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SEAFARMING AND SEARANCHING IN SINGAPORE

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ABSTRACT

Seafarming in Singapore is described in detail, covering farm design and structure, site selection criteria, current farm practices, farm operation and maintenance, species for culture, and diseases and their control.

Searanching has not been done in Singapore. Results of related work on fish stocking is briefly reported.

SEAFARMING: SPECIES CULTURED AND PRODUCTION STATISTICS (1988-1990)

Farming in floating net cages accounts for the bulk of food fish produced in Singapore. In 1988, 1,972 tons from Seafarming were produced. Fishes (471 tons, 23.9%) were mainly the sea bass (235 tons, 11.9%), groupers *(Epinephelus tauvina, Plectropomus maculatus, Cromileptis altivelis)* (141 tons, 7.1%), golden snapper *(Lutjanus johni,* 49 tons, 2.5%), and others like the yellowfin jack *(Caranx ignobilis),* golden trevally *(Gnathodon speciosus),* bream (*Acanthopagrus* sp), and rabbitfishes *(Siganus canaliculatus* and *S. guttatus)* (46 tons, 2.3%). Shellfishes (1,501 tons, 76.1%) were mainly the green mussel *(Perna viridis,* 1,191 tons, 60.4%), mangrove crab *(Scylla serrata,* 256 tons, 13%), banana shrimp *(Penaeus merguiensis,* 30 tons, 1.5%), and spiny lobster *(Panulirus polyphagia,* 24 tons 1.2%).

In 1990, the 1,856 tons production from Seafarming was fish (614 tons, 33.1%), mainly the sea bass (304 tons, 16.4%), groupers (186 tons, 10%), golden snapper (49 tons, 2.6%), yellowfin jack, golden trevally, and bream remained as minor species (59 tons, 3.2%). New fish species that have become popular are the humpheaded wrasse (*Cheilinus undulatus*, 4 tons, 0.2%) and gibbus snapper (*L. gibbus*, 11 tons, 0.6%), and shellfish (1,242 tons, 66.9%) are mainly the green mussel (1,014 tons, 54.6%), mangrove crab (151.5 tons, 8.2%), banana shrimp (39 tons, 2%), and spiny lobster (37.5 tons, 2%).

Over the period 1988-1990, fish production increased by 34.3% (143 tons). This was due to increases in production of popular species like the sea bass and groupers (especially the red grouper) and the demand by the Hong Kong market for high priced, new species like the humpheaded wrasse and gibbus snapper, which are imported for culture. Shellfish species like the spiny lobster have increased in popularity both locally and overseas. Production increased from 24 tons in 1988 to 37.5 tons in 1990. Green mussel and mangrove crab production decreased. Mangrove crab imports from Indonesia and Sri Lanka are more frequent, but more consignments are now being directly channelled to retail outlets because of high local demand. The Primary Production Department (PPD) established a Marine Fish Farming Scheme and enacted the Fish Culture (Control and Licensing) Rules in 1981. Floating fish farms are licensed at S$500 annually for an area of 0.5 hectares. Fourteen fish farms are associated with palisade fish traps. This is about half of the palisade traps still existing, and demonstrates that fish farming is a more lucrative activity.

CULTURE SYSTEM IN SEAFARMING

The floating cage system is presently the only one used for the culture of fishes and crustaceans. The design of the farm structure has generally remained unchanged and is basically a wooden pontoon (32-55 wood pieces, depending on size) of joined wooden frames (mostly 3x3 meters) provided with a work house. The structure is floated by plastic or molded drums, usually of 200-250-liter capacity. The actual farming structure is about 1,500 square meters and is anchored within the licensed space of 5,000 square meters. Polyethylene net cages, in which fish or crustaceans (like shrimp and lobster) are cultured, are suspended from the frames. Cage design and materials vary according to the type of animal being cultured, namely fish, shrimp, lobster, or crab.

Green mussels are farmed on ropes suspended on floating rafts. The design of the floating raft for mussel farming is also a wooden pontoon floated by plastic drums. The pontoon has cross beams for suspending culture ropes. Each pontoon may be 5x5 meters, 15x5meters, or 15x10 meters, and is located in sheltered coastal waters of 8-10 meters depth at low tide, with the long axis parallel to the tidal current. Spats are collected on 2 meters of nylon ropes. Mussels are grown out on 2-4 meters of polyethylene ropes tied at intervals to pieces of old netting material and immersed at four ropes to one square meter.

The systems that are described are based on prototypes developed by the PPD in the early 1980s. Information is available in handbooks published by the PPD. The Marine Aquaculture Section (MAS) provides field and other services as and when required. Commercial farm structures are made by the fanners themselves or the work is contracted out to carpenters and experienced palisade trap operators. Cages are constructed by the farmers or contracted out to fishermen. Net cage designs are also provided by the PPD.

