass is available check PL for broken or damaged appendices. Avoid the latter. If possible, shock test a sample of PL with 150 ppm formalin for 30 min. More than 80% survival is indicative of strong PL, but is not a definitive test of freedom from viral and bacterial diseases.
- Stock into a nursery area. Keep in the nursery for 20-25 days (until PL35).
- Buy enough seed to allow for 30% mortality during the nursery phase.

Nursery care tips

- Feed daily, preferably with finely powdered commercially manufactured feed. Do not use crustaceans or crabs as feed.
- Feed in the nursery at the rate of 0.2 kg feed/ day/ 10,000 PL for the first 5 days, then increase to 0.5 kg feed/day/10,000 PL for the rest of the nursery phase.
- Spread the feed as evenly as possible across the whole nursery area, including survival nets.

When buying PL, allow for a 30% loss during the nursery phase. Buy extra PL to give the desired final stocking density.

Do not put more than 2,000 PL in a single bag. Transport PL from the hatchery to the farm as quickly as possible in late afternoon to avoid temperature stress. Give the PL a chance to adjust to nursery water conditions overnight. Before stocking, acclimate the PL to nursery water in large tubs or bins for 30 minutes with aeration. Gently release PL into nursery area. Do not forget to stock the survival net with the required number of PL.

At the end of the nursery phase, count the survivors in the survival net. Use this to estimate survival and the stocking density at the beginning of the grow-out phase.

Grow-out

Use feeding trays to monitor feed intake. Don't overfeed as uneaten feed will only cause problems with water quality, particularly if the pond is not aerated with paddle wheels.

Aeration with a paddle wheel(s) is optional, but it is likely to increase survival at stocking densities up to 5 per sq m without feeding. Aeration is recommended for stocking densities of 5-10 per sq m with supplementary feeding (this will depend on the financial capability of individual farmers). Aeration is essential for stocking densities above 10 per sq m, when supplementary feeding is also necessary. Harvest in 90-120 days. Clean the bottom of the pond after each crop.

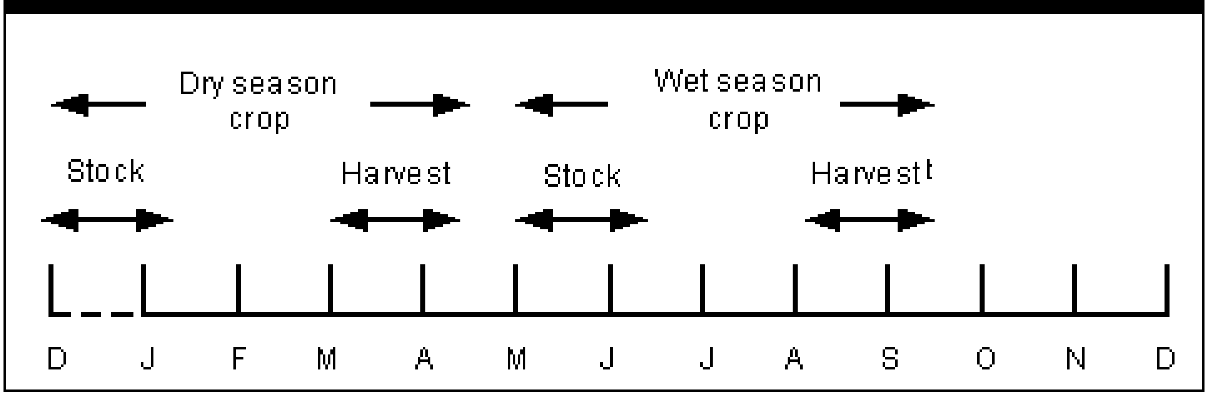
Management during growout

- Keep the water level in the pond topped up. For stocking densities up to 10 per sq m, it may not be helpful to change water too frequently, especially if the quality of intake water is worse than that in the pond.
- Drain the surface water during heavy rain to reduce rapid changes in salinity and pH.
- Check and record the size and number of shrimp in the grow-out pond at least every seven days using a feed tray, lift net or cast net. A sharp decline in the number of shrimps may indicate a problem. If shrimps are of marketable size, then harvesting could be considered rather than risk losing most of the crop.

Stocking cycles

Avoid stocking *P. monodon* at times when water quality may change rapidly, for example at the beginning of the wet season. A wet season crop has a greater mortality risk due to rapid changes in salinity and pH. Try to stock a wet season crop as early as possible, before heavy rains start. Drain and clean the pond bottom between crops, then leave the pond dry for two to three weeks before refilling.

Suggested stocking cycle for Ca Mau Province,



Health management

Shrimp health is affected by water quality, availability and quality of feeds, and viral and bacterial diseases. For brackishwater mangrove-based shrimp culture, especially in Ca Mau, Vietnam, low oxygen levels and pH are likely to be the main water quality parameters influencing shrimp health. Low oxygen can be a more serious threat when the ponds are overstocked or if shrimps are overfed. In the wet season, rapid changes in salinity may also affect shrimp health adversely. These problems can be minimized by careful water quality management.

Viral and bacterial diseases are more difficult to manage. Using disease-free seed is the first step that farmers can take to reduce the risk of diseases. However, viral and bacterial pathogens are probably present in most wild shrimp populations, so that there is always a risk that disease can be transferred from wild to cultured shrimps that were initially healthy. Crabs can also be vectors of some shrimp diseases. Hence, it would be best to exclude wild shrimp and crabs from the grow-out pond. Shrimps, like all animals including humans, are more likely to contract a disease if they are weak or stressed. Good pond and water quality management practices that keep shrimps strong and healthy will also help reduce the risk of death from viral and bacterial diseases.

Mangrove silviculture

The most common mangrove species used for silviculture (cultivation of timber trees) is *Rhizophora apiculata,* which is very suitable for poles, fuelwood and charcoal. For optimum growth, this species should be propagated in areas that are flooded for a period of 10 to 25 days per month.

It is also best to plant this species with an inter-tree spacing of 1 to 1.25 m (8,000 to 10,000 trees per ha) for silviculture. Specific thinning plans will depend on site conditions and the growth rate. For Ca Mau Province in Southern Vietnam, this species should be thinned to 5,000 trees per ha at eight years. If the trees are farmed on a 20-year rotation, a second thinning to 2,000 or 2,500 trees per ha should be carried out at 14 years. *Rhizophora* forests should not be thinned after 20 years of age.

Benefits from integrating mangroves with aquaculture

There are direct economic and environmental benefits from integrating mangroves with coastal aquaculture:

- mangroves can be used to process and clean up intake and outflow water in aquaculture ponds. To do this efficiently, farm layouts should be designed with this in mind;
- mangroves provide protection from storms and may prevent the loss of land from erosion, especially along the waterfront;
- generate income from the sale of wood products;
- provide fuel and materials for construction of houses, footbridges and other on-farm activities; and
- honey raising can be integrated in areas where there are suitable species of mangrove.

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Estuarine Aquaculture Systems

The estuary is the interface between the freshwater and marine ecosystems. As such it has the following characteristics:

- Highly variable salinity with the range depending on the volume of freshwater inflow
- Relatively more turbid than the open sea
- Generally nutrient rich with high primary productivity
- Generally high flushing rate
- Often a rich fishing ground

The estuary may be a whole bay or the immediate vicinity of the mouth of a river or a creek both upstream and downstream. Indeed there can never be a sharp delineation of the boundaries of an estuary. Its extent and the variability of its physical, chemical and biological characteristics depend on the tidal conditions and the weather. Thus the salinity of an estuary varies in time as well as with depth and distance. Salinity increases with depth and distance from the freshwater source.

Selection of species suitable for culture in estuarine environments

Even if purely marine or purely freshwater species are found within an estuarine area, not all species of fish and other aquatic organisms will be suitable for culture in an estuary due to its dynamic nature. Ordinarily, a swimming species will just move away from conditions not favorable to its survival. Since aquaculture entails confining the organism to a definite location, only species with the following characteristics can be considered for culture in an estuary:

- tolerant of fluctuations in salinity; and
- not sensitive to occasional high turbidity.

The continuous presence of a species in an estuary regardless of tidal conditions can be considered the best indicator of its suitability.

In addition to the biological requirements of a species, there are logistical and economic factors that have to be considered as well. These are:

- a good market and ready access to that market;
- locally available feed at low or no cost; and
- available seedstock (fry, fingerlings, spats, etc)

Suggested species for culture

The following species are either known to have been grown or, from their distribution and occurrence, should be suitable for culture in estuaries:

Agarophyte seaweeds *(Gracilaria* spp.)

- Viability depend on availability of market
- May be grown by planting cuttings on shallow bottoms or tied to lines or nets attached to fixed posts or afloat
- Sold fresh for direct human consumption and in dry form for processing into agar

Oysters *(Crassostrea* spp., *Saccostrea* spp.)

- Require plankton-rich water
- Can tolerate lower ranges of salinity and higher turbidity
- Maybe raised in shallow or even intertidal areas
- Should ideally be raised in clean, uncontaminated waters

Mussels (*Perna viridis*)

- Require plankton rich water
- Cannot tolerate prolonged exposure to low salinity ranges
- Best grown in deeper waters
- Best grown in clean, uncontaminated waters

Cockles (*Anadara* spp.*)*

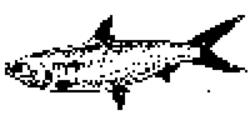
- Require plankton rich waters
- Require wide expanse of flat, shallow and soft subtidal beds
- Preferably grown in areas with low population density and far from industries

Penaeid shrimps (*Penaeus* spp.)

- Of many possible species, jumbo or black tiger shrimp, *Penaeus monodon*, grows fastest and attains largest size
- Black tiger shrimp tolerant of wide ranges of salinity but grows best in brackishwater
- Maybe grown in pens
- Require fish or molluscan biomass or formulated feed.

Mud crabs (*Scylla* spp.)

- Tolerant of wide range of salinity
- Can be raised in bamboo pens or cages
- Use of cage usually for short-term fattening
- Require animal protein diet (fish, mollusk, poultry waste)
- Not yet bred in hatcheries so seedstock may be a problem.



Milkfish (*Chanos chanos*)

- Tolerant of wide salinity range from freshwater to above seawater salinity
- Demand limited to few countries (Philippines, Indonesia)
- May be grown in cages or in pens
- May be fed rice bran but grows better with formulated feed
- Fry available seasonally but may also be produced in hatcheries

Mullet (*Mugil* spp.)

- Tolerant of wide salinity range
- Demand maybe regional
- May be grown in cages or in pens
- May be fed rice bran but grows better with formulated feed
- Fry available seasonally but may also be produced in hatcheries

Tilapia (*Oreochromis* spp.)

- Nile tilapia can tolerate salinities up to 15 ppt but higher salinity will require saline tolerant breeds such as *O. niloticus* + *O. mossambicus* hybrids
- May be raised in pens or cages
- May subsist on algae but high density in cage or pen requires feeding with formulated feed

Seabass (*Lates calcarifer*) and Mangrove snapper (*Lutjanus argentimaculatus*)

- Tolerant of wide range of salinity but grow better in lower salinity
- Best raised in cages
- Require fish biomass
- Fry/fingerlings may be collected from natural waters, but may also be available from hatcheries.

Groupers

- Cannot tolerate low salinity levels, grow best in 25 ppt or higher
- Command high price when sold live so accessibility to market very important
- Best grown in cages
- Require fish biomass as feed
- Propagation in hatcheries not yet widespread and natural so fingerlings supply can be a problem.

Rabbitfish

- May not tolerate salinity below 15 ppt
- May be grown in pens or cages
- Can be fed vegetable wastes and/or seaweeds
- Wild fingerlings occur in abundance seasonally but may also be produced in hatcheries

Pen versus cage

The main difference between a pen and a cage are as follow:

- **Pen** – a net and/or bamboo enclosure utilizing the natural seabed as the bottom barrier
- **Cage** – an enclosure that may be installed off-bottom (either on fixed frame or afloat) that has net material as bottom barrier

Generally, a pen would have a more adverse impact on the estuarine environment for the following reasons:

- It tends to require larger areas.
- It can only be installed in shallow areas making it more likely to obstruct access to the water body.
- It cannot be moved.
- It extends from the surface of the water all the way to the bottom impeding the flow of water more than cages, thus, has greater tendency to increase siltation rate.

Considerations in estuarine aquaculture

- Access by other users to common resources should not be limited.
- Navigation and right of way of boats should not be blocked.
- Flow of water should not be substantially affected so as not to increase siltation rate.
- Feeding should not compete with local requirements for human nutrition.
- Culture structure should not be crowded and the natural carrying capacity of the estuary should not be exceeded.
- Installation should not result in the destruction of mangrove and wetland areas.
- Materials for contruction should not be taken from endangered plant species nor treated with chemical preservatives.

Minimizing adverse impacts

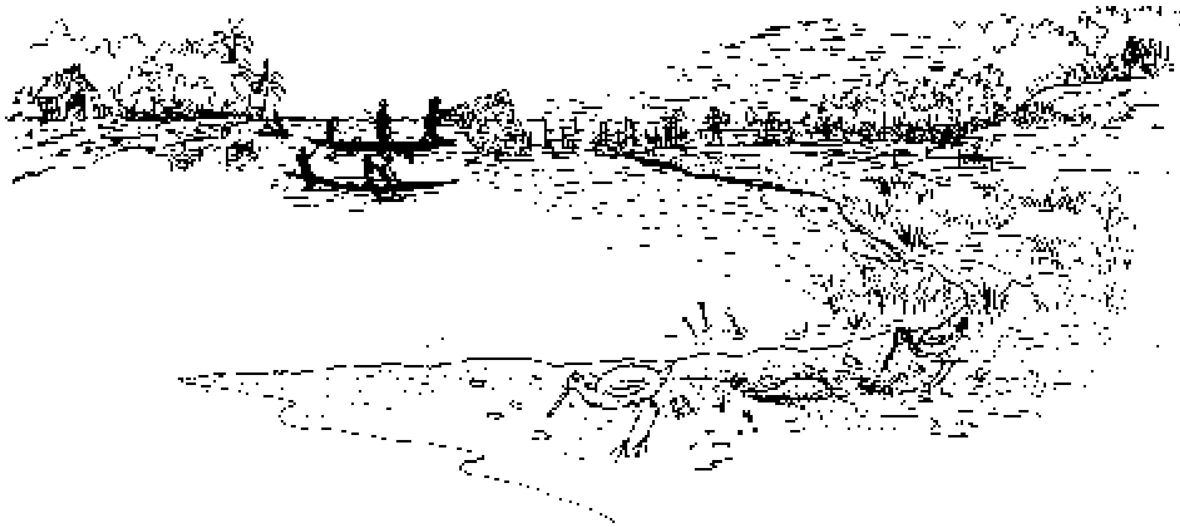
- Organize coastal communities so all stakeholders can participate in development planning and resource management.
- Work for adequate legal framework and compliance with existing laws.
- Give priority rights to local community over the use of estuary.
- Zone the estuary to provide access to all users, setting aside open areas for fishing and areas for pens, cages and other culture systems.
- Identify and use as feed species considered as pests or not usually used as human food such as golden apple snail and undersized tilapia from fishponds and shrimp ponds.

Prospects for livelihood

When a sound estuary development and management system is in place, the potential of estuaries in providing aquaculture-based livelihoods to the coastal poor is high. Aquaculture in an estuary has to be planned as an integral part of an estuary-wide, community-based, coastal resource management program.

Prepared by:
Fred Yap

Utilizing Coastal Wetlands for Small-Scale Aquaculture in Sri Lanka



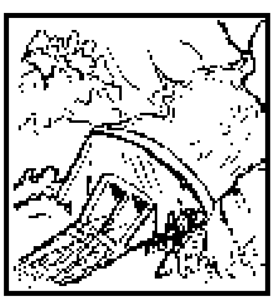
Wetlands are defined as areas of marsh, fen, peat land or water whether natural or temporary, with water that is static, flowing, fresh, brackish or salt. These include areas of marine waters, not exceeding six meters indepth during low tides.

According to the Ramsar convention, many parts of Sri Lanka qualify as wetland. More than 20 different types of wetland ecosystems can be identified in the country. Surface waters of Sri Lanka are divided into three main groups: freshwater, salt water and human-made.

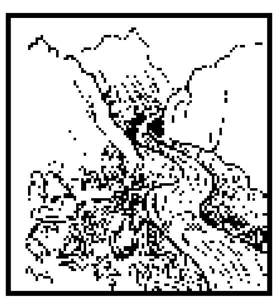
> **Ramsar is an Asian Wetland Inventory project carried out in the 1980's. Its objective was to identify wetlands of international importance in every country in Asia.**

The three types of wetlands have been further subdivided into ten general wetland types: reservoir, streams and rivers, fresh water marshes, deltas and estuaries, lagoons, marine wetlands, tanks and reservoirs, agricultural wetlands, salt pans and aquaculture ponds.

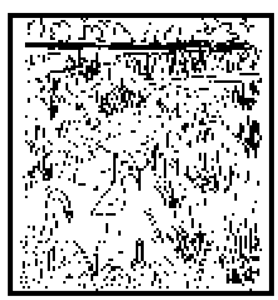
Fresh-water



Reservoir

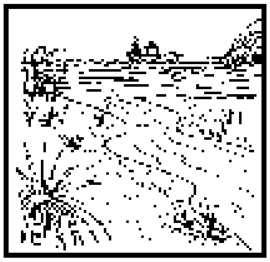


Streams/river

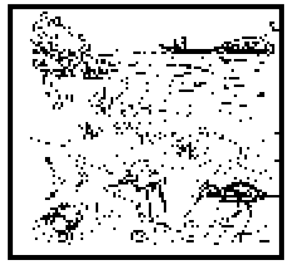


F/W marshes

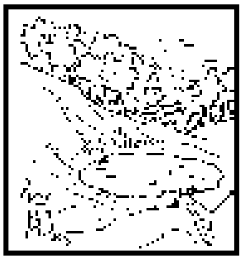
Salt-water

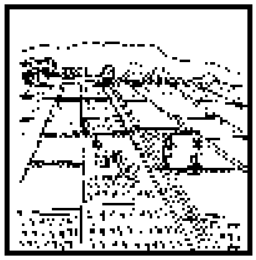

Deltas and estuaries

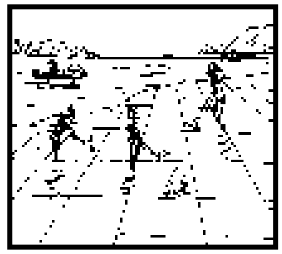

Lagoon

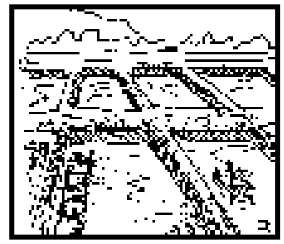

Marine marshes

Human-made


Lake


Agricultural

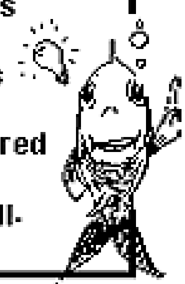

Saltpans


Aquaculture ponds

Small-scale coastal aquaculture development in wetlands

Coastal aquaculture development has become an important activity in the country's economy. In 1998, Sri Lanka earned 6732 million Rupees (US$1=Rs 78) from exports of fish and fishery products.

Deltas and estuaries, lagoons, marine wetlands and saltpans are considered suitable for small-scale



Sri Lanka has a coastline of 1585 km encompassing lagoons, estuaries, bays and fringing reefs. Lagoons and sheltered bays are common along the coast and are potential sites for aquaculture development of a variety of species. In addition, mangroves play an important role in coastal aquaculture by providing natural breeding grounds and shelter for aquatic organisms.

Most of coastal habitats suitable for small-scale aquaculture lie on the eastern and northern coasts. The western and southern coasts have little potential for aquaculture. Shrimp farmers dominate the northwestern coast. At present, only shrimp culture has been commercialized in Sri Lanka. The variety of species, which at present have the potential to be cultured, is remarkably wide. Most of the species are suitable for small-scale farming. The potential for aquaculture depends on the choice of fish species and culture system. Various criteria are used to assess

Types of coastal habitats

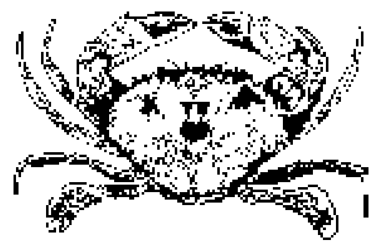
- Mangroves
- Salt marshes
- Dunes
- Beaches, barrier beaches, spits
- Lagoons, basin estuaries
- Marshes
- Other water bodies

if a species is suitable for culture.

