Eco-Friendly Fish Farm Management and Production of Safe Aquaculture Foods in the Philippines

Rafael D. Guerrero III
Philippine Council for Aquatic and Marine
Research and Development
Los Baños, Laguna, Philippines 4030
pcamrd@yahoo.com

Abstract

Aquaculture or fish farming is a major industry in the Philippines contributing significantly to food security, livelihood and the economy. The major commodities produced are seaweeds, milkfish, tilapia, shrimp, oysters and mussels in extensive, semi-intensive and intensive culture systems in ponds, pens, cages and open coastal waters.

Eco-friendly fish farm management is applied in brackishwater ponds for the culture of milkfish and shrimp. The negative impacts of intensive shrimp farming brought about by diseases due to "self-pollution" have been successfully addressed with technological innovations. Good management practices are needed to reduce the losses in freshwater and marine cages and pens attributed to heavy organic loading of open waters that result in massive fish kills. Ecological enhancement of production systems has been achieved with genetic improvement of species, disease prevention, and use of substitutes for "trash fish."

International, regional and national guidelines for responsible aquaculture through Codes of Conduct and Fisheries Administrative Orders are in effect in the country to ensure the quality and safety of aquaculture foods and other products.

Keywords: Eco-friendly, Fish Farm Management, Aquaculture Foods, Food Safety, Philippines

Introduction

Aquaculture or fish farming is an age-long industry in the Philippines that dates back to the pre-colonial period in the 1500s (Rabanal, 2000). In 2004, the aquaculture sector of the country contributed 43.7% with a value of US$896,445 to total fisheries production (Table 1). The major aquaculture commodities produced are seaweeds, milkfish, tilapia, shrimp, oysters, mussels and carp (Table 2).

While the Philippines is a net importer of foods (i.e. cereals and meat), it is also a net exporter of fisheries products (e.g. tuna, shrimp, seaweeds). Fish and other aquatic products comprised 56% of the total animal protein consumed by Filipinos on a daily per capita basis in 2003. The aquaculture sector is estimated to provide livelihoods to over one million Filipinos and contributed 1.8% to GDP in 2004 (BFAR, 2005).

Fish farming in the country is done in extensive, semi-intensive and intensive culture systems in ponds, pens, cages and coastal waters. In 2004, brackishwater ponds produced the bulk of total fish production followed by freshwater ponds, freshwater cages, freshwater pens, marine cages and marine pens (Table 3).

With the increasing demand for fish for human consumption and other aquafarmed products for supplying export markets (e.g. US, Japan and EU), the aquaculture sector has been given high priority in the Medium-Term Philippine Development Plan (2004-2010). In the Comprehensive National Fisheries Industry Development Plan for 2005-2006 (Cruz *et al.,* 2006), aquaculture is expected to produce 842,674 metric tons by 2010, an increase of 35% over that in 2005.

For sustainability, aquaculture or fish farming should be "technically appropriate, economically viable, socially acceptable and environmentally sound" (FAO, 1988).

This paper shall review the eco-friendly fish farm management and production of safe aquaculture foods in the Philippines.

Eco-Friendly Fish Farm Management

Fish farming in the Philippines can be categorized by culture system into: (1) brackishwater ponds, (2) freshwater ponds, (3) freshwater pens/cages, (4) marine pens/cages, (5) open coastal waters, and (6) integrated farming systems. For purposes of this paper, only eco-friendly traditional and innovative management practices will be discussed with insights on technological, environmental and socioeconomic concerns.

(1) Brackishwater Ponds

The extensive culture of milkfish (*Chanos chanos*) with other brackishwater species as shrimps (*Penaeus monodon* and *Metapenaeus ensis*) and mudcrab (*Scylla spp*.) in ponds developed from former mangrove areas is still the predominant type of aquaculture in the country. Traditionally, such ponds depend on tidal water flow and are cultivated for filamentous algae or lab-lab growth with or without fertilizers (organic and inorganic) and stocked with milkfish fingerlings at densities at 500-1,500/ha per crop of 4-5 months. Yields of such ponds are 0.5 – 1 mt/ha/crop.