FARM SITE SELECTION FOR SEAFARMING

Site selection criteria, as laid down by the PPD, are based on factors like the availability of sheltered water area such as the Johor Straits where all Seafarming activities are presently found and the physical, chemical, and biological characteristics of the water. Water depth is at least 5 meters for standard net cages of 3 meters deep. This gives the net cage bottom a clearance of 2 meters at lowest water. Maximum depth of the selected site is less than 20 meters to facilitate anchoring of the farm structure, otherwise this becomes difficult and more costly. Other physical criteria are wave height (less than 2 meters), tidal current characteristics such as current velocity (less than 50 centimeters/second), water turbidity (less than 10 milligrams/liter), and water temperature (27-31°C).

Chemical criteria such as salinity, dissolved oxygen, pH, organic nutrient, and heavy metal loads are also taken into consideration in site selection. Salinity is in the range of 26-31 parts per thousand; dissolved oxygen, greater than 5 parts per million; pH, 7.8 - 8.3; organic load as Chemical Oxygen Demand, less than 3 parts per million; nutrient load as ammonia-nitrogen, less than 0.5 parts per million, and heavy metal loads of less than 0.0004 parts per million for mercury, less than 0.01 parts per million for copper, less than 0.03 parts per million for cadmium, less than 0.1 parts per million for lead, nickel, zinc, and antimony, and less than 1 part per million for manganese, iron, chromium, and tin.

Biological criteria are the intensity of fouling by organisms such as the brown mussel (*Modiolus* sp.), green mussel, marine worms, tunicates, bryozoans, and algae; and frequency and occurrence of phytoplankton and dinoflagellate blooms. Deterioration and sudden changes in the environment, such as the non-toxic dinoflagellate blooms of *Cochlodinium* sp., result in fish mortalities or disease outbreak because of stress to the fish. Mortality is further aggravated by the crowded conditions in intensive culture, off-feeding and restlessness. Economic losses can be significant as mortalities can range from 10-100%. Fortunately, this problem is infrequent and more oxygen can be made available to the fish through aeration and agitation of the water.

Oil spills also affect the availability of dissolved oxygen. Strict enforcement of sea traffic regulations, high standards in water pollution control, and the excellent flushing effect of tidal currents minimize oil pollution and mitigate its effect. Fish farming activity is also kept away from the major navigational channels as a precautionary measure. With early warning of an oil spill, net cages can be protected by a canvas shield around the farm structure since the oil usually occupies the top 0.5 meters of the water. Fish are not fed during an oil spill since this causes unnecessary disturbance of the water and also increases oxygen demand.

SEAFARMING METHODOLOGY

The PPD has laid down guidelines for husbandry and farm management. Farmers have also learned from experience, and made their own improvements and innovations.

SPECIES SELECTION

Potential aquaculture species fulfill the criteria of high market demand, seed availability, and intensive stocking. Other than the species commonly cultured, potential species for Seafarming are the threadfin (*Polynemus sexfasciatus*), gibbus snapper, and brown-marbled grouper. Shrimp species with potential are more suited for land-based farming systems.

STOCKING, HARVESTING, AND TRANSPORTATION

The PPD has published guidelines for stocking of fingerlings and grow-out sizes. After 6-8 months, the fish are about 35 centimeters (700 grams) and 1.5-2.0 tons or more are harvested per 5X5X3 meters net cage with 90% survival.

In practice, most fish for culture are purchased as small fingerlings of 3.0-7.5 centimeters (2-6 grams) because they are cheaper and easier to transport. Some of the consignments are sanitized on-farm to get rid of ciliate parasites. The farmer frequently culls and transfers the largest and smallest individuals to other net cages. In about 1-2 months, most of the stock are ready for grow-out.

Harvested fish are transported in aerated fiberglass tanks on small boats to landing points where they are transferred into aerated large fiberglass tanks on lorries which bring them to restaurants and other destinations.

FEEDS AND FEEDING

Trash fish is still used as feed in Seafarming. Supplementary supply comes from the waste catch of palisade traps.

Fingerlings are fed minced or finely chopped trash fish, while grow-out fish are fed trash fish chopped to various sizes. Feeding is done twice daily, usually in the morning and towards evening, and at slack tide when the tidal current is weakest. This minimizes losses from feed swept away by the tidal current. Trash fish is fed to the cultured animals in small quantities at a time to cut down on wastage. Fingerlings are given trash fish up to 10% of their weight daily, while fish in their early grow-out stage are fed up to 8%. Late grow-out fish are fed 3-5% until they attain 600-800 grams. Food conversion ratio (FCR) is about 5-6:1.

The MAS conducts studies to evaluate nutritional requirements of the sea bass and digestibility of feed materials with the aim of formulating low cost diets, which give optimal performance. Other studies have included the use of deep net cages for fish culture and using dry pelleted feed dispensed by automatic feeders.

DISEASE AND CONTROL

Diseases do not reach epizootic proportions, and serious mortalities are usually confined to the farm, affecting fish in net cages within close proximity-Diagnostic services are available to fish farmers who consult MAS. Farmers are also taught to recognize early signs like off-feeding and abnormal swimming behavior and to detect and treat common diseases. They can consult the PPD's Fisheries Handbook on Common Diseases of Marine Foodfish.