Matrix of species

The species included in the matrix have been selected from a technical standpoint only. Although it may be technically possible to grow species in the coastal zone of Sri Lanka, the special conditions needed to develop commercial aquaculture may not be present. Following are species included in the matrix:

Mud crab

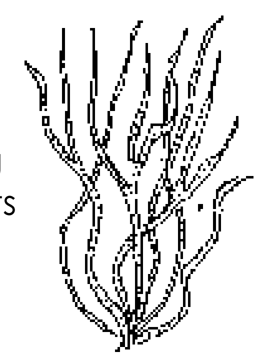


Two species of mud crab are found in Sri Lanka waters, *Scylla serrata* and *S. oceanica*. Mud crab fattening is increasingly popular among the resource poor coastal fisher folks. A recent practice is to hold molted water crabs for two to three weeks, feeding them with fish offal. Mud crab culture in ponds is likewise, done on a limited scale. The normal culture period is six to eight months. This is well suited for small-scale operations and can be done in a way that minimizes environmental impact.

Oyster

Field trials by National Aquatic Research Development Agency (NARA) demonstrated the feasibility of culturing systems. The most promising sites are to be found in the extensive lagoons and embayment of the east and northeast coast of the country. NARA scientists have developed appropriate methods for farming *Crassostrea madrasensis* in Sri Lanka. Weak local market demand is the major constraint in the development of oyster culture in Sri Lanka. Tourism offers opportunities provided the product could be certified as sanitary.

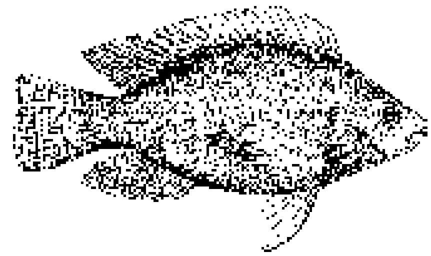
Seaweed



The genus *Gracilaria* is found in sea grass beds in the lagoons and bays around the coast of the country. The work carried out by NARA on *Gracilaria* culture indicated that there was a significant potential for its development in aquaculture. Seaweeds can be used in making jelly and to extract agar, which has both domestic and export markets depending on quality.

Hybrid tilapia

Hybrids of *Oreochromis spp* exhibit rapid growth and have high feed conversion ratios. Brackish ground water is common along the coastline of Sri Lanka and could be used to culture hybrid tilapia in small ponds. While this fish can tolerate a wide range of salinity, there should be no abrupt changes. Tilapia is also cultured in abandoned shrimp farms.



Sea cucumber

Sea cucumber, also known as *trepang* or *beche de mer,* is highly priced in East Asian markets. Its habitat requirements under culture conditions are not well known. However, the species are found in muddy sand sea floors. The most valuable species are: *Holothuria scabra*, *H. nobilis* and *H. fuscogilva.*

Brine shrimp

Brine shrimp or *Artemia* is widely used in the ornamental fish industry. It is vital to the shrimp and prawn hatchery business. Field trials done by NARA demonstrated the feasibility of both biomass and cyst production in the south and northwest coasts of Sri Lanka. Some commercialization has developed to supply local markets in the ornamental fish and hatchery sectors.

Freshwater prawn

Freshwater prawn or *Macrobrachium rosenbergii* is used in mono and polyculture fishponds. Culture of freshwater prawn in small-scale is a profitable venture.

Marine finfish

At present, marine finfish culture is limited to seabass, groupers and milkfish. Seabass and grouper are reared in cage systems. Both milkfish and seabass cultures are done in abandoned shrimp farms using seed collected from the wild. A government supported hatchery and demonstration farm could provide the necessary inputs to start an industry. Due to declining coastal fisheries and overexploited lagoon resources, there is an increasing interest in fish culture to enhance fish production, combined with aquaculture technology and community management of local fishery resources.

Need for zoning coastal aquaculture

Haphazard development of aquaculture inevitably leads to environmental overload and conflict among user groups and serious economic losses to the industry. The uncontrolled expansion of shrimp farming in Sri Lanka is just one of many examples of the consequences of inappropriate setting, overcrowding and destruction of mangroves.

Geographical Information Systems (GIS) technology gives the planner and developer the capacity to evaluate the interaction of a wide range of environmental and social factors that affect the potential of a region for aquaculture development. The complexity of environmental and other influences is integrated through a ranking and scoring system using maps or 'layers'.

Based on the result of GIS-based zoning, aquaculture development can be targeted at suitable areas through a permit process effected by, among others, committees at the national and provincial levels. The developer and financial institution can evaluate the feasibility of projects more readily.

The zoning matrix

Shrimp culture alone has been developed as a commercially viable technology in Sri Lanka. However, a number of other species have shown promise. Some of these have been subject to experimental farming while others have been successfully farmed in various tropical countries. Many are well suited for small-scale production and could have a positive impact on the economics of small fisher folk communities. Various criteria have been identified according to their impact on the technical feasibility of culture of the species included in the zone-matrix. Criteria are ranked according to their relative importance for each species. They are further refined by parameters which indicate the range over which a particular criterion affects the culture system.

Matrix criteria

Certain criteria that affect or control aquaculture systems development were identified and ranked. Ranking was done on a 4-point scale, represented on layers by a monochrome shading scale. The ranking scale was set up as follows.

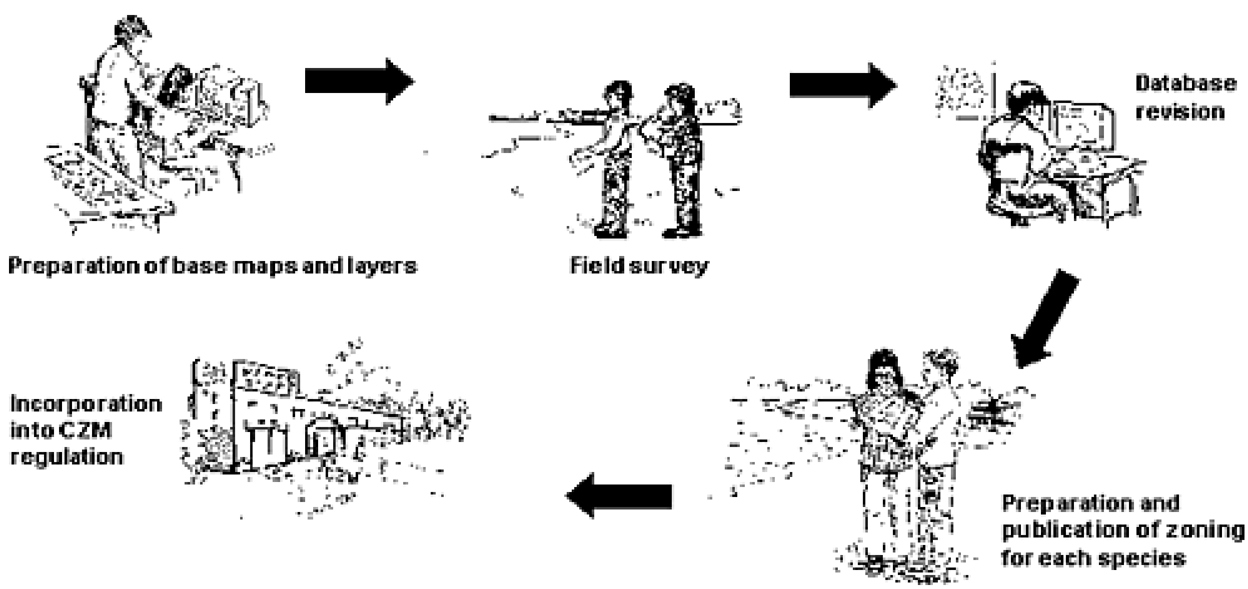
Criteria	Point
Not suitable for development	0

Not optimal, affects the culture system negatively	1
Neutral, or favors the development of the culture system	2
Positive and successful development likely	3

- Parameters are ranked using the same scale applied to criteria.
- The rank score for a criterion is the product of the criterion rank by the parameter rank.
- In situations where data are insufficient to rank parameters, an approximation of the score for a criterion may be used. In this case, the score is more intuitive than objective, as it would be based on general experience.
- The score for a species within the area in question can be indicated by the sum of its criteria scores. Assigning a value of reallign to a parameter is intended to remove sensitive sites from consideration.
- Subtracting their areas from the base map can do this. This will protect critical wetland habitats and direct development away from them and other unsuitable areas.

Physical, chemical and social parameters affect aquaculture development, but obviously not all parameters are applicable to every system considered. If a criterion or parameter does not apply to the species in question, its cell is left blank in the matrix.

Zoning for coastal



Steps for zoning coastal aquaculture

Preparation of base maps and layers

- Find, collect and collate maps, reports, studies and surveys from published or unpublished literature. Digitized maps of the coastline including lagoons, bays and harbors serve as base map. Large areas of coastline fall within certain depths of some parameters like elevation.
- Construct a series of digitized layer maps of criteria relevant to each species or species group. Plots are developed from data shown on a 1:50,000 scale maps or from specialized maps of soil.
- After layers of criteria have been completed, the parameter can be ranked through the color coding scheme.

Field surveys

- The survey plan is developed prior to the field survey. Sampling is based on transects perpendicular to the shoreline.
- The coordinates of the sampling station are listed for Global Positioning System (GPS) referencing in the field.

GIS data base revision

- Data acquired in the field can be incorporated into corresponding layers in the GIS data base. Furthermore, data collected in on-going surveys in the context of other projects can be used to continuously update the GID data base.

Publication and dissemination

- A special publication could be produced in explaining the methodology used to establish coastal aquaculture zones. This can be done by presenting maps indicating appropriate zones for different species.

Incorporation into CZM regulations

- Zoning will only be effective if it is incorporated into CZM regulations.
- When the eastern and northern coasts become accessible for development, there may be a "shrimp gold rush" to the area. When this occurs, it will be imperative to control development

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Successful Small-Scale Mudcrab Farming Development in the Thai Binh Province, Vietnam: A Case Study

Mangrove or edible mud crabs (genus *Scylla*) are commonly found within the Indo-West Pacific region, where they inhabit tropical and sub-tropical mangrove areas. They have a high economic value due to their large adult size and high meat content. They, particularly the gravid female (also known as "egg crab") which are valuable in many countries, are fished principally for the export market.

Mud crab farming has traditionally been a small-scale activity throughout Southeast Asia, most likely originating from fishermen retaining small numbers of undersized crabs in order to increase their market value. In Vietnam, mud crab culture became established since about ten years ago.

Thai Binh Province is one of the coastal provinces on the fringe of the southern part of the Red River Delta (20o30'N; 106o34'E). Its coastline is composed of lower mud flats, mangroves, upper mud flats and small sand islands located within the river mouths.

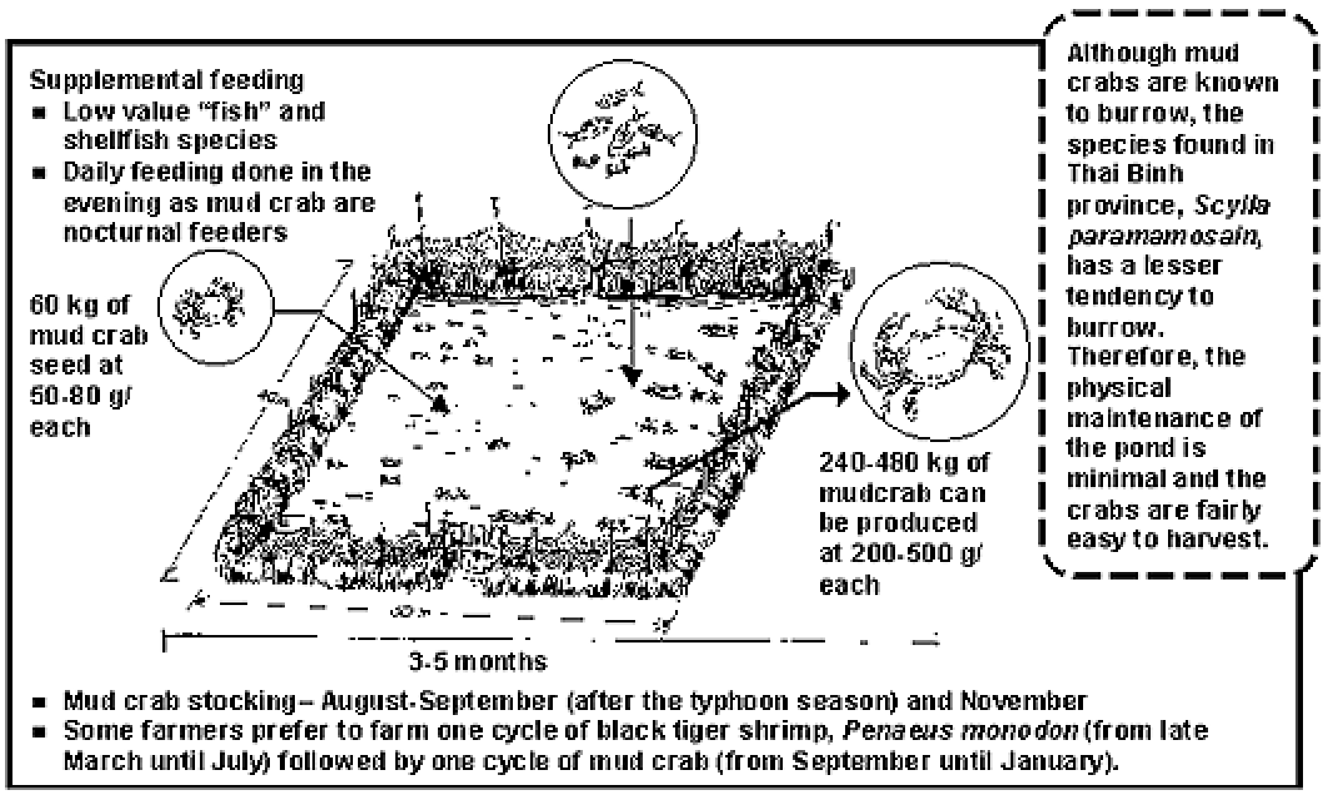
At present, 70% of families in Thuy Hai commune (mainly former soldiers and fishermen) farm mud crabs in coastal ponds in Thai Binh Province, Vietnam. Even as a spare time activity, crab farming helps boost income significantly.

Crab farms and production cycle

Mud crabs are farmed in earthen ponds. These ponds can vary in size from as small as 1,200 m2 , where the ponds are artificially stocked, to 50 hectare ponds for extensive culture where the crabs are introduced from the inflow water with some additional small crabs purchased from fishermen. These extensive ponds also trap and hold other aquatic products including wild shrimp, fish and are often 'planted' with seaweed.

Majority of aquaculture ponds are situated in front of the main sea dike but behind a recently planted area of mangrove trees (the trees are five to six years old) that act as a buffer zone against typhoons. The water quality is guaranteed to be much better in front of the sea dyke particularly since a large number of the farms rely on tidal water exchange. Over the last four years, coastal aquaculture has become more developed and formerly large extensive ponds have been subdivided into smaller, semi-intensive operations.

All ponds have a simple sluice gate for water exchange and are surrounded by some form of fencing to prevent the crabs from escaping.



Reasons for successful development of mud crab farming in Thai Binh Province

The success of mud crab farming development in the area are due to several reasons.

Site suitability

The coastal mud flats within Thai Binh Province are accreting rapidly. Every five years, about 250 to 300 ha of "new coastal land" are formed. This new land is suitable for pond construction and has good access to coastal water supply.

Water supply

The freshwater input from the Red River results in brackish water conditions ideal for coastal aquaculture. Moreover, the level of local water pollution is low due to lack of urbanization and agriculture in the immediate area.

Accessibility

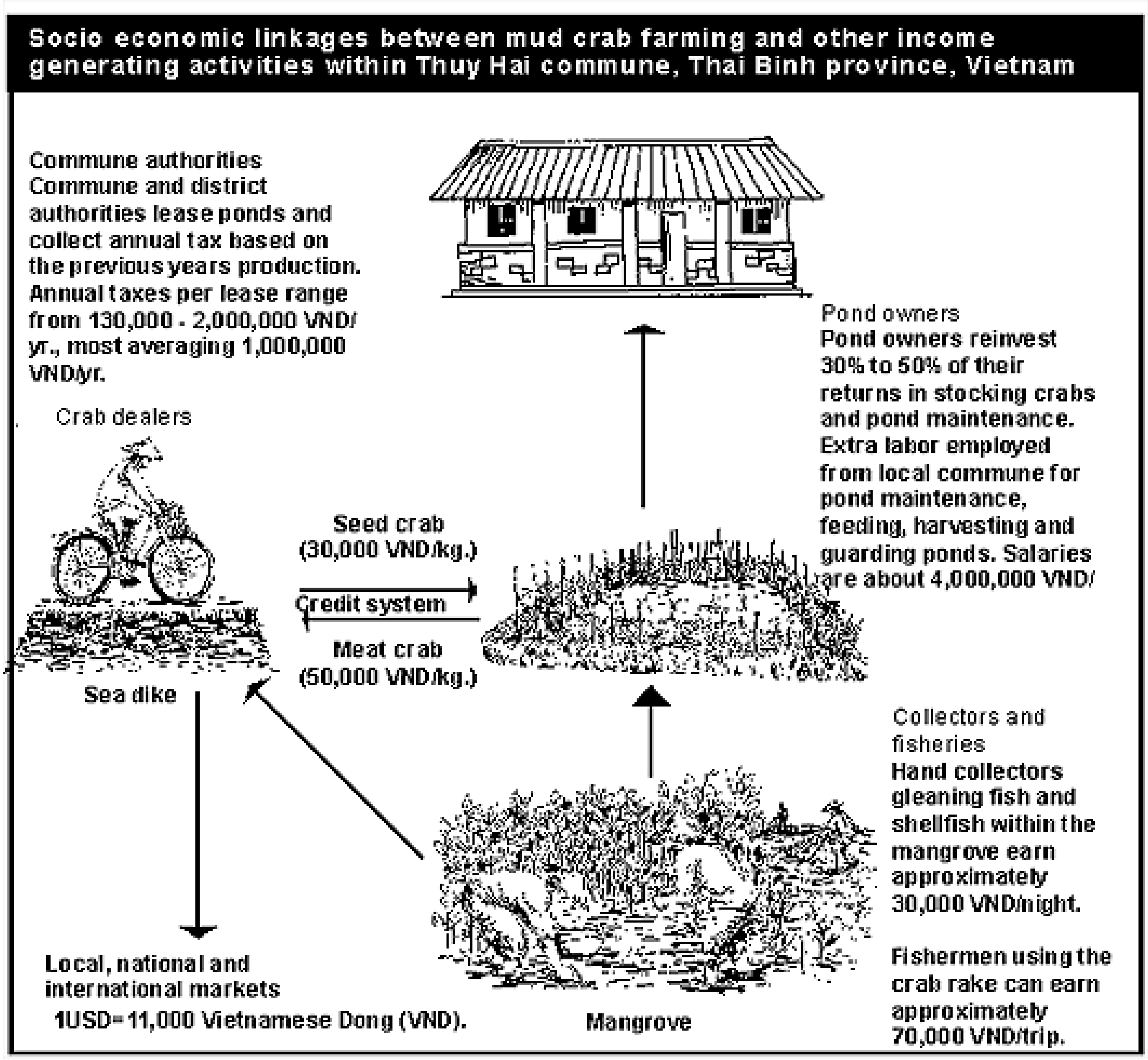
Sea dikes not only protect local villages against storm damage, but also provide the main road system between neighbouring communities. Seed, feed and harvested aquatic products are transported without difficulty. The sea dike also serves as focal trading point where traders, farmers and fishermen can trade mud crab.

Seed and feed supply

The mangrove protection belt provides the habitat for juvenile mud crab as well as other aquatic species. This has resulted in an increase in juvenile mud crab caught in stock ponds providing plentiful seed supply to support mud crab farming. Moreover, food sources for aquaculture such as low value fish species, small mangrove crab species and mollusks, are abundant in the mangrove buffer zone.

