MARINE FISH-MANGROVE AQUACULTURE

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I. Introduction

Aquaculture has often been blamed by environmental lobby groups as one of the main causes of mangrove destruction. In the Philippines, large areas of mangroves were converted through the years into fish and shrimp ponds.

There are aquaculture practices that can be done without destroying the existing mangroves. Mangrove-friendly aquaculture practices of different marine species such as extensive pond culture, culture of marine fish in a modified pond/pen system in mangrove, and cage culture of marine fish near mangrove areas are environment-friendly. These practices are described in this paper.

II. Species Selection

One of the first steps to consider in any aquaculture venture is the selection of species for culture. There should be a ready market for harvested fish either for local consumption or for export. The fish farmer should decide whether to culture a high volume and low price species or a low volume and high price species.

Some cultivable marine species are among the highest priced commodities. Depending on the species, the farm gate price of grouper species for example, varies from about US$ 8 for *Epinephelus coioides* to about US$ 40 per kg for *Cromileptis altiveles*. Other species such as siganids, red snapper, and sea bass are relatively cheaper than grouper (US$ 4-8/kg). Milkfish (*Chanos chanos*) is much cheaper than the other species mentioned (US$ 1-2/kg) but can be produced in large quantities and has a larger domestic market in the Philippines.

Another factor to be considered is the seeds for stocking which should be readily available. Although the seeds of cultivable species such as grouper and snappers abound in the wild, supply is mostly unreliable and highly seasonal.

At SEAFDEC Aquaculture Department, considerable progress has already been attained in the hatchery production of some high-value marine species such as siganid *Siganus guttatus* (Duray, 1998), mangrove red snapper *Lutjanus argentimaculatus* (Doi and Sighairaiwan, 1992), sea bass *Lates calcarifer* (Parazo et al., 1998), and grouper *Epinephelus coioides* (Duray et al., 1997; Toledo et al., 1996 and 1997). Milkfish fry on the other hand, has been routinely produced in hatcheries in the Philippines, Indonesia, and Taiwan.

The fish farmer should have a background on the biology of species to be cultured. Sea bass spawns in coastal areas near river mouths (Parazo et al., 1998).

Milkfish on the other hand, spawns in clear waters near coralline areas (Bagarinao, 1991). Spawned eggs develop, hatch, and newly-hatched larvae develops into juveniles in coastal areas. Juveniles move upstream in freshwater areas where they grow to more than 1.0 kg. Maturing sea bass and milkfish move downstream where final maturation and spawning take place. It is not yet known whether mature fish return upstream or stay in the sea to remature.

Groupers and snappers are known to spawn in aggregation near coralline areas (Polovina and Ralston, 1987). Spawned eggs and larvae move to coastal areas where the larvae develop to juvenile stage. Early juveniles of about 1 inch are caught using shelters made of twigs, bamboos, stones or their combination.

Species for culture should have a wide range of salinity tolerance. While milkfish and sea bass may be cultured in full fresh water, it is advisable to culture groupers, mangrove red snapper, and siganids in salinities higher than 15 ppt. Although some species of grouper, snapper and siganid can tolerate salinities of about 5 ppt, constant exposure of the fish to fluctuating salinities will be stressful.

III. Culture of Marine Fish in Modified Pond/Pen System

A. *Technical considerations*

1. Modified pond/pen culture

The modified fishpond/pen site for aqua-silviculture should be within the middle to lower end of the intertidal zone. Soil texture should be clay to clay loam to retain water during low tide and to have a good source of dike materials. Water source should be free from domestic and industrial pollution. Salinity for grouper, snapper, and siganids should be more than 15 ppt although they can tolerate salinities lower than 15 ppt.

The dike of the pond should have a height of at least 0.5 meter. Nets supported with bamboo slats are installed around the dikes with a height of at least 0.5 m higher than the highest high tide. A wooden or cement gate controls the inflow and outflow of water. Screen nets and bamboo slats are installed in the gate to prevent the entry of predators. Peripheral canals and connecting central canals are provided as shelters and for harvesting.

Extra care should be done in order not to damage the roots of mangroves when constructing the canals. Canals should not exceed 30% of the mangrove area.

Stocking of grouper, snapper, or siganids should not exceed 5,000 pc/ha. During the early culture period, fish may feed on natural food and prey on mysids, shrimps, and small fish. Feeding the fish daily with chopped trash may be carried out as the fish grows. Depending on the available food, fish may be harvested selectively after 6 months of culture. Survival at harvest should be from 20% to 65%.