An innovation that has enhanced the productivity of milkfish in brackishwater ponds is the modular system introduced in the 1970s. The system consists of a series of ponds with progressively increasing areas (e.g. 1, 2 and 4-hectare ponds) to allow movement of fish from one pond to another as natural food is consumed. The method has increased the production of the traditional system from 2 tons/ha/yr to 3 tons/ha/yr or more.

Control of snail pests (e.g. *Cerithidea cingulata*) and fish predators such as the tarpon (*Elops hawaiiensis*) and tarpon (*Megalops cyprinoids*) in brackishwater ponds in the past was with non-environmentally friendly organo-phosphate and tin-based chemicals which are now banned. The eco-friendly pesticides now recommended are the imported metaldehyde (for snails) and tea seed cake powder (for fish). The former is a highly selective molluscicide that is readily degraded and non-toxic to fish.

With the intensification of tiger shrimp (*Penaeus monodon*) culture in the 1980s, viral and bacterial diseases came about in the 1990s due to "self-pollution" and decimated the shrimp farming industry. From a high production of 90,426 metric tons in 1984, the production dropped to 25,000 mt in 1994. In Negros Occidental, the leading province in the Philippines for intensive shrimp culture, only 20% of the 2,500 hectares of ponds was operational due to vibriosis caused by *Vibrio harveyi*.

The use of antibiotics (e.g. chloramphenicol and nitrofurans) was the first line of defense against the bacterial pathogens applied by shrimp farmers in the Philippines at the height of the disease debacle. With the indiscriminate use of such chemicals, the potential hazard to human health and possibility of bacterial resistance development have been of major concern. The use of antibiotics for shrimp culture in the country is now discouraged, if not prohibited.

Through eco-friendly methods such as the use of reservoirs with "green water," probiotics, sedimentation ponds with biofilters, and recirculating water systems, the prevention of virulent bacterial outbreaks has been possible. Disease prevention is much dependent on good environmental management (Corre *et al*., 1999).

A 1:1 culture pond to reservoir area ratio is recommended. Water in the reservoir is allowed to settle for at least 7 days. Fish (e.g. tilapia) with a biomass of 3-3.5 tons/ha is stocked in the reservoir at 20,000 – 30,000/ha for the maintenance of "green water" with blooms of beneficial microalgae like *Chlorella* which has a suppressive effect on *V. harveyi*. The fish can also be stocked in a cage inside the shrimp pond.

Probiotics are beneficial bacteria capable of repressing the growth of pathogenic organisms either through the production of inhibitory substances or by competition (Moriarty, 1998). Regular application of probiotics is done to maintain the desired population of good bacteria and improve water quality.

Sedimentation of water treatment ponds and canals which are 10-20% of the shrimp culture pond area allow the settlement of bacteria-laden organic matter in the effluent before it is released to the outside or recirculated back to the reservoir. The use of biofilters like seaweeds and oysters as "clean-up agents" in the discharge water is also applied. The cost and return analysis for the use of a reservoir and probiotics for a one-hectare intensive culture pond showed that the return-on-investment was 26.8% (Corre *et al*., 1999).

The screening of shrimp postlarvae for detection of viral pathogens using the polymerase chain reaction (PCR) technique in laboratories of the Philippine Bureau of Fisheries and Aquatic Resources (BFAR) and other institutions has helped in mitigating the spread of viral diseases in the country. Specific pathogen-free (SPF) and specific pathogen-resistant (SPR) broodstock of the Pacific white shrimp (*Penaeus vannamei*) from the United States have been imported and are currently being reproduced by the BFAR for grow-out by accredited shrimp farmers.

(2) Freshwater Ponds

The Nile tilapia (*Oreochromis niloticus*) is the main species produced in freshwater ponds with an area of 14,531 hectares, production of 71,831 mt and productivity of 4.9 mt/ha/yr in 2004 (BFAR, 2005). The fish is largely grown in earthen ponds (0.5 – 1 ha) with semi-intensive and intensive culture systems using fertilization, supplemental feeds (agricultural by-products) and commercial feeds.