Socio-economic factors

Strong community–based structure, along with the entrepreneurial spirit and hard-working attitude of the local people, has created the opportunity for many coastal communities to benefit from crab farming. The direct beneficiaries from aquaculture tend to be to the more wealthy and enterprising sectors of the community who can afford to invest in mud crab culture. However, the poorer fishers can also benefit from collecting crab seed and food materials to sell to the crab farmer and by providing labor for many aspects of pond operation: building and repairing of ponds, harvesting, guarding against poachers etc. Hand collecting of juvenile mud crab from the mangrove is carried out mainly by women and sometimes children. Both men and women, young and old, are involved in buying and selling crab, either as primary or secondary dealers. These additional activities spread the economic benefit of crab production widely within the community.



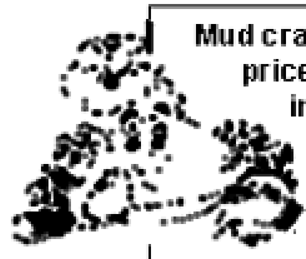
Technical knowledge base

The combination of the knowledge gained about tidal water management from salt making and the fishers' understanding of local aquatic resources means that the progression to aquaculture was a fairly easy one. In addition, local government initiatives to promote aquaculture through technical workshops organized at the district and commune level have resulted in the training of local people in various forms of coastal aquaculture, in particular shrimp and crab farming.

Adaptability of mud crab farming to other regions

Mud crab farming could be replicated successfully in other regions for the following reasons.

- Mud crabs are suitable for local market conditions (easy to move, store and trade) and the export market potential is excellent. It represents another high value crustacean product on the market and prices come close to those of farmed shrimp.
- Earthen ponds can be used to culture either mud crabs or shrimp depending on the economic climate, requiring little cost in modifying the culture system.
- Mud crabs are hardy animals. They can withstand salinity fluctuations and low oxygen levels within ponds. As long as they are kept in cool and moist conditions, survival out of water for two to three days is probable. Transporting individually tied mud crabs from the pond site to markets is easy and simple.



Mud crab fetches a high price in all major cities in Southeast Asia and the Pacific rim. Recent interest from the United States means that their potential market is global.

In Thai Binh Province, some farmers prefer to culture both shrimp and crab in order to spread their investment and reduce the associated risks of losing all the harvest, for example, through shrimp disease.

Potential constraints associated with mud crab farming

Some limitations may affect the replication of crab farming to other areas.

- Different mud crab species may have slightly different biological requirements that may affect the way they are cultured.
- Currently, mud crab culture is still in its infancy and mud crab farming still relies on seed supply caught in the wild. For the small-scale farmer, locally caught seed supply is vital for sustainability of crab farming, although they only require a few crabs to sustain their small-scale activities. A sudden and uncontrolled increase in mud crab farming for other practices such as soft shell crab farming could have a devastating effect on wild mud crab stocks through over exploitation. Moreover, the overfishing of juveniles may eventually affect the number of adult crabs available for other fisherfolk.

- The high value of mud crabs means that they are farmed primarily as a cash crop rather than as a protein source. The increasing commercial interest in mud crab farming may result in a rapid expansion of the sector. This expansion could cause problems, like competition over land, pollution and disease due to over development and/or lack of coastal planning, as has been observed widely in the shrimp industry.
- The low-cost fish used to feed crab might be better used to provide food for the poorer sectors of the community. Other potential protein sources need to

be investigated.

Further reading

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Prepared by:
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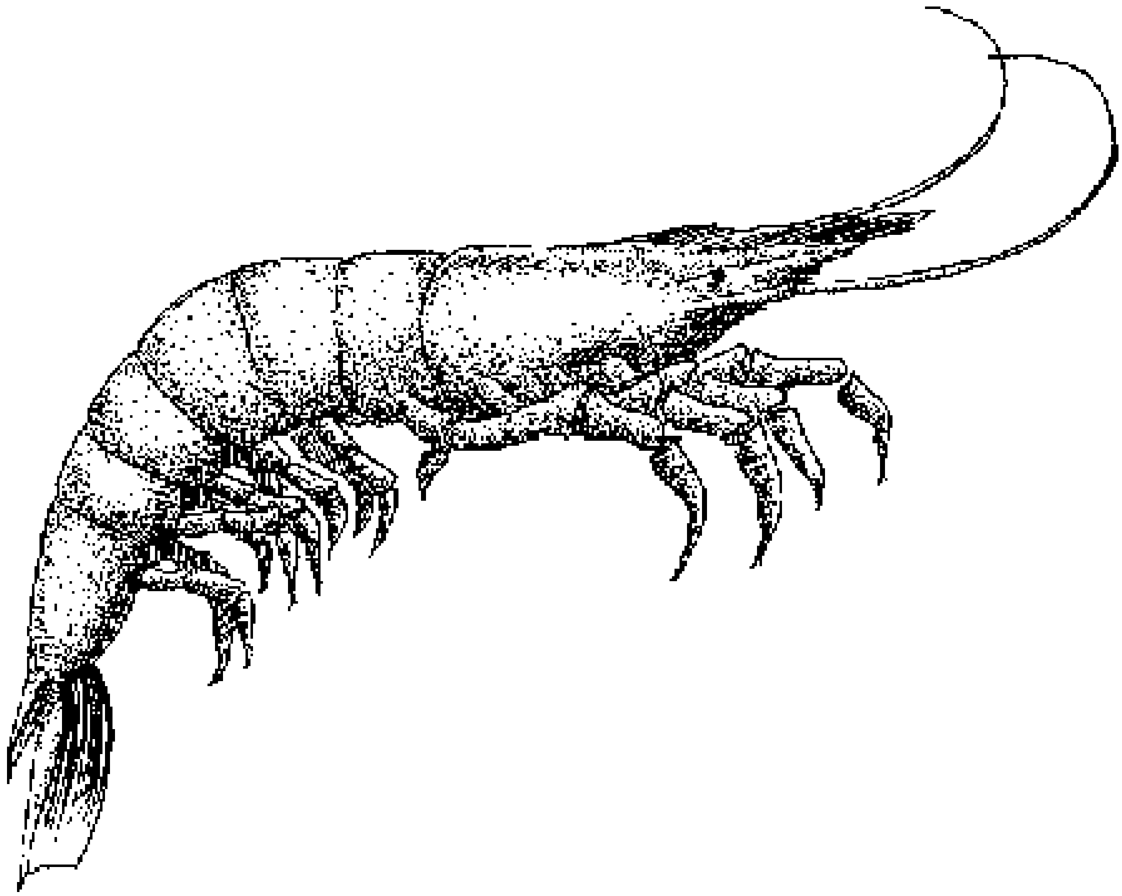
Management Practices to Improve Extensive Shrimp Aquaculture



Low yields due to low survival rates and frequent disease conditions are main problems encountered in extensive shrimp culture. A greater part of production losses occurs soon after stocking of post-larvae because of unsuitable conditions in the pond. The following management practices are recommended to reduce post-stock losses and increase production, particularly for black tiger prawn. These recommendations are based on the results of the project "Disease prevention and health management of coastal shrimp culture in Bangladesh".

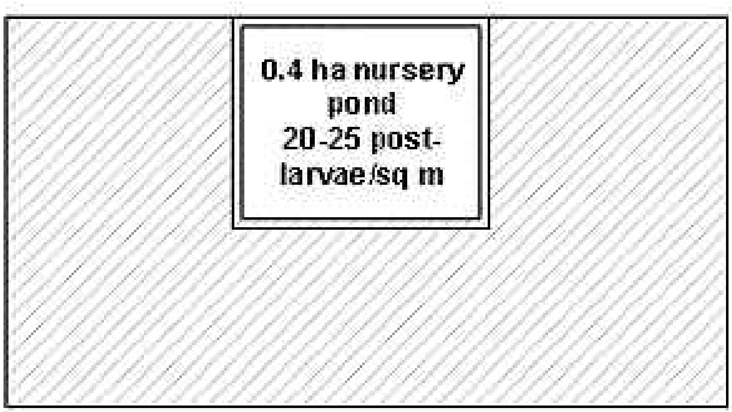
Select the correct season for stocking shrimp fry

Shrimp post-larvae are sensitive to climatic changes. Low yields and disease have been experienced when shrimp post-larvae are stocked during rainy or cold months.

During cold months, temperature fluctuation in a day usually exceeds 2°C. Temperature less than 20°C causes harm to shrimp post-larvae. Other reasons for avoiding the rainy season are:

- Sudden salinity decline in water is very stressful to shrimp post-larvae.

- Low salinity affects the molting process resulting in slow growth.
- Heavy loading of silt and suspended solids increases sediment accumulation (leading to depletion of oxygen in the water).



Establish a nursery pond

A nursery pond will provide a predator- and competitor-free environment to enhance the survival of post-larvae. Supplementary feeding of shrimp fry in the nursery will be more effective than feeding the post-larvae in the main pond.

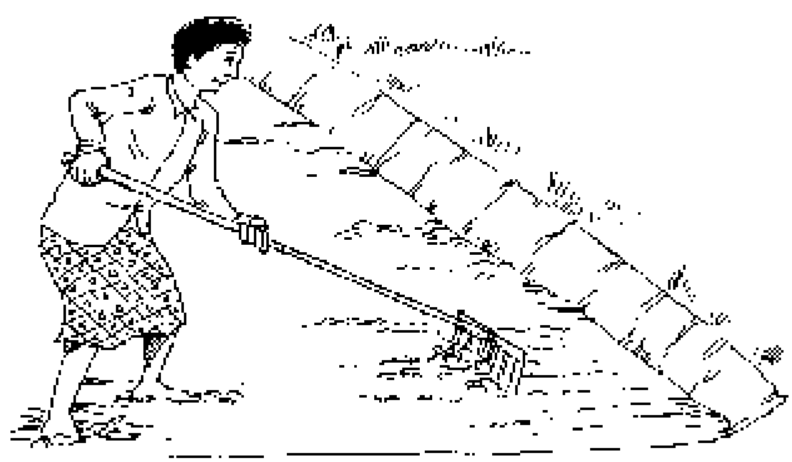
In establishing the pond, remember the following.

- A 0.4-ha nursery compartment pond should be set aside within a 6-ha pond.
- Larger ponds should have two or more nursery compartments rather than one big nursery compartment.
- Do not stock more than 20 to 25 post-larvae per square meter.

Nursery preparation before stocking

1. Dry the pond bottom thoroughly to reduce organic waste load and remove predators and competitors that entered the pond during the previous culture. Take note of the following:

- After drying the pond, scrape the surface of the pond bottom to remove the waste. When scraping, avoid exposing the subsoil, which may contain acid sulphate layers.
- Avoid waste accumulation on pond dikes. Remove and dispose of accumulated waste away from the pond so that the rain will not wash it back into the pond.



- Dry and wash the pond bottom again after scraping and plowing.

2. Apply lime to the pond to correct the soil pH and neutralize the acidic layer in the pond bottom and dike surface. Liming will also disinfect the pond. Spread lime all over the pond bottom, applying more on areas that remain wet. Also spread along dike walls up to the top of the dike.

Agricultural lime or dolomite is better than hydrated or quick lime because of its buffering action that can regulate the pond pH. Always remember to use the right amount of lime.

Types of lime

- **Agricultural lime/limestone or crushed shell (calcium carbonate or $CaCO_3$); use lime with more than 75% calcium carbonate as it does not cause a dramatic increase in pH.**
- **Hydrated lime [calcium hydroxide - $Ca(OH)_2$] can cause a dramatic increase in pH. Do not apply this type of lime in the afternoons when pH would normally be at its highest.**
- **Quick lime/burned lime or burned shell lime (calcium oxide – CaO) causes dramatic increase in pH and should not be used in ponds with shrimps. Use this to control very low soil pH during pond preparation.**
- **Dolomite [calcium carbonate – $CaMg(CO_3)_2$] can increase pH gradually.**

Use the correct amount of lime

The correct amount of lime depends on the type of lime to be used and soil pH. Use the following table to select the type and quantity of lime.

Soil pH	Quantity of dolomite or agricultural lime (mt/ha)*	Quantity of calcium oxide (mt/ha)*
6.0 – 7.0	1.0-2.0	0.5-1.0
5.0 – 6.0	2.0-3.0	1.0-1.5
less than 5.0	3.0-5.0	1.5-2.5

** 1 mt (metric ton) = 1,000 kg*

3. After liming the pond bottom, fill the pond with 30 cm of water and add fertilizer. It is necessary to fertilize the pond water to grow natural food (plankton) in the water. Some common fertilizers used are:

– inorganic fertilizer: urea and trisuper phosphate (TSP)
– organic fertilizer: cowdung

The usual fertilization amounts are as follow.

– First application: 1 kg of urea and 1 kg of TSP or 6-10 kg of cowdung per ha.
– Before the second application, leave the pond for 3-4 days until the pond water turns green- brown in color.
– Completely fill the pond with water.
– Second application: 1 kg urea and 1 kg TSP per ha each day for 5–7 days or 6–10 kg cowdung per ha every 2–3 days for 12-15 days.
– Do not apply cowdung daily because it is slow acting; daily application might overfertilize the pond.
– Applying more fertilizers if the pond water does not turn green-brown. As a last resort, add some green water from a known pond.

4. Control the entry of predators and competitors. The practice of stocking shrimp post-larvae into ponds containing other species favors predation soon after stocking, thus, causing significant production losses. To avoid this, do the following.

– Screen the incoming water through a nylon net screen with 576 holes per square inch or 24 holes in a linear inch.
– Use two net screens: a straight net screen fixed into a frame and placed in the gate at the outer side of the pond and a filter bag net screen (2 - 3 m long) fixed into the gate at the inner side of the pond.

Provide supplemental food for post-larvae

Supplemental food helps increase the survival and growth of shrimp before being released into the main pond. Large and healthy shrimp can avoid predation and withstand unfavorable conditions in the main pond.

Use the best quality feed that can be afforded. Own preparation of supplemental food would be advantageous, especially if available commercial post-larval feeds are too costly.

Supplemental food

- Use chopped fish, rice bran and cooked rice or potato. Mix the ingredients, using the following percentages:

Ingredient	Percent by weight
Whole fresh fish	50-60
Rice bran	20

Cooked rice/potato	20-30

- Mash all the ingredients and rub through a sieve in small bits (2 mm in diameter). If shrimp fry are large enough, use larger pieces about 4 – 5 mm diameter.
- Sun dry the feed for six hours before using.
- Do not use shrimp, mussel, clam or cockle meat as it might transmit virus infections.

The following daily food amounts are recommended for a nursery stocked with 20-25 post-larvae/sq m:

Period (days)	Feed per day (kg)	Expected survival (%)
1–7	0.8-1.4	100-86
8–14	1.5-2.2	84-71
15–22	2.4-3.2	70-63
23–30	3.3-4.1	62-60

Feeding

- Feed four times a day, preferably between 7-8 a.m., 11 a.m. to 12.00 noon, 4-5 p.m. and 10-11 p.m.
- Feed 25% of the daily food ration on each occasion.
- Dampen the food before adding into the pond.
- Spread the food in an area not more than 2-4 m from the slope of the dike, as this is where healthy post-larvae usually stay.

Perform regular health checks on shrimps

There are two ways to perform health checks during culture:

1. observation from the dike; and
2. observation of sampled shrimp.

Observation from the dike

Observation of sampled shrimp

- Avoid doing the observation during hot afternoons as handling would stress the shrimp.
  - Make the observation fortnightly.
  - The following conditions would indicate that the shrimp is normal. If

anyone of them is not observed, then there might be a disease problem.

Characteristics of a normal and healthy shrimp

- Appendages are clean.
- No blackening of appendages.
- Tail is not swollen or eroded.
- The body color is greenish cream.
- The body is clean and shiny.
- The shell is not soft or does not crack easily.
- The gills are clean, shiny and has a cream color.
- Hepatopancreas has a yellowish green color, not shrunk or enlarged.

Prepared by:
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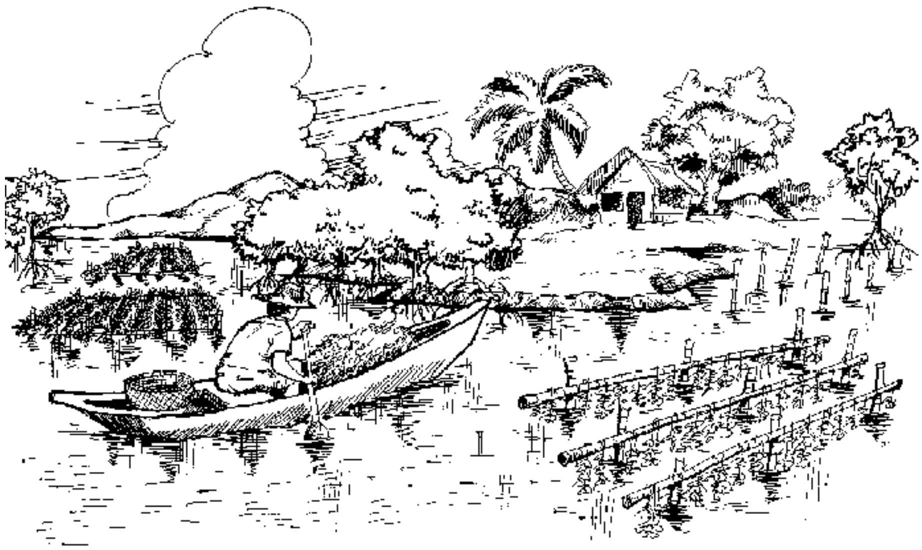
Farmers' Methods of Oyster and Mussel Culture in the Philippines



Oyster and mussel farming can be a source oflivelihood for coastal communities. Though it may not be the main source, it can contribute significantly to household income and food. Women and children can also participate. Oysters and mussels are delicious and very good sources of protein, carbohydrates, vitamins and minerals, and thus have good market value.

In the Philippines, the cultured species are the slipper-shaped oyster *(Crassostrea iredalei)* and the green mussel *(Perna viridis)*. Several culture methods for oyster and mussel farming have been reported but only a few deal with the farmers' methods. The culture methods described here are based on farmers' practice and are farmer-proven.

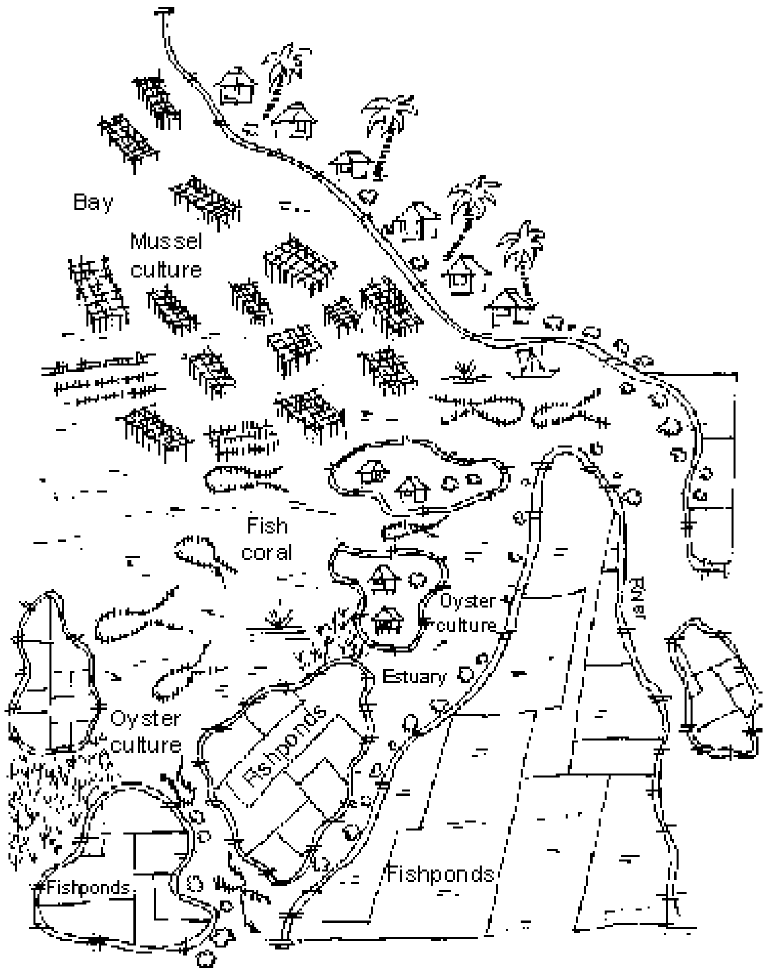
Most of the information presented is based on the study of oyster and mussel farming in Western Visayas, Philippines conducted by a SEAFDEC/AQD multidisciplinary team. The Western Visayas region is a major producer of oysters and mussels in the Philippines.

