Milkfish Production and Processing Technologies in the Philippines


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- produce, disseminate, and exchange aquaculture information

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TECHNOLOGY DEVELOPMENT: HISTORICAL PERSPECTIVE

Milkfish culture in brackishwater ponds is part of traditional practices in what are now Indonesia, Philippines and Taiwan. As such, its development cannot be attributed to any institution.

Early work in the then Bureau of Fisheries in their Dagat-dagatan station focused on improving production through better pond preparation including fertilization, liming and supplemental feeding using locally available materials such as rice bran or stale bread. BFAR also did pioneering work on developing different product forms such as soft-boned bangus and boneless bangus to widen the milkfish market.

In 1954, the modular system of culture was developed by Dr. Saturnino Abesamis of Pangasinan. This method optimizes pond utilization and natural food production and makes it possible to have overlapping crops through the use of three progressively larger ponds. The system makes it possible to produce from two to four tons per ha per year instead of only 600 to 1,800 kg per ha.

Under an FAO-assisted project in the mid to late 1960s, BFAR introduced deep water plankton method of milkfish culture adapted from what is practiced in Taiwan. This technology did not become popular probably because most Philippine ponds are shallow and require financing to deepen and improve.

Work at the UP Brackishwater Aquaculture Center in Leganes, Iloilo in the late 1970s to early 1980s led to a better understanding of the problem of acid-sulfate soil and the development of a method of neutralizing pond acidity using natural chemical processes rather than merely applying a huge volume of lime which is actually ineffective in such situation.

BFAR pioneered the development of fishpen in Laguna de Bay in the late 1965 to 1967 which led to its adoption by some small-scale operators in 1967 to 1971. However, it was the LLDA's successful demonstration in 1970 of the feasibility of commercial scale venture using a 38 ha pilot fishpen in Cardona that started the boom in large-scale fishpen development in Laguna de Bay.

Early trials on fish cages and pens in shallow brackish and marine waters were also conducted by BFAR but it was the introduction of the Norwegian type of marine cages by the private sector which expanded the area available for marine cages to deeper waters beyond 10 meters.

The private sector also developed semi-intensive and intensive milkfish farming in brackishwater ponds using full feeding, pumping and aeration. This was an offshoot of the shrimp production failure in the mid 1990s when shrimp farms started converting to milkfish as an alternative. High yields of up to 8 tons per ha per 5-month cycle can be obtained but the production costs were too high to compete with milkfish reared using natural food in ponds or in pens.

Early on BFAR recognized the importance of propagating milkfish in captivity instead of relying totally on wild-caught fry. A hatchery was established in Naujan, Mindoro in 1968. The project was under-funded and understaffed and was eventually discontinued.

Sustained work on milkfish breeding in the Philippines started only in 1975 after the SEAFDEC Aquaculture Department obtained financial support from the IDRC of Canada. A multi-national team from Canada, India, Japan and Taiwan worked side by side with Filipino scientists to eventually develop the technologies for milkfish broodstock rearing and handling as well as larval rearing and fry production.

Maturation and spontaneous spawning of captive milkfish reared in marine cages was achieved in 1980. BFAR and SEAFDEC AQD immediately launched the National Bangus Breeding Program (NBBP) in 1981 in order to be able to broodstock in all the (then) 12 regions of the Philippines. By 1986, four of the 12 regions reported maturation and natural spawning. But the next step, hatchery development and operation were no longer pursued due to lack of funding on the part of the government and lack of interest on the part of the private sector.

Commercialization of milkfish fry hatchery technology went ahead first in Taiwan in the early 1990s followed shortly by Indonesia. It should be noted that there is no fundamental difference in the basic technology for maturation and larval rearing as developed in SEAFDEC AQD and as practiced elsewhere. Differences in survival rate and hatchery production efficiency between hatcheries in the Philippines and other areas can be attributed to differences in water quality, skills and dedication of hatchery workers, and spawning seasonality among others. The failure for the technology to be commercialized ahead in the Philippines must therefore be due to other extrinsic, mainly socio-economic, factors such as general investment climate, degree of risk aversion, interest among capitalist and other factors.