Gains in the productivity of tilapia ponds have been achieved with the culture of monosex fish produced through sex reversal and genetic improvement programs that have resulted in fast-growing strains such as the GIFT, GET EXCEL, FAST and GENOMAR Supreme.

No serious disease outbreaks of Nile tilapia ponds have occurred in the country. Fish mortalities, however, have been reported in areas where poor management practices (e.g. overstocking and overfeeding) have caused water quality deterioration.

(3) Freshwater Pens/Cages

Fishpens are enclosures of synthetic nets (with no bottoms) supported by structures in shallow lakes for fish rearing. Culture of milkfish in pens began in the Philippines in 1971 in Laguna de Bay, the country's largest lake. At such time, fingerlings were stocked at 20,000 – 40,000/ha and grown to marketable size (250 grams or more each) in 4 –6 months with only the natural food in the lake.

With the deterioration of the lake's water quality in the 1990s due to land-based pollution, however, the need for artificial feeds for growing the fish made such operation less profitable. In 2001, the bighead carp became the dominant species cultured in the fishpens of Laguna de Bay because of its ability to extract the natural food in the lake more efficiently than milkfish.

The Nile tilapia is also the dominant species cultured in freshwater cages, structures made of net enclosure (with bottoms) that are either suspended or floating in shallow or deep lakes. Productivity of the cages (10 x 10 x 5 – 12 x 12 x 8 m) was estimated to be 18.8 mt/ha/yr in 2000.

With fingerlings stocked at 5,000 – 30,000/cage, marketable fish (150 – 250 g) are harvested after 4 –6 months of culture depending on the productivity of the lake and culture management. The overstocking and overfeeding of the fish in cages in Lake Taal have resulted in fish kills due to heavy organic loading that has caused dissolved oxygen depletion with water quality deterioration and lake overturns.

Rosana and Salisi (2002) reported the occurrence of 52 fish kills in Lake Taal for the period March 1999 – June 2001 which exacted heavy economic losses on cage operators. They also found that stocking densities of 10,000 – 30,000/cage gave positive returns to the farmers compared to higher densities. De la Vega (2002) recorded 2.6 kg of wasted feed per cage per day which amounted to 2,500 mt of wasted feed with a value of US$800,000 from 8,000 cages.

The need for regulating the number of cages and the culture management practices of cage farmers has been strongly advocated by authorities. Guidelines for the establishment of fish cages in lakes and coastal waters have been formulated to provide local government units and operators with information for making cage farming "sustainable, socially acceptable and environmentally sound" (Querijero *et al.*, 2006).

(4) Marine Pens/Cages

With the country's extensive coastal waters, the commercial mariculture of fishes in pens and cages came about in the mid-1990s following the success in the artificial breeding of milkfish and the availability of commercial feeds. The technology for marine cage culture of milkfish was first demonstrated by the private sector using 20-m diameter circular cages with depths of 6-12 m from Norway. With stocking of 100,000 fingerlings (5g mean wt.) per cage, 61.2 tons of fish weighing 0.6 kg each after 5 months of culture, survival of 93% and feed conversion of less than 2, were obtained. An operating cost of US$31,600 per cage and net income of over US$40,000 were reported (Guerrero, 1998).

With the initial success, there followed a boom in the cage and pen culture of milkfish in the coastal waters of Pangasinan in Luzon, Philippines. In 2001, it was estimated by Cruz (2006/a), that there were 2,400 cage units (9 m^2/cage) in the country with an average yield of 7.5 kg/m^2 producing 1.5 mt/cage/crop per year.

The uncontrolled proliferation of milkfish cages/pens in Bolinao, Pangasinan reduced the water current speed by 40-60% in the bay and caused the drop in dissolved oxygen values below the optimum level of 5 mg/l during neap tides with the high organic loading from fish wastes and excess feeds (Jacinto, 2006). Consequently, massive fish kills occurred with losses estimated to be over US$12 million.