Perna viridis **is also cultured in other Asian countries. Other species of oysters are also cultured in the region.**

Site selection

Oysters and mussels grow in brackish and salt-water areas. Specifically, oysters grow well in estuaries where salinity is lower due to the mixing of fresh and seawater. Mussels grow better in bays where salinity is higher than in estuaries. Oyster farms are generally located in shallower areas than mussel farms.

Characteristics



Presence of a natural population of oysters or mussels. This makes seed collection and growing easier and inexpensive. In areas where there is no natural population, seeds may be collected from other places and transplanted for growing.

Good growth of wild or farmed oysters or mussels in the area. This indicates the abundance of natural food and the feasibility of farming oysters or mussels.

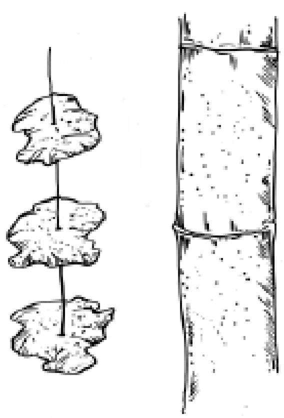
Proximity of farm site to residence for easy monitoring and guarding against poaching, a big problem among farmers.

Water current for the transport of food, waste and silt.

Availability of farm site (without obstructing navigation).

Protected from strong winds and waves to avoid damage to farm structures.

Free from domestic and industrial pollution.



Seed collection

Seeds are collected directly using substrate materials such as empty oyster shells, or the bamboo poles used in growing oysters or mussels.

By experience, farmers know the periods when seeds are abundant in the area. In Western Visayas, farmers reported using some indicators such as the presence of barnacles on the substrate materials as this would be followed by attachment of oyster or mussel seeds. The water also becomes itchy, yellowish with lots of bubbles.

These indicators are difficult to explain but they may be related to seasonal change. According to oyster farmers, the seeds are abundant when seawater mixes with freshwater in the estuary during full or new moon.

The presence of seeds is checked through ocular inspection of the substrate materials to see whether their surfaces have become rough with the presence of grain-size spots.

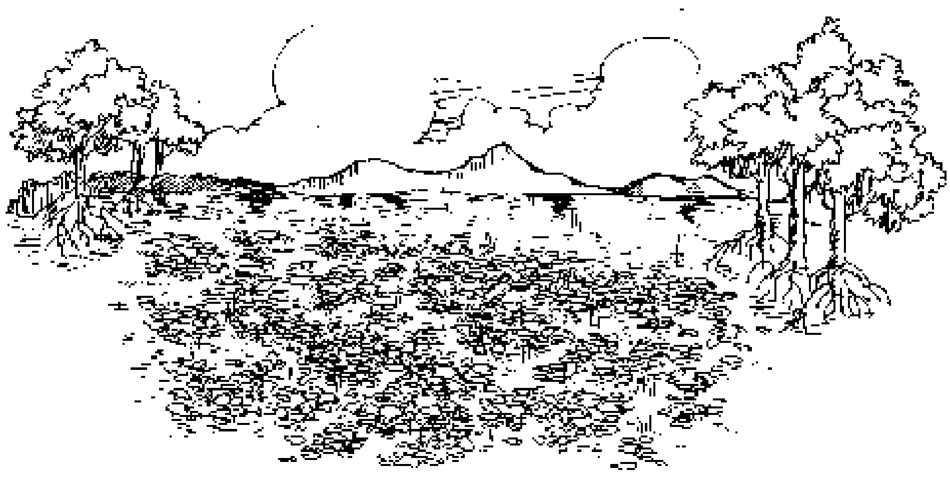
When culture is developed in a new area, a careful observation for a year or two will reveal the local seasonal pattern. Abundance of mussel seeds is pronounced during certain months of the year depending on the locality. Oyster seeds are generally available throughout the year.

Culture methods

Most oyster farmers learned the culture methods from other farmers in their neighborhood. They imitate the culture method that has been found productive and profitable by other farmers.

Oyster

The methods commonly used for oyster culture are bottom, stake and hanging either from a rack or raft-rack. The stake method is the most commonly used but the hanging method is the most productive followed by the stake then the bottom method. Bottom and stake methods are used in shallow (intertidal) areas, whereas the hanging method is used in deeper areas.



Bottom

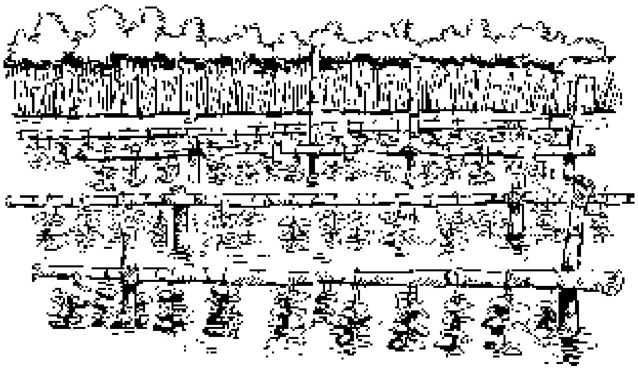
This is a natural way of growing oysters. This method is suitable for intertidal areas (exposed during low tide) or areas where structures obstructing boat navigation are not allowed.

In this method, empty oyster shells are scattered or broadcast to serve as substrate for oyster seed to attach to and grow on. This method may be the least costly but mortality due to siltation and predators is very high.

Stake

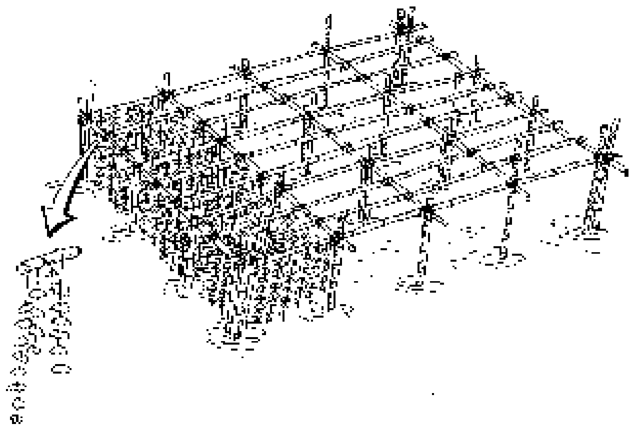
In stake method, farmers use one or a combination of different materials such as bamboo (*Bambusa* spp.), mangrove tree branches and nipa petioles.

Stakes are about 2 m long with 0.6 m embedded in the bottom. They are placed 0.7 m from each other and are usually arranged in rows 0.8 m apart.



Rack hanging

Racks are usually made of bamboo poles although some farmers use wood. Racks may be as high as 4 m and 1 m apart for easy boat navigation during monitoring and harvesting. Empty oyster shells are strung at a distance of about 20 cm from each other(1.4 m long) and hung from the rack. On a nylon string, empty shells are spaced at 14 cm from each other by knots. Some farmers use old tires (halved or whole) of motorcycle, bicycle, truck, or jeepneys as hangings.



Raft-rack hanging

Many oyster farmers do not adopt the raft method recommended in many literatures because it requires artificial floats and is, therefore, expensive. However, based on the survey, farmers use a less expensive raft made of bamboos only. Called the raft-rack method, this is a modification of the rack that floats during the early stage.

Procedure

1. Construct a raft using bamboo poles with spacing of 20 cm.

2. Stake the bamboo poles on the four corners to set the position of the raft-rack.

3. Hang the strings of empty oyster shells from the raft at about 20 cm apart. The string of empty oyster shells should be about 1 m long, depending on the water depth at low tide. More hangings may be placed on the raft but other hangings are transferred to additional rafts in the later part of the culture period.

4. Allow the raft to float and adjust it according to water level for the first two to three months. Thereafter, when the oysters are too heavy for the raft, tie the raft to the bamboo posts at 1-3 m above the bottom, depending on the water depth.

5. Stake additional bamboo poles to further support the heavy raft.

Tips

As oyster farms are usually located in estuaries (i.e., river mouth), the stake method is not recommended because the stakes impede water flow causing sedimentation. Instead, when possible and depending on the water depth, the hanging method -- either rack or raft-rack -- is recommended. Hangings are removed during harvest, allowing the water current to wash away the silt.

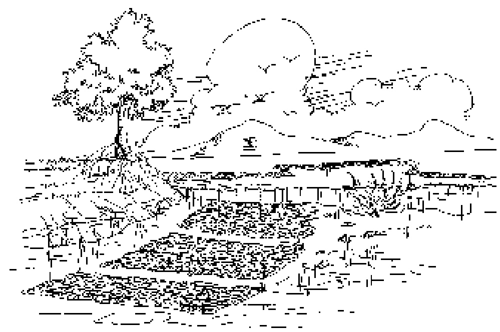
Reasons of farmers for adopting stake, rack hanging and raft-rack hanging methods of oyster culture			
Bottom	**Stake**	**Rack hanging**	**Raft-rack hanging**
■ Inexpensive ■ Good growth of oysters	■ Inexpensive and can make use of locally available materials ■ A traditional method in their area ■ Productive ■ Easy to manage (less risky even during flood) ■ Oysters not easily stolen ■ Less laborious	■ Less expensive than raft method ■ Productive ■ Ease in harvest even in high tide ■ Popular method in their area ■ Ease in seed collection ■ Good growth of oysters ■ No sedimentation in the farm site	■ Productive ■ Ease in harvesting ■ Relatively new method that is worth trying

Mussel

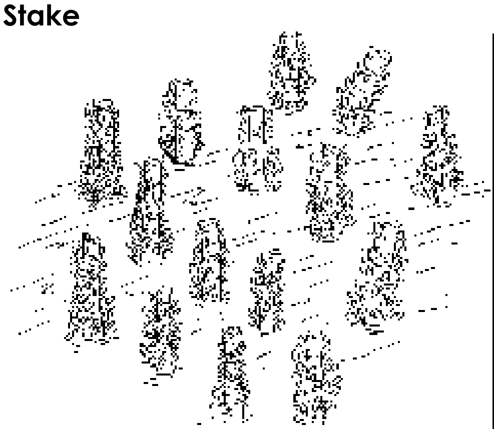
Mussels are cultured by bottom, stake or raft method. The stake and raft being off-bottom methods are used in relatively deep waters (2-4 m at low tide and 5-8 m at high tide), while the bottom method is used in shallower areas (0.60 m at low tide and 3.6 m at high tide).

Bottom

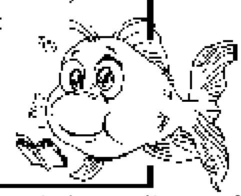
This method of growing green mussel is not reported in other literatures but it is used by farmers in a certain locality where the seed collection site is far from their residence. Since growing the mussels in the same area could result in poaching, mussel seeds are collected from the bay using bamboo poles. After one to two months, the mussels are removed from the bamboo poles and laid at the bottom of estuary near the farmers' residence.



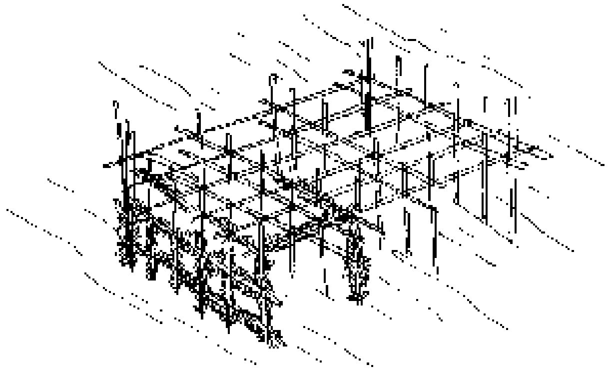
Stake



Mussel culture using the stake method results in higher production compared to the raft method. In the stake method, the productivity (natural food abundance) of the whole water column is maximized, while in the raft method, only near-surface productivity is utilized.

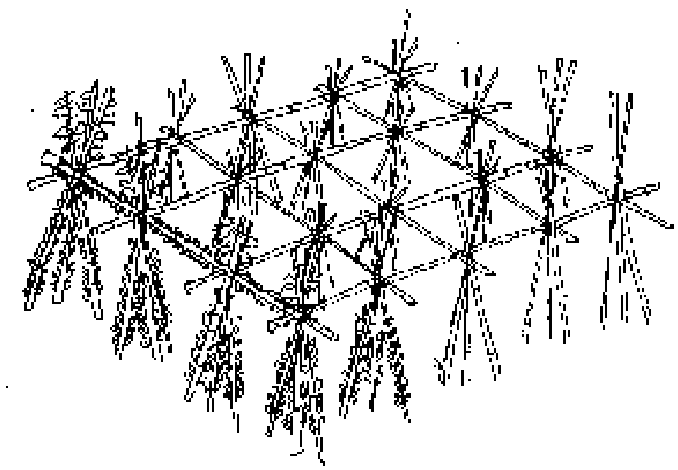


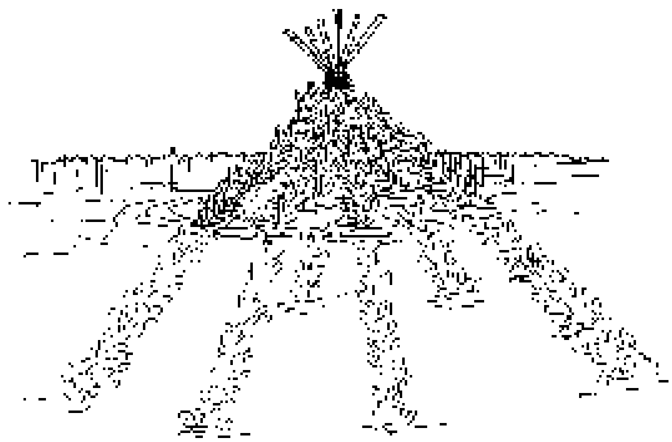
Bamboo is the most commonly used material in the stake culture of the green mussel. Some farmers use a combination of bamboos, coconut fronds and nipa petioles. Others attach old fish nets to their stakes.



The manner of staking differs according to water depth and strength of water current in the farm site. In areas where the water current is strong and the farming area is deep, full-length bamboos (10 m) are staked 1 m apart and tied to 3-5 layers of horizontal braces. In other farming areas where water is not so deep and water current is not so strong, bamboo poles are simply staked without being tied to horizontal braces.

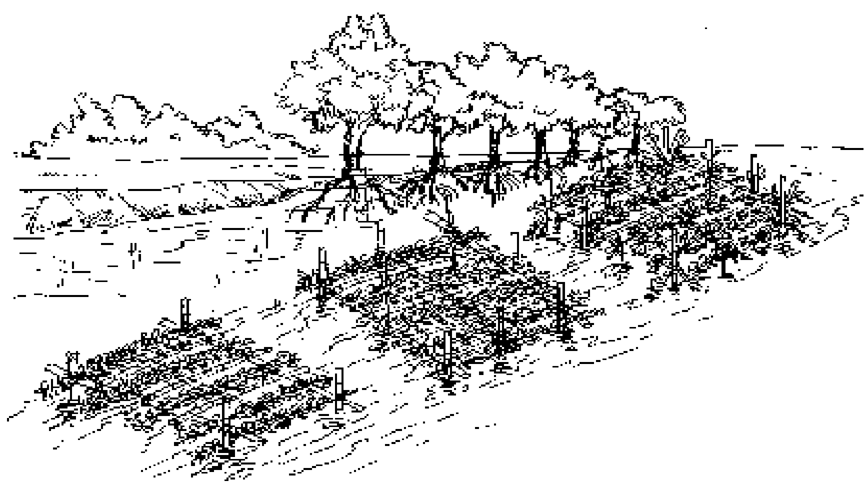
Some variations of the stake method





Raft

Raft culture of the green mussel differs from the usual system, which uses floats, anchors and hangings. Farmers use a different and less expensive raft made of several bamboos, which serve both as seed collector and substrate for growing, but without hangings.



The raft is allowed to float within the confines of the bamboo posts during the first two to three months. Thereafter, when the mussels become too heavy, the raft is tied to posts at a fixed position in the water. Additional posts may be added to further support the heavy raft.

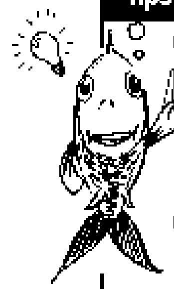
Reasons of farmers in adopting stake or raft method of mussel culture	
Stake ■ Productive ■ Popular or traditional method in the area ■ Ease in harvesting particularly where stakes are nipa petioles and coconut fronds	Raft ■ Good growth and high production ■ Popular method in the area ■ Ease in management and harvesting ■ Maximize use of bamboos (can be reused) ■ No sedimentation effect (raft can be transferred or moved to allow washing away of silt)

Maintenance and management

Bed degradation (i.e., sedimentation), pollution (domestic or pond chemical effluents), occasional lack of seeds (especially for mussel), and biofouling (attached organisms) are some problems reported by oyster and mussel farmers. Many farmers admitted that sedimentation is primarily caused by their farm structures, particularly stakes. Their solutions to these problems include:

- removing stakes after harvest or moving the raft to another available space (but very few farmers do this);
- cleaning or removing biofoulers such as sponges, barnacles, filamentous algae (more mussel farmers do this than oyster farmers); and
- maintaining broodstock (big oysters or mussels) in the farm to ensure a steady supply of seeds.

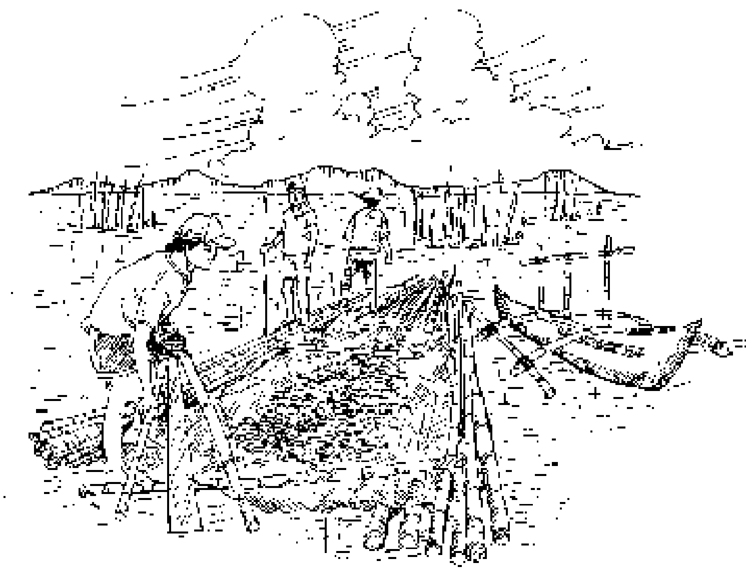
Tips



- **The stake method of mussel culture may be used only in deep areas with strong water current to avoid sedimentation.**
- **The bottom method should be used in areas with hard (non-shifting) bottom to avoid mortality due to siltation**

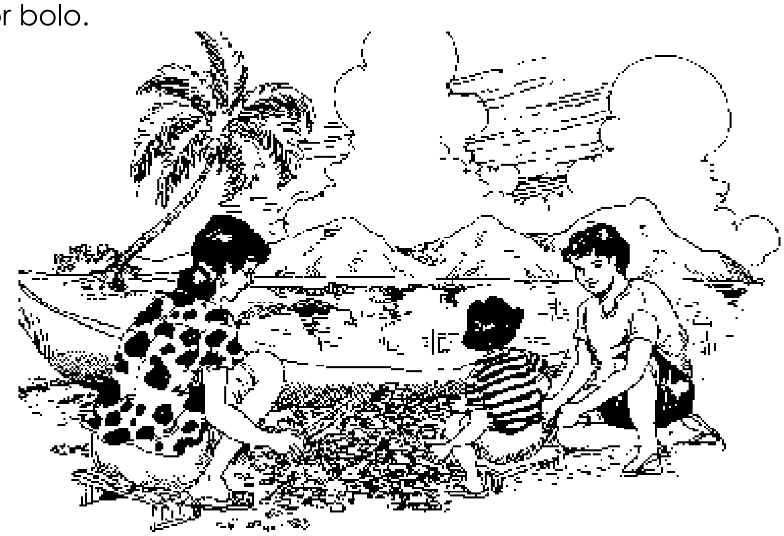
Some farmers remove some oysters or mussels in overcrowded substrates to allow faster growth of remaining oysters or mussels. Removed oysters or mussels are either marketed or transferred to another growing area or substrate.