MILKFISH SEED PRODUCTION

Broodstock Development and Maintenance. Milkfish is grown in brackishwater ponds or in marine cages for five years to reach sexual maturity. When grown in brackishwater ponds, these are transferred to marine waters either in floating sea cages or land-based tanks and fed high protein (36 - 38%) diet for them to develop their gonads. In land-based tanks, a flow-through water system at an exchange rate of 200% per day is maintained. A canula is used to sample the gonadal material through the genital opening in order to identify the males and the females. Clove oil (Eugenol) or MS222 is used to anesthetize the fish during the procedure as well as for transferring the stock. The fish are allowed to spawn naturally although they may also be induced by hormone injection. Milkfish eggs are collected by using fine mesh nets.

Larval Rearing and Fry Production. Milkfish larvae can be reared in indoor or outdoor tanks made of concrete or fiberglass at full seawater salinity (above 30 ppt). The rotifer *(Brachionus plicatilis)* is reared in advance using the nannoflagellate *Nannochloropsis* sp. as feed so that it is available once the larvae start feeding. The eggs are allowed to hatch in hatching tanks and the day-old larvae transferred to larval rearing tanks at 30 larvae per liter. Feeding starts once the yolk reserves are consumed (36 hours). Additional live feed in the form of *Artemia* nauplii and artificial larval diet are added on the 12th day. Larval rearing water is changed at the rate of10% per day during the 2nd to 10th day and increasing to 50% on the 11th to 15th day and 75% on the 16^{th} to 20^{th} day and 100% daily from 21st day to harvest. The fry is marketable at 21 days.

GROW-OUT IN BRACKISHWATER PONDS

Straight-run Pond Culture. The traditional milkfish pond is designed to have a small nursery pond for growing the milkfish fry and a large rearing pond which could range from one hectare to 50 or even 100 ha. Typically the fry are reared for one to two months in the nursery pond and the fingerlings transferred to the rearing pond for rearing up to harvest. Pond preparation consists of drying, pest eradication then liming and fertilization. For pest control, two methods are recommended: tobacco dust at 300 to 400 kg per ha or an admixture of hydrated lime and ammonium sulfate fertilizer (21-0-0) at a ratio of 5:1 on wet areas of the pond bottom during sunny day. Basal fertilization should be followed by dressings at regular intervals to sustain natural food production. The use of vertical net substrates can increase the amount of natural food by providing more surfaces for growing algae. The use of a transition/stunting pond after the nursery stage can increase production by making large-sized fingerlings readily available when needed. Stocking density ranges from 1,000 to 3,000 fingerlings per ha depending upon availability of natural food and target harvest size. Harvest likewise ranges from 300 to 900 kg per crop or 600 to 1,800 kg per year.

Modular or Progression Method. A continuous program of pond preparation, stocking, transfer and harvest characterize this method using three progressively larger ponds at a ratio of 1:2:4 or 1:3:9 and takes about 30 to 45 days for each stage. The fish are moved from a smaller to a larger compartment as they grow. This method allows 4 to 8 crops per year with an annual yield ranging from 2,000 to 4,000 kg/ha. Basic pond preparation in terms of pest control, liming and fertilization recommended for straight run applies as well to this system of culture.

Deep-water Plankton Method. This method utilizes deeper ponds (at least 1 meter in depth) in rearing milkfish at higher density using primarily plankton instead of benthic algae as food. Deeper pond water increases water volume per unit area and therefore more space is available to the fish and natural food production. This method was developed when it was observed that milkfish can utilize phytoplankton and zooplankton in the water column as food source. This method is less prone to snail infestation. Stocking rate is from 4,000 to 6,000 fingerlings per hectare depending on the availability of natural food in the pond and the desired size of fish at harvest. About 3 to 4 crops can be attained in a year producing an average of 3.5 tons of milkfish per hectare per year.