Learning from costly lessons, the local government of Dagupan City in Pangasinan has enacted an ordinance for the zonation of its coastal waters and regulation of the marine pens/cages therein (Cruz pers. comm.). Mariculture zones throughout the country have been identified by the BFAR.

Aside from milkfish, high-value fishes such as groupers, seabass, snapper, pompano, cobia and siganids are also now commercially cultured in marine pens/cages in certain areas of the country. However, there are constraints on the availability of fry for stocking and trash fish for feeding as well as diseases, particularly for the growing of groupers.

(5) Open Coastal Waters

The culture of seaweeds, oysters and mussels in open coastal waters has been a boon to small fisherfolk as a supplemental and/or alternative livelihood to fishing. Cultured red macroalgae or carrageenophytes (i.e. *Kappaphycus* and *Eucheuma*) represent more than 70% of the total aquaculture production of the country and are among its top exports. Oysters and mussels, on the other hand, contribute only 1.8%.

Seaweed farming is relatively simple with the growing of seedstocks or cuttings attached to plastic monolines suspended in the open sea. The plants are grown without the benefit of artificial fertilization and are harvested after only 45-60 days depending on the locality, season and plant variety. In a 0.5-ha farm using the fixed bottom monoline method in shallow waters, as much as 24 tons of fresh seaweeds can be produced per crop of two months with five croppings in a year.

A more eco-friendly method of seaweed culture is the use of floating rafts in deep waters. This method is non-destructive to the bottom ecosystem and produces 50% more yield compared to the bottom method because of the better water quality, lesser predation of rabbitfish and reduced fouling by other plants that compete with the seaweeds for nutrients and sunlight.

Varietal selection of red seaweeds has been done for improving growth rate, disease resistance and carrageenan yield of cultured plants. In field tests, *Kappaphycus* Sacol variety had the best growth and resistance to "ice-ice" (a disease related to adverse environmental conditions such as high temperature and poor water circulation) in Batangas and Bohol. In Tawi-Tawi, the *Eucheuma* cultivars had faster growth compared to the *Kappaphycus* cultivars. In terms of carrageenan yield, the *Kappaphycus* Sacol-Bohol variety gave the highest yield in Batangas followed by the local *K. alvarezii* cultivars (Guerrero, 2001).

Oyster farming has been practised in the Philippines since the early 1900s. It is simple and appropriate for providing supplemental and/or alternative livelihood to subsistence fisherfolk in estuaries with muddy bottom and rich in the natural food (plankton) of the filter-feeding bivalve. In the traditional culture method, bamboo poles are staked to the bottom for attachment of the oyster young (spats) that grow to marketable size in 6-8 months. A production of 2.5 $kg/m^2/yr$ is reported. The use of rafts for the hanging culture method for oysters is more eco-friendly than the stake method because it causes less siltation and pollution on the ecosystem. Contamination of oysters with domestic sewage and pesticides in the effluent of fishponds is a food safety concern in certain areas.

Traditional green mussel (*Perna viridis*) farming in Manila Bay is similar to that for oyster culture using bamboo poles that are staked to the bottom at a spacing of 2 meters. An innovation in mussel culture developed by a Filipino farmer is the use of the net method which is more productive and efficient than using bamboo poles alone. The method uses only 2,000 bamboo poles for hanging the polyethylene net (4-inch mesh) in the sea compared to 5,000 poles in the old method. The yield with the new method is 30 tons of mussels more per hectare compared to that of the old one. Moreover, the nets last much longer than the bamboo poles (Guerrero, 1999). The occurrence of "red tides" caused by harmful algal blooms (e.g. *Pyrodinium bahamense*) in some areas of the country has adversely affected mussel farming.