Harvesting and post-harvest practices

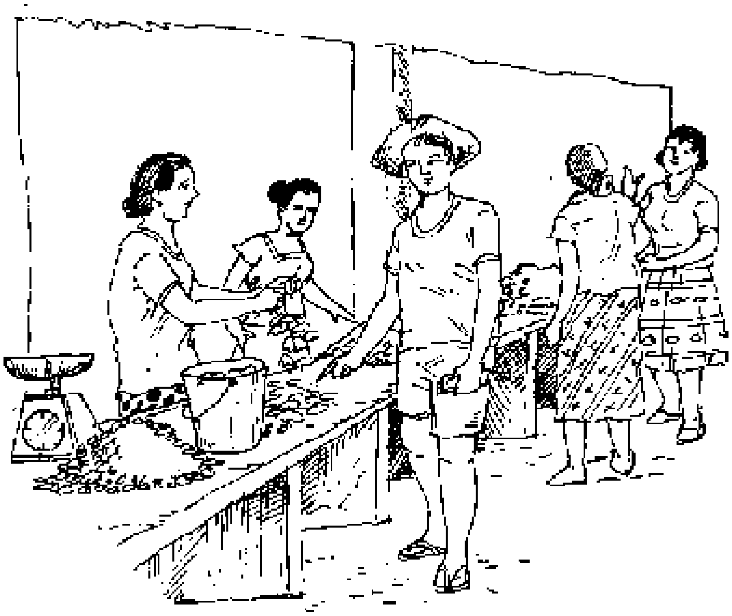


Oysters are harvested when they are 7-8 cm (3 inches) long or 10-12 months after seed collection. But harvesting can also be done at six to eight months, if oysters have good growth. On the other hand, mussels are harvested nine to 12 months after seed collection.

Oysters and mussels cultured using the bottom method are harvested during low tide by taking them from the muddy bottom and placing them inside a sack. In stake culture method, bamboo poles are pulled and hauled to the boat or raft where the mussels are scraped off using a bolo (large knife) or boat paddle. In hanging method, the strings of oysters are simply removed from the rack and placed in the boat for subsequent cleaning and washing. However, if harvesting is partial, big oysters are removed from the clusters using a bolo. Mussels cultured using raft method are harvested by cutting the ropes assembling the raft, hauling the bamboos to the harvesting raft with net flooring, and scraping off the mussels using either a paddle or bolo.



Harvested oysters or mussels are cleaned by placing the harvest in a basket, sack, or screen nets and shaking them underwater (seawater) to remove mud, algae and other attached organisms. Cleaning tools such as brush or bolo are also used to scrub and scrape attached organisms. After cleaning the oysters and mussels, sorting by size is done to make it easier for the buyer to price the products when reselling to market retailers.



Marketing

Oysters and mussels are sold either as:

shell-on fresh;

shell-on cooked;

shucked (meat removed from shell) fresh; and

shucked preserved.

Shell-on fresh is the most preferred form by buyers who are mostly household consumers and restaurant owners. The buyers can then choose the kind of cooking desired by family members or customers.

Costs and returns of a 1000 sq m oyster or mussel farms, by culture method (US$1 = ₱45)

	Bottom	Stake	Rack hanging	Raft-rack	Stake	Raft
Returns	2804	10937	16979	61110	40253	22968
Costs						
Operating costs						
Materials	265	5393	7891	33428	19613	8147
Hired labor	10	970	1235	3881	5513	3508
Miscellaneous	189	277	184	142	1055	715
Total	464	6640	9310	37451	26181	12370
Non-cash costs						
Unpaid owner labor	220	871	1946	4952	1102	941
Unpaid family labor	245	871	1197	3047	992	706
Depreciation	266	950	815	2075	1568	3321
Total	731	2692	3958	10074	3662	3321
Total production costs	1195	9332	3268	47525	29843	15691
Operating income	2340	4297	7669	23659	14072	10598
Net farm income	1609	1605	3711	13585	10410	7277
Rate of return on capital investment (%)	58	80	138	478	196	134
Payback period (year)	1.7	1.3	0.7	0.2	0.3	0.4

**Includes municipal permit, boat reantals, transportation fees*
(not enough data on bottom method of mussel culture, thus, no analysis)

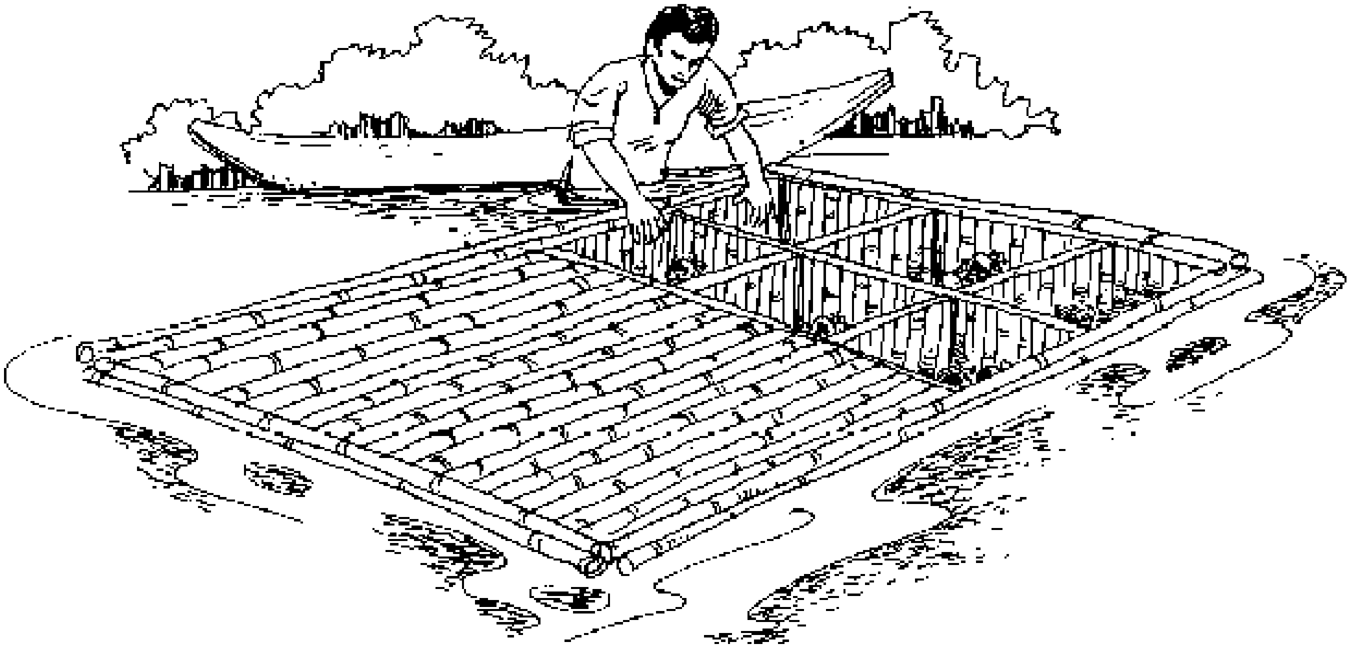
Source: Samonte G. P. B., W. G. Gallardo, R. F. Agbayani, S. V. Siar, R. S. Ortega, R. E. Tumalian, D. Z. Bermejo and L. A. Espada. 1993. Socio-economic study of oyster and mussel farming in Western Visayas, Philippines. Asian Fisheries Social Science Research Network Report. Southeast Asian Fisheries Development Center, Aquaculture Department. 177 pp.

Conclusion

In oyster culture, the raft-rack hanging method gives the highest yield and income compared to rack hanging, stake or bottom method whereas in mussel culture, the stake method gives better results than the raft method.

Farmers' methods of oyster and mussel culture by raft-rack hanging and raft methods, respectively, are productive methods, which have not been sufficiently documented in other literatures.

Mud Crab Systems for Small-Scale Aquaculture



Mud crab farming has traditionally been a small scale activity, originating in China over 100 years ago and spreading across Asia over the last 40 years. Its close affinity to coastal mangrove areas within the Indo-West Pacific limits mud crab fishery to coastal, artisanal style fishing. It was, therefore, natural for fishermen to improve the value of their catch by retaining both underweight and juvenile crabs for rearing purposes. As a family level occupation, mud crab farming proved to be quite profitable, provided there was a sustainable seed supply from the local fishery.

The traditional trade in mud crab has been for hard-shelled crab products, namely meat crab and egg crab. However, in recent years the market for mud crab products has extended to soft-shell crab and processed crab meat.

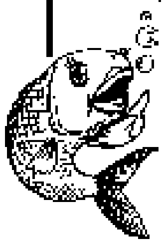
Mud crab belongs to the genus *Scylla*. There are four mud crab species currently being recognized for culture purposes:

1. ***Scylla serrata***
2. ***Scylla paramamosain***
3. ***Scylla olivacea***
4. ***Scylla tranquebarica***

Mud crabs are temperature and salinity tolerant (12-35°C and 2 to 60 ppt, respectively). They are amphibious (they can breathe both in or out of the water). They can crawl out of the water when water quality is sub-optimal and they can avoid the desiccating effects of the sun by burrowing. As such, holding facilities with tidal water exchange can be used and can even be drained completely without any detrimental effects to the crabs. The movement of crabs out of the water and/or burrowing indicate a problem with the water quality, which requires changing the water in the system.

Various mud crab products

- **Egg crab** – mature female crabs with mature gonads.
- **Meat crab** – adult crab sold as a live animal. Male mud crabs are more desirable due to their large claws (in a mature male up to 45% of total bodyweight).
- **Soft shell crab** – recently molted crab, whose shell is still soft.
- **Processed crabmeat** – crab meat removed from the shell and usualy marketed cooked and canned.



Meat crabs are the only mud crab product most applicable to small-scale aquaculture. The other products require high investment both in terms of technology and food supply. Also, there are environmental considerations with soft-shell and egg crab farming, as they tend to exploit parts of the natural crab population that are most sensitive to overexploitation by requiring a high turnover of juvenile and pre-spawned females, respectively. For these reasons, the rest of the paper will concentrate on production of meat crab.

Two types of meat crab culture

1. Fattening

This is the holding of fished crabs that have recently molted (also known as thin or "watery" crabs) for 10 - 30 days until meat weight has increased.

2. Grow-out

This is the process of stocking juvenile crabs (10 g to 100 g) and allowing them to molt and grow. Harvest is after 3-8 months or once the crabs reached 200 g to 500 g size.

Mud crab fattening is the most suitable for small-scale aquaculture because:

- Turnover is fast, hence, the period between investment and returns is short.
- Fattened crabs can be stocked at higher densities (15 crabs/sq m) compared to grow-out systems (1 crab/sq m) as no molting occurs and therefore losses to cannibalism are dramatically reduced.
- Short production time reduces the risk of losing crabs to disease, thus, rendering a higher survival rate for fattening (>90%) compared to grow-out systems (40%).

In addition, crabs can be traded in small numbers as mud crabs are valuable as individual animals. This means that farmers can hold small numbers of mud crab at a moderate stocking density and still make a reasonable profit. Meat crabs can be farmed in ponds, cages and pens both using the fattening or the grow-out systems of stocking and harvesting.

General considerations

Seed supply

At present, hatchery-produced mud crab seeds are not widely available. Therefore all crabs used to stock the mud crab systems are caught by the systems' operators themselves and/or are bought from local fishermen.

Feed

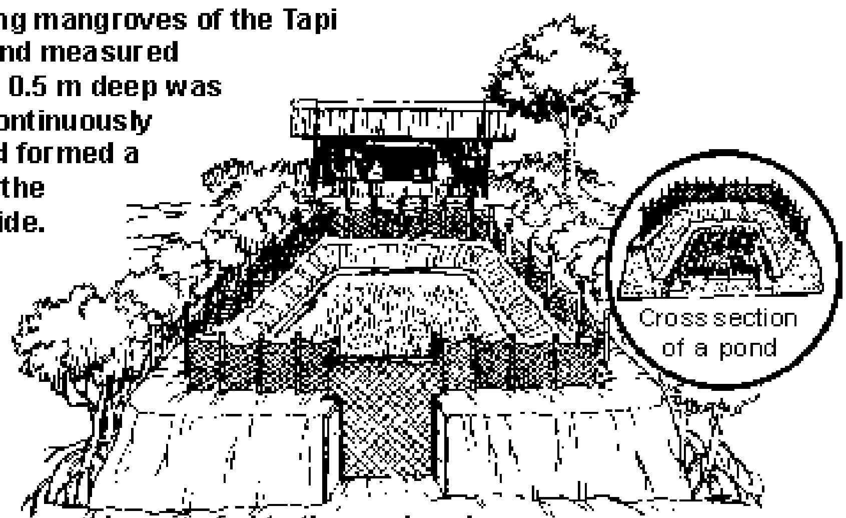
Mud crabs are carnivorous and scavengers. In all cases, the mud crabs are fed with locally caught fish species, which have a low market value. These low value fish species are harvested by the mud crab farmer themselves or are bought locally from other fishermen.

Pond culture

Earthen ponds are most commonly used in small scale culture of mud crab. Small ponds are built in the homestead (200 sq m or less). Farmers usually build a fence around the perimeter of the pond to prevent crabs from escaping to keep away predators. The fence can be made of a range of materials, e.g., roofing tiles (Vietnam), concrete slabs (Sri Lanka), polyethylene sheets (Philippines) or mesh (Vietnam/Thailand). A simple sluice gate is used to allow water exchange. The method of stocking, feeding and harvesting as well as the level of pond maintenance varies widely from farmer to farmer. The example below is of a very simple system observed in Surat Thani province, Thailand

Pond culture of mud crab in Klong Mai Ban, Surat Thani, Thailand

The homestead was set in the remaining mangroves of the Tapi river, Surat Thani Province. A single pond measured about 9 m x 9 m. A canal 1 m wide and 0.5 m deep was dug around the edge of the pond and continuously filled with water. The center of the pond formed a raised platform with vegetation, which the crabs could use as refuge during low tide. Water exchange was tidally controlled. Polyethylene netting was used to prevent the crabs from escaping. Any underweight crabs caught were returned to the pond along with supplemental stocking of thin crabs bought from other fishermen. Feeding depended on availability. Low-value fish, mangrove snails, crabs and horse mussels were fed to the mud crab. Fattening took 30 days.



Cage culture

Cage culture of mud crab makes use of estuaries, lagoons and brackishwater ponds. Floating cages, made of bamboo or polyethylene/galvanized wire net, are mainly used for mud crab fattening. The cage culture of mud crabs has been used in the Philippines and Indonesia. These cages can include those that are divided into compartments for individual crabs, thus reducing the mortalities due to aggression and cannibalism. The cages are floated using plastic floats and empty oil barrels to keep the upper side at surface level. A mesh screen is needed on top of the cages to prevent the crabs from escaping. Cages will allow individuals who do not have access to land to farm mud crab.

Mud crab fattening in cages in Indonesia

A recent study has been carried out on the fattening of mud crab using floating cages placed in *tambaks* – or large extensive tidally-fed ponds. These *tambaks* are used for farming milkfish (*Chanos chanos*). The cages are 9 sq m with a stocking rate of 10 crabs/sq m. The average size of the crabs stocked is 350 g. The crabs are fed, approximately 10% crab body weight, with dried fish and small crabs caught from the *tambaks*. The crabs are held for 20 days before harvesting (450 g each). The survival rate is over 85% of the crabs stocked.

Pen culture

Pen culture has been used for grow-out of mud crab in the Philippines and Sarawak, East Malaysia. This method integrates the system of crab rearing with the coastal mangrove forests, which does not involve the clearing of mangroves to construct ponds. Instead, the mangrove forest is penned-off and stocked with crabs. The pens can be made of plastic netting supported with a bamboo network (as in the Philippines) or made of wood (as in Sarawak). They rely on tidal water exchange and supplemental feeding. Pens for culturing mud crabs may also be constructed within ponds and shallow rivers.

Pen culture of mud crab in the mangroves of Sematan, Sarawak

In 1992, the Department of Agriculture, Sarawak, East Malaysia, introduced the pen culture system to Sematan to help artisanal fishermen improve their income and, at the same time, to conserve the mangrove resource.

The pens are constructed from trunks of the local palm (*Oncosperma tigillarius*) split into planks of about 6 cm x 9 cm x 370 cm. These strips are driven 1.2 m into the soil to form a pen which keeps the crabs in and any potential predators out. The pens have a 18 x 9 x 2.4 m dimension – 162 sq m. Within the stockade a ditch is dug about 0.3 - 0.9 m wide and 0.3 m deep. The ditch is continuously filled with water. Mangrove trees in the center of the pen provide shade for the crabs. Roughly 1000 to 1500 crabs are stocked per pen. These crabs are usually about 100 g each. It takes about two months to complete stocking. The crabs are fed once a day during high tide with low-cost fish species and horse mussels. About 2.6 kg of food organisms are needed for every kg of harvested crab. The crabs are harvested 4 to 7 months later. Selective harvesting of crabs 300 g or more is used. The average net income from such a system is around Malaysian Ringgit (MR) 424.31/pen/month (US$1 = MR 3.78) for a production cycle of five months . Although this system is more environmentally sound than pond culture, the rate of survival is low (47% of crabs stocked are successfully harvested). This is believed to be due to loss (escaping crabs) and cannibalism. Lower stocking densities have been suggested to remedy the situation.

Integrated culture of *Scylla*

The mud crab has been shown to be a good polyculture species, particularly with finfish species (milkfish and Tilapia) and seaweed (*Gracilaria*). An example of this is in the Thai Binh Province, North Vietnam. Mud crabs also have the potential to be farmed in coastal rice fields during the dry season.

Advantages of mud crab culture

1. Mud crab is a high-value species and its culture can significantly increase the income of rural coastal communities.

2. The technology required to culture crab is relatively uncomplicated (this refers mainly to ponds and pens) and can be easily disseminated to farmers.

3. Previously abandoned shrimp pond areas can be conv

erted for crab culture with relatively little additional conversion costs, e.g., fencing to prevent the crabs escaping from the ponds.

4. The mud crab has an international market (e.g., the restaurant trade in Singapore, Hong Kong, Bangkok and Taiwan) therefore the culture generates much needed foreign exchange.

5. Unlike exotic species, the mud crab is indigenous to the Indo-West-Pacific, therefore its market trading system is already well established within the region from fished mudcrab products. The transition to also include farmed crab will be relatively easy.

6. Transportation of mud crab is very simple. Individually tied mud crabs are transported in damp conditions in baskets from the pond to the market place. Moreover, crabs can be transported and stored in this way for three to
four days.

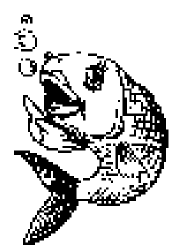
Rice/crab farming in Tra Vinh Province, Vietnam

Both crab growout and crab fattening are practiced in rice fields in Tra Vinh Province. In both cases, minor modifications are made to the rice fields, namely installing a mesh net around the perimeter or the area that is being used to farm crabs and deepening the waterways.

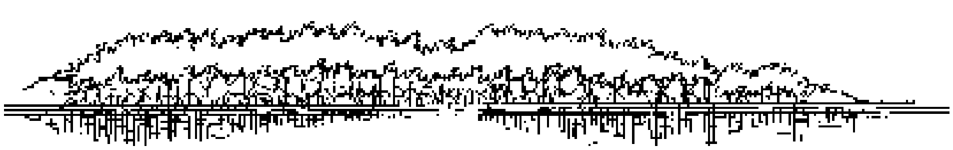
The grow-out system is an extensive system where the crabs are stocked and harvested but there is no supplemental feeding involved. Fattening requires feeding to improve the weight of the crabs in a short period of time; low-cost fish species are used to feed the crabs.

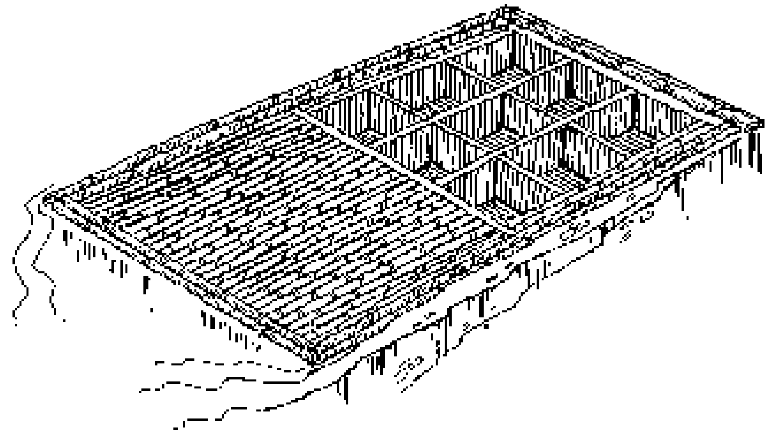
The grow-out systems proved to be the more profitable as smaller crabs, which were cheaper, were used to stock the ponds and there were no feed costs. However, survival was low in the extensive system, mainly due to cannibalism. Both systems are family run, extra labor only being employed during the harvest season.