Semi-intensive Culture. This method is characterized by smaller pond size of 1 to 5 hectares, at least

1 meter depth of water, and an increased stocking rate of 8,000 to 12,000 fingerlings per hectare in the rearing pond. Water exchange is enhanced by widening the gate, provision of separate drain gate and using water pump. Oxygen supply is improved by providing paddlewheel aerators and maintaining good phytoplankton growth later in the growing period. Natural food, mainly lab-lab, is grown and used as food in the first 45 to 60 days of culture in the grow-out ponds and commercial formulated diet with at least 27% protein is supplied thereafter. This method allows 2 to 3 crops and yields of up to 7.5 tons per ha per year.

Stock Manipulation Method. This system aims to maintain a balance between the fish population and natural food supply by periodic stocking of multi-size fish and partial harvesting. Under this technique of periodic stocking and partial harvesting, fish biomass in the pond fluctuates between 250 kg/ha to a maximum of 750 kg/ha until each harvest. The carrying capacity of brackishwater ponds is from 700 to 800 kg /ha. Annual fish yield using this method is 2,000 to 3,000 kg/ha. This method was developed and popularly practiced in Taiwan.

Polyculture. Milkfish is reared with shrimps, mudcrab, rabbitfish, seabass, tilapia, seaweeds, mollusks, and many other fish species either as primary or secondary crop. The polyculture of milkfish with shrimps or with crabs however, are the most popular and profitable. They compliment each other in terms of habitat and food requirements. Annual yield of milkfish as the primary stock when grown together with shrimp ranges from 1,200 to 1,800 kg/ha while annual shrimps production is from 100 to 200 kg/ha. On the other hand, about 550 kg per ha of milkfish and 1,500 kg/ha of crabs per crop can be attained using the polyculture method. Generally a minimum of 2 crops per year can be undertaken when milkfish is polycultured with either shrimps or crabs.

Intensive culture. The intensive milkfish culture requires smaller (0.1-1 hectare) but deeper (1-2 m) grow-out pond, enormous capital investments, large working capital, and technical proficiency. This type of culture allows 2 to 3 crops a year and produces a high yield of up to 12 tons/ha/yr but is considered a high-risk venture. Mass mortality is a constant threat due to accumulations of toxic metabolites such as ammonia and sulfides, oxygen depletion, and diseases. Procedures in pond preparation, maintaining good water quality, feeding and care of stocks are very similar with semi-intensive method but with more material and technical inputs.

GROW-OUT IN PENS AND CAGES

Pen Culture in Eutrophic Freshwater Lakes. The fishpen consists of an outer barrier net with 7 knot mesh and an inner enclosure net with finer mesh (17 knots). Fishpen size ranges from 1 ha up to 50 ha (maximum allowable in Laguna de Bay). In eutrophic (plankton-rich) lakes, the milkfish feed mainly on plankton and also forage for food at the bottom. However, there are times that supplementary feeding may be required especially when stocked at higher densities or natural food becomes depleted. Pen operators in Laguna de Bay (average water depth 3 meters) stock 30,000 to 50,000 fingerlings per hectare which equals 1 fish per m^3. The fish grow to market size (250-300 g) in 4 to 8 months with survival of 60-80% and yield from 4,000 kg/ha to as high as 10,000 kg/ha.

Marine and Brackishwater Fishpens. Fishpens set in coastal waters are generally smaller in size (500 – 1,600 m^2). Depending on depth and water current, stocking densities are from 6 – 12 fingerlings per m^2. Commercial formulated diet containing 27-31% protein is fed daily at 3-4 times a day starting from stocking until harvest. The fish reach harvest size of 250-275 g in 4-5 months with a survival rate of 80-90% and production of 1.5-5 kg/m^2.