2. Extensive pond culture

Fish production in this system utilizes existing large ponds of more than 1.0 ha per compartment. Since this is done extensively without or with limited supplemental feeding, organic wastes from this system may be readily absorbed by the environment. Before stocking, ponds are drained of water, and soil is dried until in cracks. Lime and chicken manure are then added at 1.0 mt and 0.5 mt/ha, respectively.

Commercial fertilizers may be added to enhance natural productivity of the pond. Predators are eliminated before stocking by applying tea seed powder or a combination of lime and ammonium sulfate at a ratio of 1 part lime to 2 parts ammonium sulfate.

Omnivorous fish such as milkfish and siganids may be stocked at a density of about 2,000 to 3,000 fingerlings/ha. Chicken manure or commercial fertilizers may be added between the culture period to maintain natural food production. Depending on food availability, harvesting can be done after 6 to 10 months of culture. Yield at harvest varies from about 600-800 kg for milkfish and 300-500 kg for siganid per crop.

In the extensive pond culture of carnivorous fish such as sea bass, grouper, or red snapper, the ponds are prepared as previously described. Adult tilapia of at least 10,000 individuals/ha are stocked one month before the stocking of the desired species. Once the tilapia reproduce in the ponds, sea bass, grouper, or red snapper may be stocked at a density of 3,000 individuals/ha. These carnivorous fish will prey on tilapia juveniles. Fertilizers are added if needed to maintain the natural food for tilapia.

Towards the end of the culture period, supplemental feeding of trash fish may be needed once the tilapia juveniles in the pond are almost consumed. Harvesting may be done after six months of culture. Survival of 40-85% and a yield of 700 to 1000 kg of carnivorous fish and about 100-300 kg of tilapia, can be attained using this system.

IV. Culture of Marine Fish in Floating Net Cages

A. *Introduction*

The culture of fish in cages is a century old practice. Cage culture started in China by using wooden box-like structures to grow freshwater fishes in rivers. It has evolved and developed over the years and is now an established industry for a variety of species such as salmon, yellow tail, and European sea bass.

Most if not all of the present cage culture systems are located in bays or lagoons protected from adverse weather conditions. Recently, cage culture in offshore areas using the latest technological advances has become popular. The deep waterways and rivers near mangrove areas offer similar conditions but these areas have not been fully utilized. This section describes a sustainable way of producing several species of marine fish near mangrove areas without destroying the existing mangroves.

B. *Technical Consideration*

1. Site selection

The site for a floating net cage farm should have a water depth of at least 3.0 m during the lowest low tide. Salinity should be from brackishwater to marine ($\geq$ 15 ppt). Although some marine fish species can tolerate a wide range of salinity, a site with a highly variable salinity should be avoided to minimize stress to the cultured species. The site should be free from domestic and industrial pollution, near the source of trash fish, and secured from poachers. It should also be readily accessible to the source of seeds and the market.

2. Species selection

Species cultured in floating net cages are usually those of low volume but high priced commodities. Groupers, mangrove red snapper, and sea bass are popularly cultured in this system because of their high market price. Seeds are available from the wild and hatchery production of the fry of these species have made considerable progress in the past decade. They can also tolerate a wide range of salinities.

Milkfish is presently cultured in floating net cages in the Philippines at high densities using intensive culture system. However, it has been reported intensive culture of milkfish in pens and cages in the Philippines have resulted in nutrient overload and plankton blooms in the surrounding waters.

3. Design and construction

A floating net cage is basically made of a raft, floats, and nets and is anchored. The raft is the frame or structure that supports the nets and the workers. It may be made of bamboo, lumber, G.I. pipes, or HDP (high density polyvinylchloride). The floats may be empty plastic or metal drums, styrofoam, wooden box, or HDP.

Nets in box or rectangular shapes are used to keep the culture species in place. Net material varies from nylon, polyethylene, polyester, or kuralon. Choice of the materials depends on the financial capability of the farmer. Bamboo frames, empty plastic drums, nylon or kuralon nets are widely used because they are relatively cheap.

C. *Operations and Management*

1. Nursery Phase

Grouper, sea bass, and red snapper fry of about one inch size should be reared in the nursery cages until they reach 3.0 inches. Size of nursery nets should be manageable for one or two persons. Sizes vary from 1x1, 1x2, or 2x2 m by 1.5 m deep with a mesh size of about 1-2 mm.

Initial stocking density is between 60-100 fry/m^3. Stocking should be done early in the morning or late in the afternoon. Fish should be fed to satiation 3 to 4 times daily. Natural food such as copepods, mysids, and small fishes may be attracted at night using a strong incandescent lamp positioned at the center of the nursery cages.