Common diseases are bacterial infections caused by *Vibrio parahaemolyticus* and *V. algynoliticus,* which are present in coastal waters and are opportunistic, causing secondary infections in cultured fish under stress. Ectoparasite infestations are caused by ciliates, *Cryptocaryon irritans, Trichodina sp., Brooklynella* sp., and the digenean trematode *Diplectanum* sp. The presence of a picorna-like virus in the brain of imported young sea bass fry and fingerlings may explain high mortalities encountered by farmers, besides those caused by transportation stress. The extent and value of fish losses have not been estimated, but stress and disease can account for 20-80% loss in the first few weeks after stocking.

Control of disease by preventive measures and the practice of good farm management is by far the most effective. Deterioration and sudden changes in the environment have been linked to mortalities or outbreaks of diseases in cultured marine fishes, disease and mortality being often the result of stress. Plankton blooms are usually due to diatoms or dinoflagellates and last for about 5 days. So far, these blooms have not been toxic, However, annual fish losses due to non-toxic plankton blooms are second in importance only to mortalities caused by transport stress. Neap tides concentrate blooms over fish farming areas. Immediate fish kills are apparently caused by asphyxiation. A week or two later, deaths from secondary bacterial infections reach their peak.

The protection of farmed fish lies in minimizing contact between fish and plankton blooms. This is done by (1) using deep cages in areas where conditions are favorable, thus allowing fish stocks to stay below, (2) wrapping the entire farm's perimeter with a 2 meters deep canvas shield to prevent entry of the bloom into the cages, (3) pumping air at high pressure and volume on to net cage bottoms, and (4) drawing up bottom water and spraying on to net cages, or (5) towing the farm sections to safer areas.

FARM OPERATION AND MAINTENANCE

Farm operation involves mainly net cage changing and cleaning, and the husbandry practices described. The net cage is cleaned monthly. Fouling is removed by high pressure water jet. Net cages are dried and checked for damage.

The raft structure is repaired every 1-2 years and metal parts replaced every 1-3 years. Fouling on drum floats that are usually plastic drums is removed every 2-3 months by scraping and repainting with antifouling paint. Farms that are floating with dangerously low freeboard are contacted by the PPD for rectification to be made.

SEARANCHING

Searanching is not done in Singapore, although a preliminary study on the rehabilitation of a part of Singapore River was made in July 1986-December 1990, including artificial seagrass implantation. Results showed that sea bass, stocked at Boat Quay made-their niche in the vicinity, and that artificial seagrass provides a good hiding place for sea bass and indigenous fauna. However, heavy siltation caused the strands to collapse and to reduce the availability of hiding space after about 2 weeks.

An effective searanching program for Singapore would require the necessary expertise, staff and facilities, identification of suitable locations, establishment of a fish stocking program assessment of appropriate methodology, and making improvements in fish stocking methods including studies on artificial habitats and audio recall.

REFERENCES

Anon. 1986. Manual on floating netcage fish farming in Singapore's coastal waters, 1986. Fisheries Handbook No. 1. Primary Production Department, Republic of Singapore. 17 p.

Chong YC, Chao TM. 1986. Common diseases of marine foodfish. Fisheries Handbook No. 2. Primary Production Department, Republic of Singapore. 34 p.

Anon. 1988. Training manual on marine finfish netcage culture in Singapore (Prepared for the Marine Finfish Netcage Culture Training Course), ASEAN/ UNDP/ FAO Regional Small-Scale Coastal Fisheries Development Project, Manila, Philippines, UNDP/ FAO Regional Seafarming Development and Demonstration Project, September, 1988, UNDP/ FAO RAS/86/024, ASEAN/ UNDP/ FAO RAS/84/ 016. 291 p.

Chou R. 1989. Singapore country paper on the progress of Seafarming activities, Research and Development. Third National Coordinators Meeting of the Regional Seafarming Development and Demonstration Project, 24-27 August 1989, People's Republic of China. 21 p.

Cheong L. 1990. Aquaculture development in Singapore, p 325-332. In: Aquaculture in Asia. Mohan Joseph (Ed.). Asian Fisheries Society, Indian Branch. 395 p.

Cheong L, Lee H.B. 1984. Mussel farming. SHFIS Extension Manual Series No. 5. 51p.

Chou R. 1990. Singapore country paper on the status of disease and health management of cultured fish in Singapore, Workshop on Fish Disease and Fish Health Management in the Asia Pacific Region, 8-15 October 1990, Pusan, Republic of Korea. 8 p.

Chou R. 1991. Singapore country paper on fish nutrition and feed development, ASEAN-EEC Aquaculture Development and Coordination Programme (AADCP) Component 4 (Singapore) Fish Nutrition Workshop, 28-29 June 1991, St Pee sur Nivelle, France. 20 p.

Chou R. 1991. Natural constraints and incentives for coastal aquaculture development in Singapore. ASEAN-EEC Aquaculture Development and Coordination Programme (AADCP) Component 3 (Indonesia) Workshop on the Natural Constraints and Incentives for Coastal Aquaculture in Southeast Asia, 13-15 June 1991, Nantes, France. 14 p.