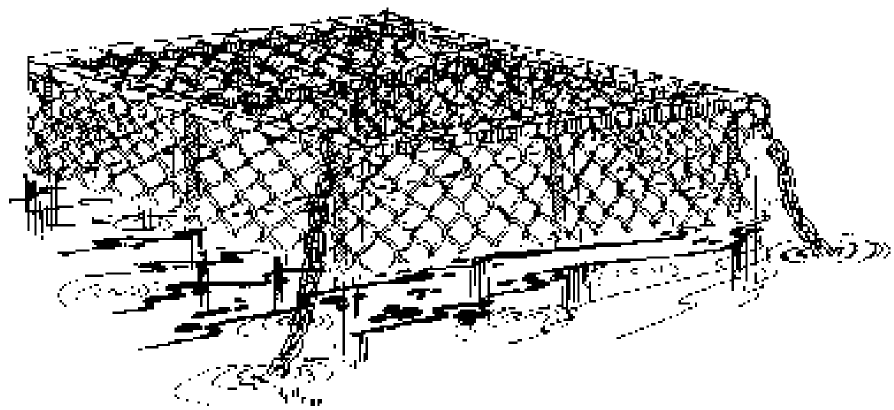
This system is profitable as long as the salinity levels are kept low to ensure a good rice crop. It also helps farmers save money by avoiding the use of pesticides, which are detrimental to the health of the mud crabs.



The species of mudcrab found is S. paramamosain. It does not burrow, therefore, does not affect pond infrastructure.







7. Mud crab farming also involves other sectors of the community who do not have the capital or the land/water access to start crab farming themselves. These people may be involved in collecting food items or crab seed, providing labor for pond maintenance and guarding and harvesting of ponds, as well as transport of harvested crab to the marketplace.

8. The link between the mud crab and the mangrove provides an incentive to preserve the mangrove resource.

Constraints of mud crab culture

1. A fundamental pre-condition for the future sustainability and expansion of the mud crab industry is a reliable seed supply, particularly in soft-shell crab farming, which has a high turnover of juvenile crabs (~ 80g each). Ongoing research into hatchery production of mud crab is starting to produce reasonable survival rates of crab seed. However it is still not on a scale that can be deemed economically viable. Thus, the expansion of mud crab farming is constrained by the availability of seed supply from the wild.

2. Crabs can suffer high mortalities from diseases similar to those that affected shrimps.

3. Although pen and cage cultures have been shown to be suitable for mud crab production, the majority of mud crab is cultured in ponds. This means that any expansion in mud crab farming is going to be influenced by the same issues that faced the shrimp

industry, including competition for coastal sites for ponds and pollution from over development.

4. The high value of mud crab makes it very attractive to richer sectors of the community and in some cases outside investors. This can marginalize the poorer households and prompt them to use less suitable locations to farm crab.

5. There may be competitition for locally caught low-value fish species that could be protein sources for the poor members of the community. This potential conflict needs to be outlined and efforts are needed to find alternative sources of crab food.

Conclusion

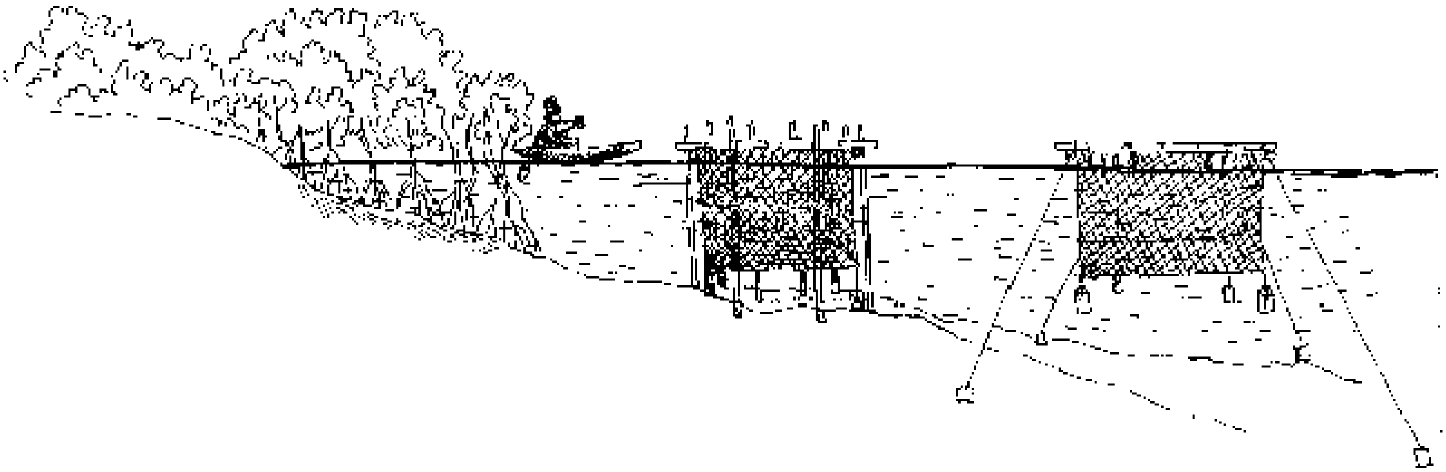
Mud crab culture is suitable to small-scale farmers as hardy and high value crabs can improve the income of the household even when small numbers are farmed in very simple culture systems. Soon hatchery-produced seed will be available to farmers, substantially reducing fishing pressure on wild crab stocks.

Reference

Keenam, C. P. and Blackshaw, A. 1999. Mud crab aquaculture and biology. Proceedings of an international scientific forum held in Darwin, Australia. April 21-24, 1997. ACIAR proceedings No. 78. 216 p.

Prepared by:
Julia Lynne Overton and R. K. U. D. Pushpakumara

Small-Scale Seabass Culture in Thailand



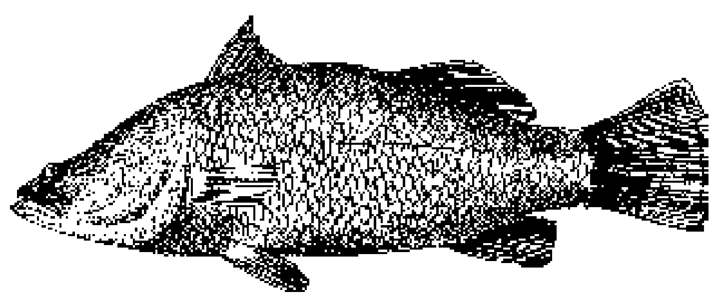
Seabass or giant sea perch (*Lates calcarifer*) has been cultured in Southeast Asia in marine, brackish and freshwater areas. This species is widely distributed in the tropical and subtropical areas of the Western Pacific and Indian Ocean. Its range of distribution includes Australia, Southeast Asia, Philippines and countries bordering the Arabian Sea. Seabass culture in Thailand is still small-scale compared to marine shrimp culture. The market for marine shrimp is global, while the market for seabass is largely regional.

Advantages of seabass as a species for aquaculture

- Can tolerate wide range of salinity from freshwater to 35 ppt making it suitable for aquaculture in estuaries, river mouths, inner bays and mangrove swamps where the salinity condition is unstable
- Feeds and grows well in high turbid waters
- Fast growing
- Can tolerate high density conditions and handling stress
- Easily tamed for aquaculture conditions and accepts either fish flesh or artificial feeds
- Availability of eggs/fry in commercial quantities

Spawning of seabass

Two major techniques are employed in mass production of seabass fry: artificial fertilization and induced spawning.



Artificial fertilization

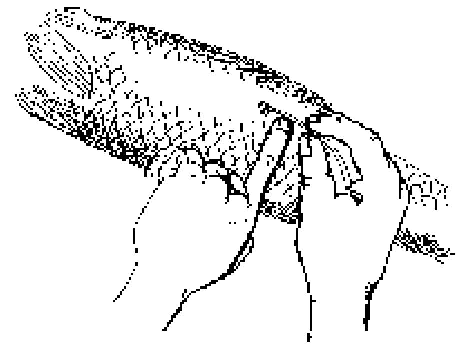
- Spawners are caught in natural spawning grounds where the water depth is about 10-20m.
- The degree of maturity is immediately checked.
- The unfertilized eggs are stripped directly from the female.
- The eggs are then placed in a dry and clean container with clean seawater and milt is added. A feather is used to mix the milt and eggs.

- Clean sea water is stirred into the mixture, which is then left for five minutes.
- The fertilized eggs are transported to the hatching tank.

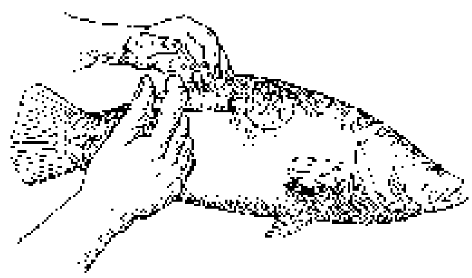
Induced spawning

Two methods are normally used for inducing seabass to spawn in captivity: hormonal injection and environmental manipulation.

Induced spawning by hormone injection



- Seabass brooders are stocked in the pre-spawning tank for two months. The fishes are checked twice a month during spring tide.
- A polyethelene cannula is used to sample eggs from the female broodstock.
- The fish is either anesthetized or inverted gently with the black hood over the head. The cannula is inserted 6-7 cm into the oviduct.Eggs are sucked orally into the tube.
- The female is ready for hormone injection when the tertiary yolk stage (egg diameter 0.4 - 0.5 mm) is reached.
- Spawners maybe injected intramuscularly below the dorsal fin with the required hormone dosage.
- The fishes are transferred to the spawning tank and are expected to spawn within 12-15 hours after injection.



Induce spawning by environmental manipulation

Steps in stimulating seabass spawning in captivity:

1. Change the water salinity to simulate fish migration.

2. Decrease the water temperature to simulate the decreased water temperature after rain.

3. Lower and subsequently add seawater to the tank to simulate the rising tide and the moon phase.

Hormone dose to induce spawning in seabass

	Male	Female	
Puberogen	20- 50	20-200	i[/kg of fish
LHRHa	20-100	40	[g/kg of fish
HCG + pituitary gland of Chinese carp	250-1000	250-1000	i[/kg of fish

The fish will spawn in about 36 hours after injection. In case no milky white scum is produced (fatty texture) in 12-15 hours after injection, a second injection with double dosage should be given to female spawners.

At the beginning of the new or full moon, the water temperature in the spawning tank is manipulated by reducing the water level to 30 cm deep at noontime and exposing it to the sun for two to three hours. This procedure increases water temperature in the spawning tank to 31-32°C. Filtered seawater is then added to the tank to simulate the spring tide. In effect, the water temperature is drastically decreased to 27-28°C. The fish spawn immediately the night after manipulation. If no spawning occurs, manipulation is repeated for two to three more days, until spawning is achieved.

The fish will usually spawn for three to five consecutive days. Since seabass spawn intermittently by batch, the same spawners will continue to spawn during full moon or new moon for the next five to six months.

Larval rearing

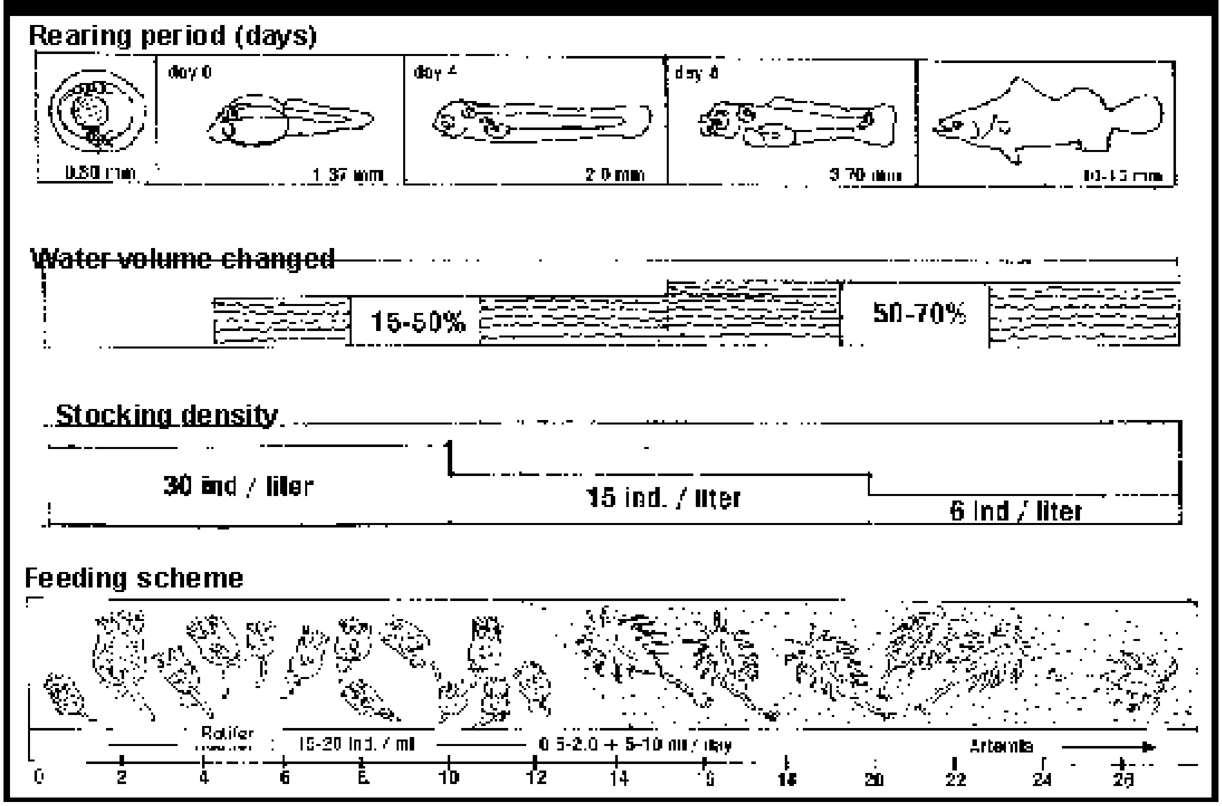
Rearing tanks

- Fabricated from plastic, fiberglass, wood or concrete
- Rectangular or round shape
- Located outdoors, protected from strong heat and heavy rains by a roof tile cover

Stocking density

- Newly-hatched larvae density in rearing tank is between 30-100 larvae/liter

Schematic presentation of sea bass larval rearing based on age of larvae



Feeds and feeding

- Green water *(Chlorella* or *Tetraselmis)* is added on the first day of rearing to maintain good water quality.
- Beyond three days, rotifers are introduced as feed and are maintained at a density of three to five rotifers/liter with green water.
- Under developing stages (ten-day-old larvae, juvenile and subadult), artemia and

minced fresh fish are available on demand.

Grading

- Grading of size is needed for homogeneous growth and to minimize losses due to cannibalism.
- This process is done a week after the larvae have started to feed on artemia and every week thereafter.
- Grading trays used are made of plastic with many holes.
- Each tray has specific hole or mesh size which ranges from 0.3 - 10 mm.

Nursery

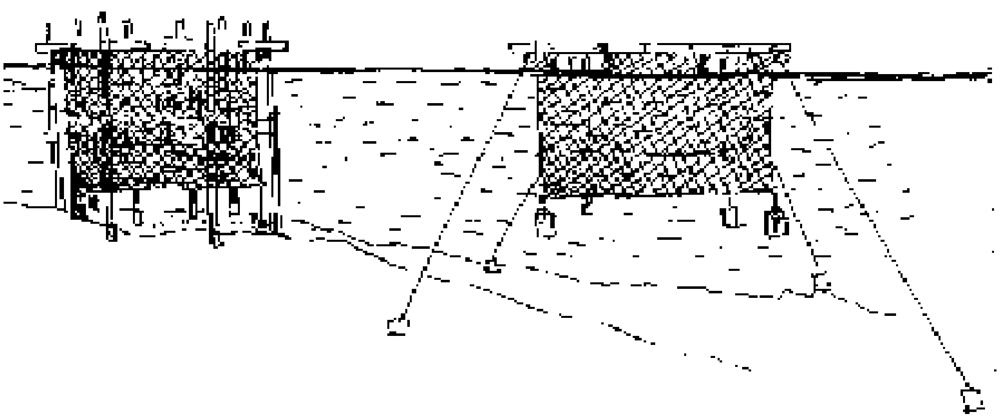
- Fry from the hatchery are cultured.
- Solves the problem of space competition.
- Increases the fry survival rate.

Design of nursery

	Pond	Net
Material	Concrete, plastic, canvass, fiber	Synthetic netting
Location	Earthen or concrete pond	Flow through water area
Size (sq m)	500-2000	3 (3x1x1 m) to 10 (5x2x1 m)
Density (fry/sq m)	20-50	80-100
Duration (day)	40-50	25-35

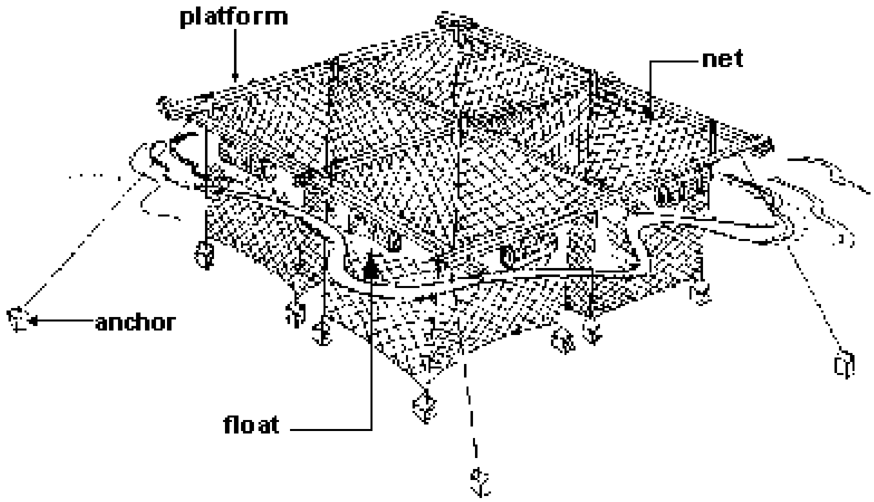
Types of cages

In general, the size of a square or rectangular cage ranges from 20 to 100 m3. The cages are hung from floating wooden or bamboo frames using styrofoam blocks or polypropylene tubes fastened to poles and set in shallow waters. The fish is mostly fed with chopped trash fish, the amount of which is 5-10% fish weight/day, with a stocking density of 10-40 fish/sq m.



Floating

The net cages are attached to wooden or bamboo frames. The cages are kept floating by materials such as plastic, styrofoam drum or bamboo. The shape of the cage is maintained with the use of concrete weights attached to a corner of the cage bottom. Floating cages are suitable in areas where the water is more than 2 m deep and the tidal fluctuation is wide.

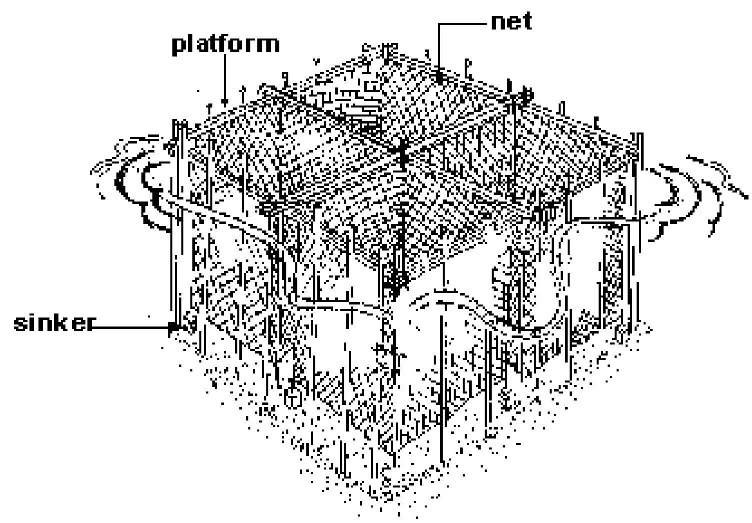


Floating cages are more popular because these are:

- usually placed in sites with better environmental conditions;
- generally located at greater distances from pollution sources; and
- these can be stocked with more fish than stationary cages.