Milkfish Culture in Cages. Milkfish cages may be installed in freshwater lakes, estuarine areas, and coastal marine waters. Cages may be square or rectangular using bamboo frames or G.I. frames with drum floats. More advanced design consists of high-impact polypropylene pipe frame which serve also as float. Feeding of complete formulated diet (27-31% protein) is essential from stocking of the fish to harvest. Small-sized fingerlings (5-10 grams) are initially stocked at higher density in cages with nets having small mesh size for 1-2 months before being transferred at desired density to grow-out cages. Stocking density depends on the carrying capacity of the cage and the environment. Typical stocking densities in floating and stationary cages are 10-40 pcs/m^3 with a survival rate ranging from 70-90% and yield of 3-20 kg/m^3. Offshore cages can be stocked with 40-100 pcs/m^3 with a yield from 20-35 kg/m^3. Sizes at final harvest typically range from 350 to 500 grams. Partial harvest when the fish have reached an average body weight (ABW) of 200 grams is often done to thin the stock and to realize a cash inflow midway. Total production and income is higher when deliberate overstocking and partial harvesting is practiced.

MILKFISH PROCESSING

Preservation by Curing. Drying, smoking and fermentation ("buro") are the traditional way of preserving milkfish. Drying involves splitting the fish into butterfly cut and brining before being laid under the sun. Drying time ranges from 10 hours up to 32 hours under the sun depending on fish size to achieve 20% moisture content. Smoking involves only gutting and brining without splitting. The drum-type smoker is the most affordable smoking chamber. Fermentation involves filleting the fish and the use of cooked rice and "angkak" (a type of fungus). Improvements in these traditional processes are needed to improve product quality and wholesomeness.

Freezing and Canning. The introduction of freezers and pressure cookers has given rise to new way of preserving fish through freezing and canning (or bottling). Freezing of whole fish is not widely practiced due to poor local market acceptability for frozen whole milkfish. Canned milkfish enjoys a good market because of its convenience but is done only by large canneries as an additional product line. For cottage industry level operation, bottling in glass jars is more popular because it does not require expensive machineries and glass bottles are cheaper than tin cans.

Deboning and other Value Adding Processes. Deboned milkfish or "boneless bangus" is undoubtedly the most popular value-added milkfish product. These are sold fresh-chilled, smoked, marinated and chilled, or individually packed and frozen. These enjoy good market both in the Philippines and abroad. It is a tedious process involving the removal by hand of more than 170 inter-muscular bones. The production of "boneless bangus" has also given rise to many other value-added products as processors find ways to use the trimmings and bits of flesh that are invariably removed with the bones. These new milkfish products include fishballs, milkfish lumpia, quekiam, embutido, and chicharon from the skins.

Part One

DEVELOPMENT OF MILKFISH PRODUCTION TECHNOLOGY

1. WHY MILKFISH?

The milkfish is the most important fish species being farmed in the Philippines. It is cultivated in freshwater, brackishwater and marine environments. A number of milkfish production technologies have been developed to fit these diverse culture situations. These production technologies are modified depending on the location, climate, topography, tidal fluctuation, water current, water depth, available land/space, available supplies and materials, available capital and level of viability.

Milkfish can be considered as the superstar of Philippine aquaculture because of the following attributes:

a) True to its name the milkfish provides not only reasonably priced source of nutritious protein to millions of people in the Indo-Pacific region but also livelihood to countless of families engaged in aquaculture.

b) Herbivore/detritivore – Milkfish is low in the food chain. It eats primarily plant materials and detritus but will readily eat rice bran, trash fish, formulated diet and etc. when natural food becomes scarce. It can exploit food found from the surface of the water up to the bottom.

- It is a filter feeder which utilizes fine gill rakers to concentrate plankton inhabiting the water column.
- It is also a benthic feeder which browses on complex benthic organisms (lab-lab), filamentous algae, and detritus on the bottom.

c) Euryhaline – It can tolerate and live in extreme salinity ranging from 0-100 ppt but growth is optimal between 0.5-40 ppt. which means it can be cultured in a wide range of environment from fresh to highly saline waters.

d) Eurythermal – It has a wide temperature tolerance range (10- 40°C) with optimal growth ranging from 25-30°C.