With the progress achieved in the hatchery production of juveniles of the sea urchin (*Tripneustes gratilla*) and abalone (*Haliotis asinina)* in the country, culture of the same in grow-out cages with feeding of the macroalgae, *Sargassum* and *Gracilaria*, is now being piloted for commercialization in the coastal waters of Pangasinan for sea urchins (Juinio-Menez *et al.*, 2001) and of Guimaras for abalone (SEAFDEC/AQD, 2004).

(6) Integrated Farming Systems

Integrated farming systems that utilize the resources and enhance the benefits of two or more culture methods are efficient and cost-effective. The integration of aquaculture with other production systems as agriculture and forestry has been widely applied in the Philippines.

A 1,000-sow level hog farm in Negros Occidental does not pollute the environment by utilizing its wastes for biogas generation and tilapia production. The 0.5-ha grow-out ponds of the farm are stocked with Nile tilapia fingerlings (0.5 g) at 2-3/m^2 and fertilized with regulated amounts of effluent from the washings of the pig houses. With natural food produced in the ponds through controlled organic loading, the sex-reversed fish grow to an average market-size of 150 g each with a survival of 75-80% in four months. The cost of production is much less than that with feeding of the fish with commercial feeds (constitute up to 70% of the operating expenses of intensive culture system) while protecting natural water bodies from organic waste pollution (Guerrero, 2000/a).

The integration of mangrove forests with aquaculture has been promoted by the Aquaculture Department of the Southeast Asian Fisheries Development Center to reduce the impacts of aquafarms on the environment. Natural stands of mangroves in the ASEAN Region contribute 21% (1.4 million tons) annually to the inshore capture fisheries (Singh *et al.*, 1994). Primavera (2000) reported that the culture of seaweeds, mollusks and fish in cages in sub-tidal waterways is compatible with mangroves and amenable to small-scale farming operations.

The ecological role of mangroves is manifold. Aside from the many forest products that they provide and the vast biodiversity that thrives in them, mangroves serve as a vital nursery ground for a host of crustaceans, mollusks, fishes and other organisms, and as a "carbon sink." They also protect the shoreline from erosion and damage due to wave action.

The use of mangrove filters for absorbing effluents of intensive shrimp culture ponds is now highly recommended in the region (Primavera, 2000; Baliao and Tookwinas, 2002). It has been estimated that 2.91 – 6.54 hectares of mangroves are needed to treat the nitrogen waste from a one-hectare intensive shrimp culture pond with stocking densities of 10-30 postlarvae/m^2. Mangrove to pond ratios of 7.82 – 2.7 hectares for intensive shrimp culture ponds are recommended to efficiently treat the effluent.

Among the mangrove-friendly aquaculture systems tested, the pen culture of mudcrab (*Scylla sp*.) in mangrove areas that are minimally disturbed has been found to be the most lucrative and eco-friendly (Primavera, 2005).

In a mangrove pen (400 m^2) stocked with mudcrabs (150-200 g each) at 5-7/m^2 for fattening, the crabs attained weights of 200-250 g each after 10-15 days of culture with feeding of trash fish and "golden apple snail" (*Pomacea canaliculata*) meat. With a crab survival of 80%, a net income of US$0.80 per kilogram of the harvested crab was obtained (Guerrero, 2000/b).

The use of fisheries by-catch or trash fish for aquaculture particularly for the feeding of carnivorous species such as catfish, grouper and mudcrab is considered non-sustainable. Conversion of trash fish into processed foods for human consumption is believed to be a more efficient way to utilize such a resource (Anon., 1998).

A substitute for trash fish commonly used by fish farmers in the Philippines for the feeding of shrimp, prawn, mudcrab and carnivorous fishes is the *P. canaliculata* which is a pest of irrigated rice fields. The snail is gathered by-hand from infested areas and sold fresh to fish farmers who process it for feeding to cultured species. The regular supply of the snail, however, is not ascertained and its contamination with rice pesticides is a possibility.