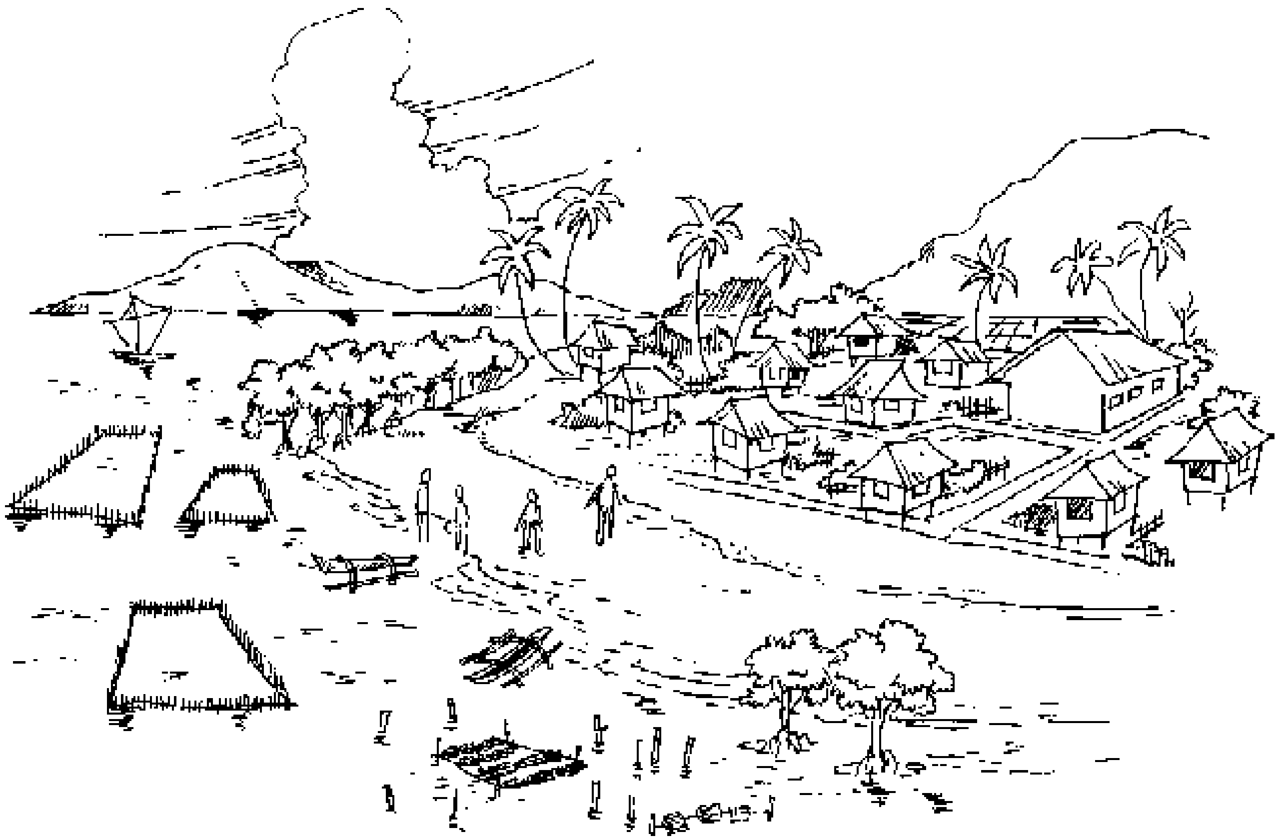
Stationary

Stationary cages are fastened to bamboo or wooden poles installed at its four corners. These do not move with tidal fluctuations. These are popularly used in shallow bays where tidal fluctuations are less than 1 m.



Prepared by:
Khorkiat Koolkaew

Coastal Aquaculture Options



Small scale aquaculture in coastal areas has been slow to develop new approaches and spread existing technology in most countries. The developments that have taken place are largely with the investments of non-residents and are larger scale production systems like shrimp ponds and marine fish culture. The notable exceptions are oysters, mussels and seaweeds in a few countries.

Aside from some seaweeds, mussels and oysters, most coastal aquaculture technologies have been aimed at moderately-high to high valued species. These species are too expensive for poor people to consume at home. The culture of high valued species entails considerable investment in the security of the crop, either for physical confinement or protection from theft. They are thus, for practical purposes, difficult for poor fishers to develop unless they have some existing infrastructure.

In the following sections several species are presented with a brief description of culture methods used. Some of these are of moderate value and the culture technology may be adapted for species that might be used for family consumption or local markets.

The presentations are meant to provide only an indication of the technology, the requirements and the potential. In most cases, there may be sufficient information for interested people to try the techniques with local adaptations of material, feeds and management. Before the details of particular species are presented some general guidelines for coastal aquaculture development are discussed.

General Guidelines

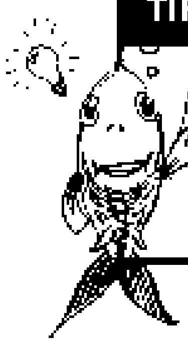
Try it. Change it.

The information provided here is designed to provide the basis for assessment of the practice and perhaps for preliminary trials. These methods have been used in other places but the many variations can not be shown. Fishers are encouraged to try alternatives, to make adaptations, and to monitor and evaluate the results.

If you use a cage or pen, try culturing a few species together to make better use of the space. First attempts should be at low stocking density to ensure the compatibility of the species. Use your knowledge of species carefully as you do not want to introduce a species which will eat your main species!

Tenure

Perhaps the biggest constraint to developing aquaculture along the estuaries and marine coastlines is the lack of tenure. In most countries individuals are not permitted to "own" such areas. In only a few cases local governments (municipalities or villages) have authority to manage adjacent marine and estuarine waters. Even when local governments have legal mandates for control, they often lack the resources to enforce national or local fisheries regulations or to protect private property in the water.



TIP

Work with the local community and government to assess legal means to permit and protect aquaculture development.

Under such circumstances it is difficult to establish aquaculture, which requires an investment and a growing period. Such investments are at risk during the growing period when crops are exposed to natural calamity (storm, floods, etc.) and to theft and vandalism.

Social acceptance

Whether one has legal permission for an aquaculture venture or not, it is important that the activity is recognized by neighbors as an acceptable and worthwhile practice. Since coastal aquaculture is likely to develop in "our waters", in other words, water areas that have been traditionally used by multiple users, the traditional users of the area will have to support the changes. Peer pressure in a community is often the most effective means to enforce regulations and protect private property.

> **TIP**
>
> Work with the community to ensure they agree with proposed changes.

Make the new options available to all interested. Or at least have the community establish a means to decide who will have access.

Site selection

Aside from the legal and social aspects of site selection, there are a number of points applicable to most species and places:

> **Remember**
>
> Overstocking will reduce growth, survival and yields. Especially in first trials, use a low stocking density and assess the conditions of the site.

- Carefully observe the conditions where your chosen species occurs naturally in your are
- Observe the site and note; also observe daily and seasonal changes, particularly salinity changes, current/tidal flow, and exposure to waves.
- Ask fishers in the area about normal and unusual factors, storms and floods.
- Look for sources of domestic and industrial pollution.

Growing out

Periodic samples should be taken to observe growth and survival.

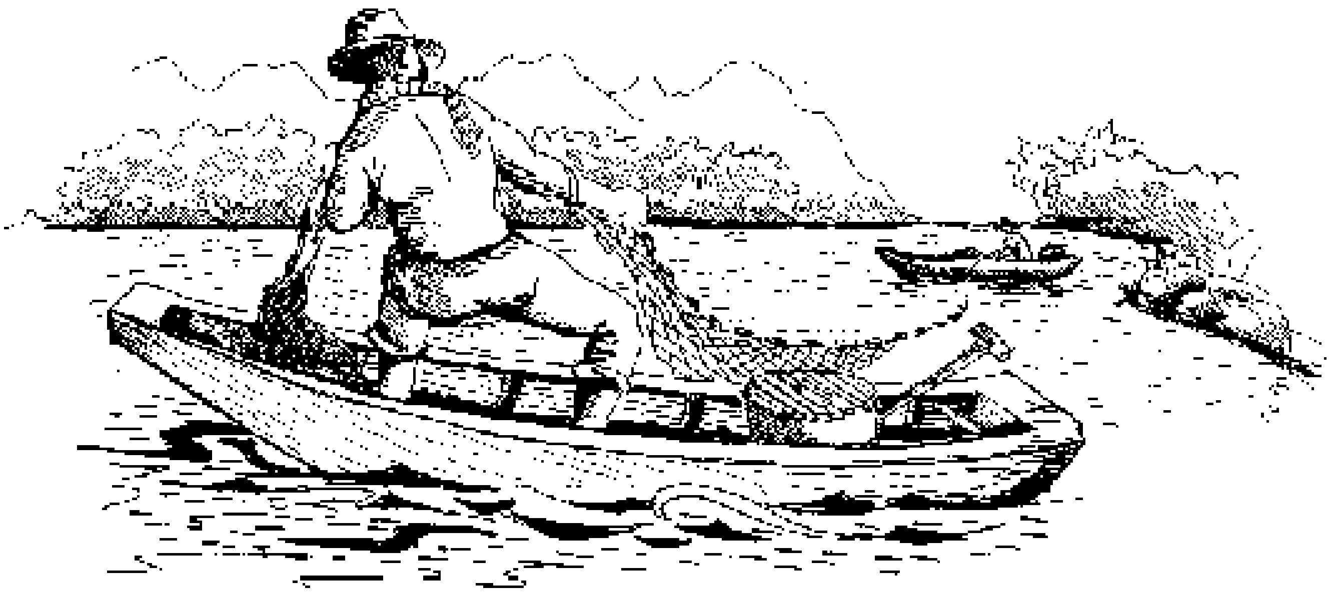
Watch for the occurrence of predators and pests. Do what you can to remove them but often it is difficult to control many species. If losses are high, try another area.

Extension and technology transfer

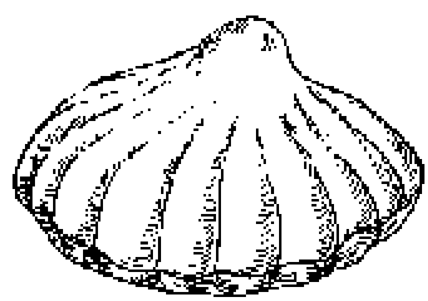
Refer to other chapters in this resource book and look for appropriate means to involve users in adapting technologies.

Explore means for experienced aquaculturalists to share experience with others.

Avoid raising expectations that poor people will get rich quick by culturing high valued species. Encourage small trials and include local species that can be used for family consumption.



Clams



There are many clam species found in shallow coastal waters. Candidates for aquaculture should be those that are naturally found at fairly high densities in mud or sand flats. Species found at very low densities can be tried but seed supply may be a constraint.

If exclusive use of small plots can be assured, clams can be cultured for family consumption and combined with other species. Such culture can reduce the time spent gleaning and provide clams of a larger size.

Cockles are treated in a separate section and giant clams are not considered here because of the difficulty of seed supply. However, some programs are developing hatcheries for giant clams.If the seed is available you can probably obtain advice on grow-out from the hatchery personnel.

Sites

Avoid areas currently used for communal clam collection. Because of water circulation patterns, a culture site may have a low natural seed or adult density and still be good for growing.

Generally you should look for intertidal areas of sandy mud or sand. Avoid areas that are so muddy it is difficult to walk.

There should be a good tidal exchange as this will bring in the suspended food for the clams.

Pen

Most clams do not migrate or do so with limited range once they are a centimeter or more. (You should observe your local species to see how they behave.) Thus an enclosure or pen is not normally required for larger clams. But a pen may be useful for small seed, especially after seeding and the animals have not established themselves.

On the other hand, sometimes a pen is useful to keep out other species -- especially humans. In some areas fish, like rays, can be serious predators and a pen may help in excluding them.

A pen may be constructed with poles and a low net (up to a meter high). An area can also be staked off with a row of bamboo or other sticks.

Stocking/seed Supply

Clams spawn seasonally. Observe clam beds for the occurrence of juveniles.

There might be a conflict with those who collect adult clams if you remove a large quantity of clam seeds. Moderate thinning of natural stocks will not have an adverse impact on the yields but do the seed collection carefully and try to collect from different areas.

Initially stock at densities no more than two to three times the natural density with trials in the range of 200- 600 seed clams per sq m.

Maintenance

Feeding is NOT required! In fact there is nothing you can do after you have spread the seed clams. Aside from maintaining the pen, if one is used, and keeping the area free from debris and obvious predators like snails, there is not much to do.

Harvesting

Harvesting can start whenever the clams reach an acceptable size.

One of the reasons for culturing clams is that you can keep them until they reach a larger size. Thus, you should harvest the larger ones and return the smaller ones so they can continue to grow. The small ones should be left on the surface when the tide is rising so they can quickly reestablish themselves in the sediment.

It is best to harvest an area in a systematic way so you do not dig an area frequently.

Market

Carefully consider the value of clams in the market according to size. Harvest your clams when you think they will give you the best price.

Economics

The investment costs for clam culture are small. Even though the market price may not be very high, the returns can be reasonable.

Risks

The risks involved in clam culture are low as long as you have security of tenure and there is not much threat of theft.

Since there is no feeding or other daily maintenance, the stock can be left in the water until you are able to harvest them. However, you will have to determine if there is a possibility of seasonal losses due to low salinity. This will depend on the tolerance of the species selected.

Complementarities

Using an area for clam culture does not preclude its use at high tide for fishing or other purposes, as long as this does not adversely affect the bottom or pollute the clams. It is not advisable to allow dragging fishing gear over clam beds.

Other aquaculture, like pen culture of fish, is possible in the same area. The detritus from fish culture can enhance the food supply for the clams.

Special notes

Like other bivalve mollusks, clams are efficient at removing bacteria and viruses from the seawater. It is best that clams be cultured away from residences to avoid contamination from domestic sewage. However, if clams are only eaten after being cooked well, the threat of contamination from sewage microorganisms is reduced.

Clams are also able to accumulate toxic algae. If you are not aware of the status of toxic algal blooms in your area, consult local fisheries or health authorities.

Cockles

The main cockle species of interest is the blood cockle, *Anadara granosa,* which is cultured in Malaysia, Thailand and a few other places. There may be other species of local interest and they can be investigated to determine whether the methods suggested here for *A. granosa* would be appropriate.

Sites

Blood cockles are mostly found around the mouths of estuaries in muddy areas. The adults need a subtidal area but the seed clams can be found on intertidal flats.

Observe the local occurrence of cockles to assess their salinity tolerance and substrate preference.

Choose a site where the water is in the range of 1-1.5 m at low tide.

Stocking/Seed supply

Seed clams can be found in soft-bottom intertidal flats. Usually the mud is too soft for walking and a sled or "scooter" with flat bottom is needed to work in the area.

Observe the mud for the presence of juvenile clams. It may take time to learn how to do this. Other fishers in the area may already know how to recognize them and what time of year to expect them.

The seed clams (4-6 mm) are skimmed off the surface of the mud with fine meshed scoops. The mesh size should be adjusted to the size of the seed clams.

The seed clams are then distributed over the growing area from a boat by throwing them over with a scoop. Experience will be the best guide to determine stocking density. This will depend on water flow and depth. Start with low density and increase in subsequent crops. Use a target of 200-300 cockles/sq m at harvest.

Maintenance

There is little to be done between seeding and harvest. There is no feeding and little that can be done about predators.

Observations are important during the growing period to check growth and survival. Gastropod predators should be observed and their distribution determined. You may find some areas unfavorable to predators produce higher yields.

Harvesting

Cockles are harvested with a "basket rake". This is a rectangular wire basket attached to the end of a 2-3 m pole. A rope is attached just above the "basket" and tied to the boat. As one person drives the boat around the site in a systematic pattern, another pushes the rake down to the mud surface allows it to skim over the mud, picking off the clams. The basket is periodically emptied into the boat.

Market

Cockles can be taken to market in sacks as long as they are kept damp and cool. But hey will not last more than a couple of days.

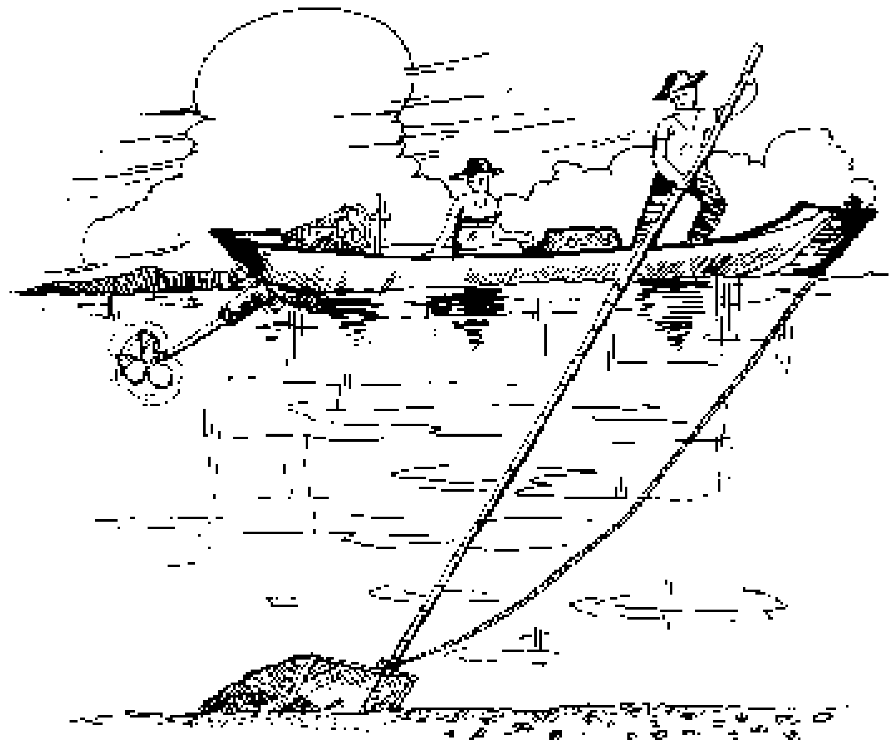
Economics

There is not much equipment required specifically for cockle culture. However, a motorized boat is needed. Cockle culture, thus, may be suitable for a fisher who owns or has use of such a boat.It would not be wise to invest on a boat specifically for cockle culture because the use is rather infrequent.

Aside from the boat the major investment is labor and time. The profit from cockle culture will depend on the local market, supply from fisheries and whether the species is in demand. These factors should be assessed at an early stage.

Risks

There is not much risk of loss of the cockles if a suitable site has been selected. Before a site proves to be acceptable, however, there is a risk of mortality due to predation or unsuitable water quality. Thus, early trials should be small.



Use of the bottom area does not preclude multiple use of the overlying water for fishing and transport.

Labor

Seed collection may involve several family members as it is not heavy labor. Harvesting is more intensive work and may not be suitable for all ages.

Sea cucumbers

Sea cucumbers (various species of the following genera *Holothuria*, *Thelenota*, *Stichopus*, *Actinopygya*, and *Bohadschia*) are of varying values in local markets depending on local tastes. However, they are often exported. Sea cucumbers occur in seagrass beds and in sandy/muddy bottoms. If you are in doubt about the value of your local species, inquire with fish exporters.

Not much has been published on sea cucumber culture even though a number of attempts to culture them have been made. The methods discussed here can be tried for growing sea cucumbers from a small size or for short term holding, with some growth, prior to processing for market.