e) Milkfish is not piscivirous so it can be grown at higher densities and can be polycultured with other finfishes and crustaceans.

f) It is resistant to diseases with no known occurrence of serious disease outbreak in aquaculture.

g) Milkfish can be stunted under sub-optimal circumstances such as overcrowding or scarcity of food but grows fast when conditions become favorable once more.

h) High fecundity and longevity – a single female fish can produce 1-9 million eggs in one spawning season in captivity and has been observed to spawn every year during the spawning season for over 20 years.

i) Milkfish broodstock husbandry and hatchery technology have already been developed, thus a continuous supply of seedstock can be assured.

j) Milkfish is highly acceptable in fresh, frozen, fillet, deboned, smoked, canned and many other product forms. Its only negative attribute – having so many fine bones embedded in its muscles can be removed during processing to increase its commercial value and acceptability such that it is now exported to the US and EU; and among other countries its export is increasing.

2. TECHNOLOGY DEVELOPMENT

2.1 The Early Beginnings

Milkfish farming in brackishwater fishponds in Southeast Asia particularly in what are now Indonesia and the Philippines predates the arrival of European colonizers in the 15th century. But for centuries, such farming was more a trap-and-grow operation based on the natural stock of milkfish fry that comes in with the tidal waters. At that time of course, there was no control on stocking density or on the entry of other species including possible competitors and predators. When the gathering and trading of milkfish fry started or who started it as well as the stocking in fishponds in regulated density will never be known.

For a long time, milkfish farming was purely a private sector effort. Any technology development was empirical in nature and largely undocumented. Traditional milkfish production areas include the Central Luzon provinces, Pangasinan and Iloilo. All early accounts on milkfish culture in English from the early days of American rule (Radcliffe, 1912; Day, 1915; Herre and Mendoza, 1929) up to the early post independence (1946) were merely description of existing practices rather than results of experiments.

2.2 Culture in Brackishwater Ponds

After the formal organization of the Bureau of Fisheries (as it was then known) in 1947, the agency started to conduct research on milkfish culture primarily in their brackishwater research station in Dagatdagatan, Navotas (which is now part of Metro Manila). It was here that the Bureau of Fisheries conducted most of its early work on fertilization, lablab production (Rabanal, 1949) and supplementary feeding. In the late 1970s, BFAR (Bureau of Fisheries and Aquatic Resources) under a UNDP (United Nations Development Fund) assisted project was able to make a production calendar to guide milkfish farmers in different climatic zones. One schedule was made for Types I and III climates and another for Types II and IV (BFAR-UNDP, 1981).

By default, the Bureau of Fisheries was to remain the only institution working on fisheries research and development for a long time. When the Philippine Institute of Fisheries Technology (PIFT) was transferred from the Bureau of Fisheries to the University of the Philippines (UP) to become the UP College of Fisheries, fisheries research and development ceased to be a monopoly of the Bureau. But during the early years, most of the research work on brackishwater aquaculture continued to be done in the Dagat-dagatan station since the university's own aquaculture facilities was limited to some experimental freshwater ponds in its Diliman campus. This was so until the early 1970s with the establishment of the Brackishwater Aquaculture Development Center (BAC) by the UP College of Fisheries in Leganes, Iloilo.

The research and development work up to the early 1970s remained focused on improving pond production by recognizing the role of pond soil acidity, organic matter and nutrients in inducing the growth of natural food in ponds. But real understanding on the chemistry of pond soil acidity was to come only with research work done by UP-BAC during the late 1970s.

With the problem pinpointed to the reaction of ferric sulfide in newly excavated ponds to exposure to the atmosphere and water, UP-BAC developed a system of neutralizing ponds with acid-sulfate through repeated drying, soaking, and flushing (Singh and Poernomo, 1984). This method used the natural chemical processes instead of applying a large quantity of lime that is at any rate ineffective in an acid-sulfate situation.