Since grouper, sea bass, red snapper are highly cannibalistic during the nursery phase, "size grading" should be done at least once a week. Fast growers should be taken out and transferred into separate cages during each grading. The fish may grow to 3.0 inches between 45 to 60 days with a survival rate of as high as 90%.

2. Production phase

The fishes are grown from fingerling to marketable size in the production net cages. These cages vary in shape (square, rectangle, circular) and size (from 2x2 m to 5x5 m) with mesh size between 0.5 to 2.0 inches depending on the size of the fish stocked. Although stocking density may be as high as 60 fish/m^3 the recommended sustainable density should not be more than 30 fish/m^3. Stocking should be done early in the morning or late in the afternoon when the weather is cool.

Fish should be fed daily following the sliding rule: initially at 10% then slowly reduce to 5% of the total fish biomass daily as the fish grow. To compute for the feeding rate, randomly sample and weigh 20-30 fish from each cage every two weeks, compute the average weight, multiply the average body weight with the total number of stocks in a cage (total biomass), then multiply with the feeding rate used.

Nets should be regularly cleaned to allow sufficient water inflow and outflow, and should be changed when excessive fouling is observed which hinders water flow. Nets should also be inspected regularly of any hole or damage to avoid the escape or loss of stocks. Drifting objects should be removed from the net in order to avoid possible damage. The conditions of the fish such as appetite, swimming behavior, and any sign of diseases should be monitored every day.

Selective harvesting may be done from four to six months after stocking the fingerlings when some of the stocks are more than 400g/fish. Stocks should not be fed a day before harvesting to empty the stomach. Since grouper, red snapper, and sea bass are usually sold live, harvesting should be done carefully to minimize stress and injury.

Harvested fish are temporarily held in conditioning tanks before packing where the water temperature is slowly reduced to 20°C within one hour. The temperature of the packing water should be similar with that of the conditioning water. Fish from the conditioning tanks are scooped individually, weighed, and transferred in packing bags.

Three to four fish (weight: 400-500g each) should be placed in double lined plastic bags with water depth just enough to cover the nostrils and eyes of the fish. The bags are inflated and sealed with rubber bands, and placed in plastic bags with sufficient ice to maintain low temperature during shipment.

V. Economic Consideration

A. *Assumptions*

1. Technical

a. Nursery phase (8 units 2x2x1.5m)

i.	Stocking rate	- 600 ind/cage
ii.	Survival	- 70%
iii.	Culture period	- 2 months

b. Production phase (4 units 4x4x2.5)

i.	Stocking rate	- 800 ind/cage
ii.	Survival	- 80 %
iii.	Culture period	- 8-10 months
iv.	No. of crops per year	- 1.5
v.	Total harvest	- 2,560 pc
vi.	ABW at harvest	- 500 g
vii.	FCR	- 4 kg
viii.	Selling price	- P250/kg

2. Financial

a. Miscellaneous cost is 2% of variable cost.
b. Caretaker's salary will be P1,000 per month.
c. Interest rate on investment is 8% per year.
d. Sales tax 1% of revenues.

B. *Cost estimates*

1. Development Cost

a. Cage frame and floats

i.	30 pc bamboos at P60/pc	- P 1,800
ii.	12 pc plastic drums at P1,000 each	- P 12,000
iii.	4 kg monofilament #180xP100	- P 400

b Nursery net

i.	1 roll 5 mm black net	- P 2,000
ii.	2 rolls 5 mm nylon rope at P200	- P 400

c Production net

i.	2 rolls 210D/32 kuralon net at P15,000	- P 30,000
ii.	5 rolls 5 mm nylon rope at P200 each	- P 1,000
iii.	5 spools 210D/32 kuralon twine at 200	- P 1,000

Total of development cost - P 48,600

2. Operating cost

a Variable Cost

i.	4800 pc grouper fry at P15 each	- P 72,000
ii.	5120 kg trash fish at P10/kg	- P 51,200
iii.	2 caretakers at P1,000/mo x 13 mo	- P 26,000
iv.	Miscellaneous cost	- P 2,984

Sub-total of variable cost - P152,184

b Fixed Cost

i.	Interest on investment	- P 3,888
ii.	Subtotal of fixed cost	- P 3,888

Total Operating Cost - P156,072

Total Investment - P204,672

3. Cost and return and partial budgeting analysis

a.	Sales: 2560 pc x 0.5 kg/pc x P250/kg	- P320,000
b.	Less: Operating Cost	- P156,072
c.	Net income before tax	- P163,928
d.	Net income after tax	- P162,288.72

Conversion Rate: 1 US $ = 38 Philippine Peso (P38)

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