Sites

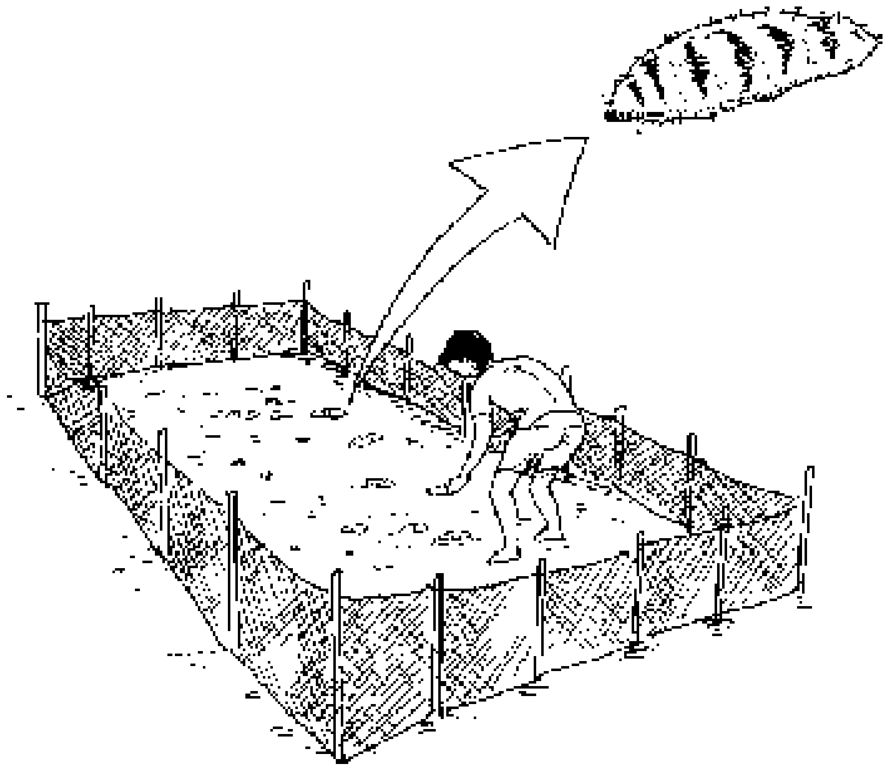
Although sea cucumbers may be found on tidal flats, a shallow-water, subtidal site is preferable for culture. Sea cucumbers also occur in sea grass beds but care should be taken in using these sites for culture because they are very important for fisheries and biodiversity.

Seed supply

Collect sea cucumbers from local sources. You will probably find a range of sizes available. The smaller they are at stocking, the longer it will take to grow to market size. For first trials, it would be best to start with larger, submarket-size animals.

Pen and stocking

A simple pen made of stakes and mesh should be set up. The sea cucumbers feed on the detritus on the bottom so each one will need considerable area. The size of the pen will depend on conditions. It may be better to have a few smaller pens rather than one large one, just for safety sake.



Try stocking about 2-3 animals per square meter. Monitor the growth and survival and decrease the density if there are signs of stress.

Maintenance

There is little to be done between seeding and harvest. There is no feeding.

Observations are important during the growing period to check growth and survival.

Harvesting and processing

Harvesting will be done when you think the size is appropriate. Consult buyers for preferred size and base your decision on the risk of loss if marketing is postponed and the value of the harvest at a smaller size. Sea cucumbers are marketed in the dried form. They must be completely dry to avoid spoilage due to mold.

Clean the sea cucumbers by cutting open the belly and removing the internal organs.

Immediately scrape the body wall to remove the hard, chalky growth on the outside.

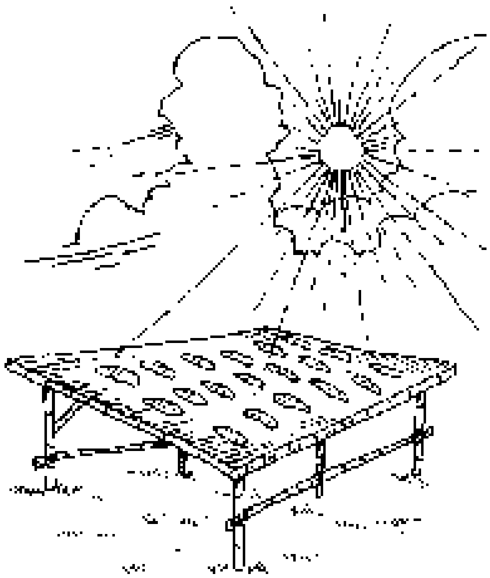
After cleaning boil them in sea water until they become rubbery. Add one teaspoon of alum to the pot to inhibit the growth of mold.

Thoroughly dry the sea cucumbers by smoking or sun-drying until they are .

Pack in plastic bags for market.

(Source: DENR. 1998. Sustainable Livelihood Options for the Philippines. Booklet 3. Department of Environment and Natural Resources, Philippines.)

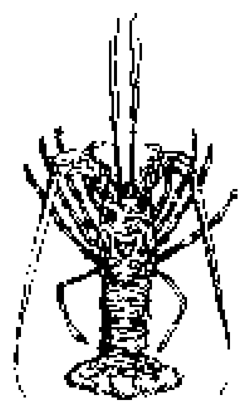
Economics



The investment in equipment is minimal for sea cucumber culture and the seed stock is obtained locally. The main investment is time to set up, monitor and harvest. A rough estimate of profitability can be made once you have decided on the size of pen and the stocking density and have determined the local market price.

The product is dried and thus can be stored for marketing later .

Lobsters



There are several species of lobsters and it should be determined which are available locally and, of these, whether there are different market values. Fishers will be able to provide information about the ecology of the local species. This information can help in site selection, determining whether juveniles are available, and the size that one might expect to achieve.

Sites

Lobsters normally require full seawater with little exposure to brackish water.

They cannot tolerate much reduction in oxygen levels so a moderate flow of seawater is needed. For pen culture, seek a site with a sandy or rocky bottom as this normally has good water exchange.

The water depth should be at least one meter at low tide.

Security will probably be a concern, so the site should be near the residence or such that other arrangements (e.g., a guard house) can be made for monitoring.

Culture unit – pens or cages

Pens

If funds are available, the farmer may want to invest in a pen.

A good pen size would be about 5 x 5 m and this can be divided into sections (4 sq m for nursery, 6 sq m for transition and 15 sq m for rearing to market size).

The pens can have bamboo or mangrove poles at the corners and on the sides for support.

Plastic netting used to enclose the pen should cover the ground to prevent the lobsters from escape. Farmers may resort to other netting but should watch out for the deterioration of material other than plastic.

The sides can be re-inforced with bamboo slats, coconut slabs or other seawater-resistant material to protect the netting. Care must be taken to ensure good water exchange and that the whole unit is not subject to destruction by strong waves or currents. (Sometimes the more open the cage is the less resistant it is to water flow.)

Cover the top of the pen with bamboo or nipa for security but allow access for feeding and harvesting.

Cages

Small, floating or suspended cages offer an alternative to pens. Cages can be less expensive although the number of lobsters grown may be less. This is a good way for a person to start lobster culture. They first learn to handle the animals and provide feed. Later they can assess whether a larger investment of money and time is warranted.

Note

You might provide some material like pieces of bamboo or plastic pipe in cages and pens in addition to rocks where they can hide in pens .

Cages can be adapted to local conditions and materials (bamboo, wood) and the size to a person's situation. Cages can be suspended from a wharf or hung from poles but they should never be left to be exposed to air during low tide. Access through the top is needed.

In Vietnam, fishers are culturing lobsters in cages and in pens. The cages are of different sizes (2 x 2 x 1 m, 3 x 2 x 1 m and 3 x 3 x 1.5 m). They are constructed with iron frames (12-12 mm diameter iron) and covered with netting. They sit off the bottom on legs or are suspended 3-4 m below the water surface. The pens in Vietnam are about 5 x 5 x 5 m or 6 x 6 x 5 m and made of wood and netting.

The juveniles are stocked for nursery at 6.5-8 mm carapace length (CL) and 20-25 mm for culture. At the nursery stage they are stocked at the rate of 150-200 animals per cage and in cages or pens for growing at five to ten animals per sq m. Food consists of small fish, crabs and mollusk that are of low economic value.

The time from stocking to market size is 18-24 months for the ornate rock lobster (Panulirus ornatus) and three to four months for the green scalloped lobster (P. homarus).

Stocking/Seed supply

Juvenile lobsters can be captured by the lobster farmer or purchased from other fishers. Care should be taken during capture and handling of the juveniles to avoid damage. Care should be taken so that lobster culture does not pose a threat to the local supply of juveniles to the fishery.

Note

Some other swimming species, like grouper, can be cultured in the lobster pen because lobsters will stay at the bottom.

Stock lobsters of the same size in any one unit. They are carnivorous and the bigger ones will eat the small ones.

Feeding

Feed the lobsters daily, preferably in the morning. Lobsters will eat a variety of foods and the farmer should experiment with various fish, mollusks and seaweeds. Remove uneaten food before it rots. The food should be cut in small pieces.

Maintenance

The pen and cage should be kept clean to maintain water circulation. Remove biofouling organisms. Leave them in the cage if the lobsters will eat them.

Make sure the pen or cage remains intact and there are no escape holes.

As in any aquaculture, the stock should be observed daily to see if there are sick, dying or dead animals. They should be removed immediately.

Remember that lobsters shed their shell when they molt. Do not remove the empty shells because they will be eaten by the lobster and provide nutrients.

Harvesting

The time to harvest will depend on the stocking size, growth conditions, food and preferred size in the market. This may be from six to 24 months.

Harvest lobsters in the morning by gently scooping them up with a net.

Lobsters are best taken to market alive. Wrap the lobsters in paper or cloth pre-soaked in seawater and place them in Styrofoam boxes.

Avoid exposure to fresh water.

Economics

The profitability of lobster culture will depend on what material and feed must be purchased and what can be obtained directly by the lobster farmer.

The biggest investment is probably time.

The labor needed is in the collection of feed and the daily feeding and maintenance. This can be done by any family member who is available.

Risks

Lobsters may attract thieves.

They are sensitive to poor water quality (low oxygen or pollutants) and can be killed quickly.

Growing to market size is long, exposing the lobster farmer to the possibility of losses.

Environmental issues

Lobsters can be cultured with minimal environmental impact. Feeding rates should be adjusted so there is no waste that might pollute surrounding waters. Such pollution will also have an immediate and adverse impact on the lobsters.

Care should be taken to use juveniles wisely. Only enough should be stocked to give good growth and survival rates. Heavy stocking densities will result in poor growth and survival and less returns for the farmer.

Sea urchin

Sea urchins have been a traditional food in many countries. With recent infrastructure for export of sensitive seafood products like sea urchin eggs, demand has risen and over-exploitation of sea urchins is now common. Small-scale pen culture of sea urchins exist in the Philippines but they have not been well documented. However, the methods are quite simple and local adaptations are likely to be needed anyway.

The first step is to assess the local situation. Are there commercially important sea urchins around? Is there a shortage of supply or other reasons to establish culture of sea urchins?

Sites

Sea urchins are grazers on coral reefs and associated hard or sandy bottoms. They are usually found among seaweeds. A similar site, close to home, should be identified although it should be kept well away from source of fresh water.

A site with good water flow is needed as the pen will have unnaturally high concentrations of sea urchins and seaweeds.

Pen or cage

A pen or cage to hold sea urchins should be constructed. It does not have to be very large (up to 2 m x 2 m in area). Poles stuck in the sand with netting would be suitable. If a net is a problem, bamboo slats or small mangrove sticks could be used for the sides.

Stocking and seed supply

There are no guidelines available but common sense in terms of over crowding should be used. Small urchins are collected and placed in the pen. It may be best to start with sub-market size animals and see how the system works.

Feeding and maintenance

Seaweed is collected and added to the pen as needed. Try different species of seaweed. Monitor the condition of the pen to see how much is eaten and whether there is a build up of organic material such as fragments of the sea weed. Clean the pen as needed and continue to supply fresh seaweed.

Check the pen to ensure it is intact.

Harvesting and market

Pick out large sea urchins as needed for festivals or for market.

Check with local buyers to determine how best to market your urchins and when. With a stock of urchins you should be in a good position to work with buyers on a marketing strategy because you will be able to supply the buyer with the product when it is needed.

Economics

The profitability of sea urchin culture will depend on what material is used for the pen. It is assumed that the seaweed will be collected by a family member.

The biggest investment is probably time.

The labor needed is in the collection of feed and the daily feeding and maintenance. This can be done by any family member who is available.

Risks

Sea urchins are valuable and may attract thieves.

They are sensitive to poor water quality (low oxygen or pollutants) and can be killed quickly.

The growth from small to market size is long, exposing the farmer to the risk of losses.

Environmental issues

Sea urchins can be cultured with minimal environmental impact. Feeding rates should be adjusted so there is no waste to pollute surrounding waters.

Care should be taken to use juveniles wisely. Only enough should be stocked for good growth and survival rates. Heavy stocking densities will result in poor growth and survival and not result in better returns to the farmer.

Seaweeds

Seaweeds have both an export market and local use in many countries. Seaweed culture for export is an important occupation for many communities in southern Philippines and eastern Indonesia. It can be undertaken on a small-scale but marketing often requires a large quantity depending on the proximity of buyers. In this chapter we will present a few alternative culture systems for consideration. The user will have to determine whether there are local markets and what species are preferred.

The common species for culture are *Gracilaria* spp., *Eucheuma* spp. and in some cases *Caulerpa lentillifera*.

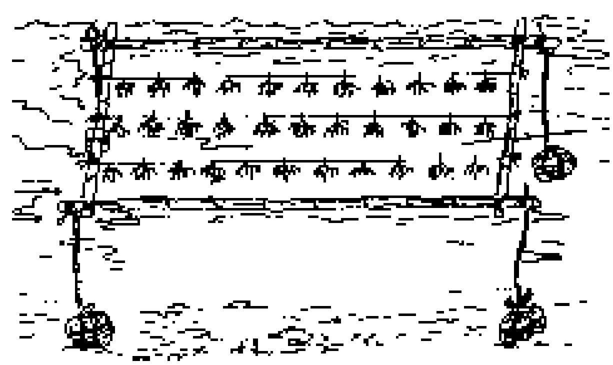
Sites

Seaweeds can be cultured in open water but they are frequently heavily grazed by fish. This may not be a constraint if there are large areas of seaweed culture but small plots tend to be heavily affected. *Gracilaria* can be grown in ponds if they are available and would be suitable in mudcrab ponds. *Eucheuma* and *Caulerpa* can not tolerate salinity below approximately 28 ppt so ponds are unlikely to be an option except during the dry season when pond salinity will not drop. These species may be suitable for small-scale culture inside pens used for other species, except rabbitfish, which will definitely eat the seaweed!

Open water sites should be protected from strong waves and current but have good water exchange. The depth should be at least 1m at low water. Sites with firm, sandy or rocky bottoms will probably be more desirable.

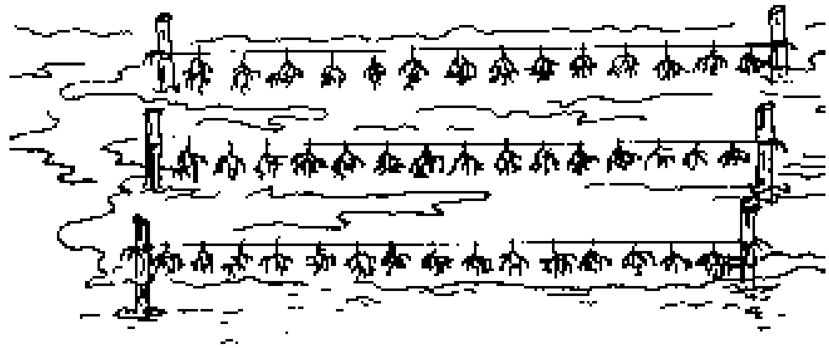
Culture methods

Bottom culture in ponds



Both *Gracilaria* and *Caulerpa* can be grown by planting small bundles of plant material in the bottom mud of a pond. Spacing would be about 15 cm for *Gracilaria* and 1m for *Caulerpa*. For more intensive culture in ponds dedicated to seaweed culture the addition of inorganic fertilizer would increase yields.

Lines and floats



Eucheuma and *Gracilaria* can be tied to lines attached to short posts, on rafts or on long lines suspended from floats. Experiment with different line available.

Various methods have been used and much depends on the local environment, the scale of production anticipated and the materials available. One can use simple rafts of a bamboo frame or other materials or lines attached to plastic bottles.

Tie cuttings or clusters of plant material to the lines at approximately 20 cm intervals.

Keep the plants and lines clean of other plants and debris.

Maintain the lines and floats in good condition.

Harvest

Harvest the plants after 35-45 days depending on the growth and the weight on the lines.

Clean the harvested plants of foreign material and select the best plants for stocking the next crop.

Processing and market

If the plants are to be sold dry, spread them on a raised platform or on cement pavement on top of a mesh net or dried coconut fronds.

Turn the plants regularly to promote drying and protect from rain.

The plants should be washed after drying for two to three days by placing them in a basket and shaking in seawater. Spread the plants out again to dry.

Other market products may be appropriate and if you are not familiar with how to prepare the plants consult people who are now harvesting them from wild stocks.

Advantages/Risks

Seaweeds are simple to grow but are at risk to grazing by fish. The equipment needed is not expensive and may be obtained with little or no cost. On the other hand, the market price is not high and commercial markets may require a considerable quantity to make the effort worthwhile.

This section was adapted from DENR. 1998. Sustainable Livelihood Options for the Philippines. Booklet 3. Department of Environment and Natural Resources, Philippines

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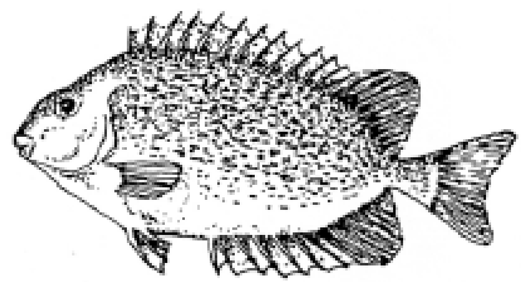
Rabbitfish

Rabbitfish or siganids (*Siganus* spp) are desirable fish on most markets. They are found in various coastal habitats usually associated with reefs and seagrass beds. They are herbivorous and unlike groupers are suitable for culturing in higher densities because they commonly occur in schools. (The technology discussed here may be useful for other herbivorous species.)



Sites

Site selection will depend on the culture method used. Pen culture may be more suitable for a larger effort and cover up to a hectare. Such a large pen may be suitable for a group or communal effort and would have other benefits in management of an area. Rabbitfish can be cultured in cages in a smaller area but this will require more frequent inputs of feed.

The culture site should be in an area where fingerlings are available. It may require some trials to assess the suitability of the species available. In the Philippines, *S. guttatus* has been found to be suitable.

The desired salinity should be determined by the tolerances of the species to be grown. Investigate this before selecting a site.

For pen culture the site should have natural feed available such as seagrasses. Much of the area can be shallow or even exposed at low tide as long as there are tidepools at least 1m deep within the area. The bottom should be sandy-to-muddy. The area should be protected from strong water currents and winds.

For a cage the site should be deep enough at low tide for the size cage to be used, with a buffer of at least 1m below the cage.

Culture methods

For pen culture enclose the area with a fence made of bamboo strips or other poles and nylon nets. The net should be at least 1 m higher than the highest high tide. Use a fine-mesh net reinforced on the outside with a stronger polyethylene net.

See the sections in this kit on fish culture for other ideas on pens and for cage designs. Note in particular the chapter on seabass.

Stocking

Collect fingerlings using a beach seine with fine mesh or whatever is used locally. If the fish are 1-2 cm in length (fry stage) they should be held in a cage or pen with mesh of appropriate size, approximately 0.5 cm mesh. These are often called a happas. Fry can be stocked at 600-1,000 fry/m3.

For fingerlings in a pen the recommended density is about 50,000 fish per 1 ha. This will require some careful monitoring as it depends conditions but mainly on food supply. (Large numbers can be "counted" by weighing a counted sample and then quickly weighing larger quantities using the number/kg from the sample to determine the count.)

Stocking a cage will depend on the frequency of feeding and water exchange and trials are recommended.

Feeding

The need to feed will depend on the conditions in the pen and the stocking density. Any additional food is likely to be of benefit in increased yield. Additional feed will be necessary in a cage. Try different foods available locally including seaweeds, rice bran, waste fish (if available.) or other plant material. Commercial fish feed can be tried if resources allow.

Try to monitor fish sizes and numbers and feed approximately 3-5% of the total fish body weight per day giving half the amount in the morning and the rest in late afternoon.

Monitoring of growth will indicate whether you are supplying enough food. Also monitor for signs of disease or stress.

Harvest

Determine the optimal size for the local market and try to harvest at that size. You should be able to reach 10-11 fish per kg in three to five months.

Seine the pen or pull up the cage and scoop out the fish.

Advantages and risks

Pen culture of rabbit fish requires a large area, which may be possible for a family but more likely is best done as a communal effort. This can be a productive venture as rabbit fish are primarily herbivorous and the cost of production should be low.

Pens and cages are subject to damage and losses but careful monitor should reduce the losses.

This section was adapted from Livelihood Options for Coastal Communities Volume II, IIRR and SMISLE 1998.

Prepared by:
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