It was a physician turned fish farmer in the person of Dr. Saturnino Abesamis who developed a whole new system of milkfish farming in 1954 that he called the "modular system" (Cagauan, 2004). The modular system makes it possible to achieve higher yields by subdividing large fishpond areas into modules of three ponds, each pond in a module is double the size of the previous (e.g. 1 ha, 2 ha, 4 ha). It optimizes area usage (no need to use a large pond when the fish are still small), optimizes natural food production, and makes overlapping crops possible.

The next innovation in brackishwater pond culture came in the form of semi-intensive and intensive system of culture with full pumping, aeration and feeding. Again, this came from the private sector, namely shrimp growers facing disease problems in the mid 1990s. Since they already had the machinery and equipment for intensive culture, not a few converted their shrimp ponds into semi-intensive and intensive milkfish farms. This occurred particularly in the Negros Occidental and Panguil Bay area where many of the intensive shrimp farms were found. The system was found capable of producing up to 12 tons per ha in 4 to 5 months. While technically feasible, the milkfish produced in the intensive system proved too expensive to compete with those produced in extensive or traditional ponds using natural food and those produced in fishpens.

2.3 Culture in Freshwater Ponds

There was an attempt in the mid-1970s in the Freshwater Aquaculture Center of Central Luzon State University to develop the culture of milkfish in freshwater ponds in polyculture with freshwater shrimps, *Macrobrachium* sp, and tilapia. Stocked at the rate of 150 fingerlings (1.5 g mean weight) and 0.5 kg juvenile shrimps per 500 m^2 fertilized earthen ponds, only 36% of the milkfish survived in one pond and 66% in another after 150 days of culture with a mean weight of 120.8 g and 35 g respectively with no feeding. The low survival was attributed to sensitivity of milkfish to handling during sampling (FAC 1976). Better survival of 80.4%, 82.8% and 82.8% were obtained on subsequent trials using larger fingerlings (27.25 g to 28.46 g) in polyculture with all male Nile tilapia. In spite of the large initial sizes, the final weight of the milkfish after 127 to 135 days of culture ranged only from 85.08 g to 124.09 g (FAC, 1977). The studies were not pursued and the culture of milkfish in freshwater was to become commercial only with the introduction of fish pens in Laguna de Bay.

2.4 Culture in Pens and Cages

One innovation in grow-out culture clearly came from the then Bureau of Fisheries – this is the growing of milkfish in freshwater fishpens or cages rather than in a brackishwater fishpond. Felix (1975) experimented on the culture of various species of fish including milkfish in floating cages and pens along the Cardona shoreline of Laguna de Bay between 1965 to 1967. The experiment was said to be prompted by the observation that milkfish fry stocked by the Bureau in the open waters of Laguna de Bay between 1957 to 1959 were observed to grow up to 2 to 3 pieces per kilogram in size after only three months and up to one kilogram after eight months. The promising results of the experiment encouraged one Mr. Dennis Bello to develop his own fishpen in a shallow cove in his resort island, Cielito Lindo, with the technical assistance of the Bureau of Fisheries in 1967. However, commercial-scale operation can be said to have its start with a 38 ha fishpen developed by the Laguna Lake Development Authority (LLDA) in Looc, Cardona in 1970. LLDA's commercial success through the efforts of Ms. Medina Delmendo led to large capitalists to venture into big-time fishpen operations which later resulted in overcrowding and conflicts with small fishers.

The use of fishpens and cages in brackish and marine waters came much later in the mid-1990s. While the Bureau of Fisheries may have made the initial moves, the industry could not have developed to the same extent and would have been limited to shallow coves without the pioneering effort of the son of Dr. Abesamis who developed the modular system of milkfish culture. Mr. Maximo Abesamis was the first to import to the Philippines circular cages with plastic frames from Norway, the very same type the Norwegians use for salmon. Mr. Abesamis was able to demonstrate that one can safely moor such cages in fairly deep waters (12 to 15 m) far from the shore in the waters of Pangasinan.