Another potential substitute for trash fish that is of high quality and economical to produce at the level of small-scale farms are composting earthworms (e.g. *Eudrilus eugeniae*). In field studies, Cruz (2006/b) found that live *E. eugeniae* (aka “African nightcrawler”) could be produced at US$0.20/kg using agricultural wastes (e.g. rice straw and animal manures) and suggested its feasible replacement of trash fish for farm-made moist feeds. A fish farmer in Bukidnon operating an African catfish (*Clarias gariepinus*) hatchery uses municipal solid wastes to produce *E. eugeniae* for fry/fingerling feeds.

Production of Safe Aquaculture Foods

It is the responsibility of every aquafarmer to produce products of good quality and ensure the safety of aquaculture foods for human consumers. Towards this end, technical guidelines for responsible aquaculture in Southeast Asia have been formulated based on the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). Proper management of aquafarms throughout the entire production cycle is required for product quality (FAO, 1997).

The Department of Agriculture (DA) of the Philippines pursuant to Section 47 of Republic Act No. 8550 and upon recommendation by the BFAR issued Fisheries

Administrative Order (FAO) No. 214 in 2001 for the implementation of the Code of Practice for Aquaculture in the country. The FAO embodies "the general principles and guidelines for the environmentally sound design and operation" of aquaculture for sustainable development. Included in the provisions of the FAO, among others, are: (1) Banned chemicals shall not be used for any purpose; (2) Use of drugs, antibiotics and other chemical treatments shall be in accordance with recommended practices and comply with national and international regulations; (3) Records shall be maintained regarding the use of chemicals in ponds suggested by the HACCP method; and (4) Discharged water shall meet quality standards.

FAO No. 212 for Guidelines on the Implementation of HACCP System was also issued by the DA in 2001 pursuant to Sections 62, 65 (1) and 67 of R.A. No. 8550 and upon recommendation by the BFAR. The HACCP System is a preventive food quality management system which identifies, evaluates and controls the hazard significant to food safety specific to a product. Food processors are required to prepare and implement a HACCP Plan based on the seven principles of : (1) Identifying significant food safety hazard whether product- or process – related that must be controlled; (2) Identifying CCPs in the processing steps where control measures can be applied; (3) Establishing critical limits or criteria to be met at the CCPs identified; (4) Setting up procedures and instituting a frequency schedule in monitoring the CCPs identified; (5) Establishing a corrective action plan and a set of procedures to be followed when deviation occurs; (6) Developing verification procedures and frequency plan to assess effectiveness identified; and (6) Establishing a record keeping system to document all necessary information in the HACCP Plan.

HACCP compliance certificates are issued to fish processing plants that are HACCP compliant and apply good management practices (GMPs) and sanitation standard operating procedures (SSOPs).

In providing laboratory services for fish quality control, the DA, upon recommendation by the BFAR, issued FAO No. 213 in 2001 for the "Establishment and

Maintenance of BFAR's Quality Control Laboratories and Collection of Fees and Charges for Examination Services." Such laboratories undertake and provide advisory services on chemical, microbiological and sensory evaluations of fish and fishery products for quality evaluation; undertake special chemical and microbiological investigations on fishery products suspected to be toxic, contaminated and decomposed, or unfit for human consumption; examine all fish and fishery products for export or import which may be sources of fish pests or diseases to ensure quality of product and meet international standards; and update the fishery industries on quality control of fish and fishery products through regular dissemination and technical assistance.

Pursuant to Section 61 (d) and 100 of R.A. No. 8550, FAO No. 210 for "Rules and Regulations on the Exportation of Fresh, Chilled and Frozen Fish and Fishery/Aquatic Products" was issued by the DA in 2001, upon the recommendation of the BFAR. Such rules and regulations require that: (1) Only fish products which have been processed in fish processing establishments certified by the BFAR to be compliant with the SSOP and HACCP System shall be allowed for export; (2) Fish products shall be subjected to product tests required by the importing country at any BFAR laboratory or accredited laboratories, the results of which shall be presented to BFAR as among the basis for issuance of the Sanitary Health Certificate and that fish products shall be derived from species whose biological and chemical characteristics meet the standards (Table 4).

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