2.5 Milkfish Processing

BFAR also started to develop various methods to process milkfish to make milkfish acceptable to more people many of whom are averse to the numerous inter-muscular spines. Two product forms are specifically addressed towards mitigating the effects of the spine: the "soft-boned bangus" and the "boneless bangus." The first is achieved by pressure cooking pre-seasoned milkfish until the bones become soft. The second involves the process of deboning. It is the latter which proved more popular and now comes in various variations such as smoked, marinated, bangus belly, etc. The trimmings produced in the process of deboning also led to the development of many other products such as fishball, quekiam, lumpia, etc.

2.6 Seed Production

The BFAR early on recognized that the industry cannot develop further as long as it is totally dependent on natural supply of fry. As early as 1968, the Bureau established a hatchery project in Naujan, Mindoro to propagate milkfish among other species. The site was selected due to the easy availability of potential milkfish broodstock as they migrate to the sea to spawn after having grown to mature sizes in Lake Naujan. The project was hampered from the start from lack of funding. It also appeared to have failed to develop a focused strategy. Its first report after one year mentions attempts to also breed mullet and prawns in addition to milkfish.

Serious work on milkfish breeding in the Philippines started only after the establishment of SEAFDEC AQD (Southeast Asian Fisheries Development Center Aquaculture Department) in 1974. With a US$1.7 Million grant from the International Development and Research Center (IDRC) of Canada, SEAFDEC AQD formulated a short-term and a medium-term approach to solving the problem. The short-term approach involved the use of wild-caught sabalo (adult milkfish) and inducing them to spawn in captivity. For the medium to long term approach, pond-reared milkfish from the AQD brackishwater station in Leganes were transferred to and reared further in circular sea cages in the oceanic waters of Igang, Guimaras Island since information on their biology indicated spawning in marine waters. SEAFDEC AQD assembled an international team consisting of experts on fish reproduction from Canada, India, Japan and Taiwan to work side by side with Filipino scientists and technicians.

The use of wild-caught broodstock proved to be a dead-end approach and was not continued once the captive milkfish stock reached sexual maturity. However, it enabled the SEAFDEC AQD Milkfish Team to have a head start of at least 4 years in tackling the problem of larval rearing and fry production even as the captive broodstock was still growing in cages. By 1979, several technical papers on the broodstock development, spawning, and larval rearing of milkfish came out of the work in SEAFDEC AQD (Liao et al, 1979; Lacanilao, 1979; Juario, 1979; Rodriguez, 1979). It was in 1980 that maturation and natural spawning of the captive broodstock in SEAFDEC AQD floating sea cages in Igang took place. The same year, Taiwan first reported on induced spawning of pond-reared milkfish.

The knowledge that milkfish can achieve sexual maturity and spawn naturally in captivity led to the establishment of the National Bangus Breeding Program (NBBP) by BFAR and SEAFDEC AQD in 1981 which aimed to jumpstart the mass production of milkfish fry by BFAR and demonstrate its technical and commercial viability. By 1986, four of the 12 NBBP sites reported maturation and spontaneous spawning. But due to funding problem, the hatchery component was never adequately pursued. The various BFAR regions could not even sustain the feeding of the sexually mature milkfish in their care. Typhoons took its toll on some of the cages and many of the valuable broodstock escaped. The project died a natural death with the remaining milkfish broodstock eventually sold to the interested parties for possible use in hatcheries in 1995. For a very long time it was only SEAFDEC AQD that was operating a milkfish hatchery in the Philippines.

Why the commercialization of milkfish hatchery in the Philippines did not take place in spite of its head start in technology development will be a good subject for future study. Instead, commercialization took place first in Taiwan and then in Indonesia by the mid 1990s. A review of the basic technology involved in milkfish larval rearing shows no fundamental difference in the method used in the Philippines, Taiwan and Indonesia. What maybe different are the social milieu, investment climate, and the degree of risk aversion of people in the three milkfish producing areas.

What has been commercialized for a long time already in the Philippines is fingerling production in brackishwater ponds. This again was developed by the private sector rather than any research institution. The milkfish fingerling production gained additional impetus with the development of fishpens and cages all of which require large size fingerlings rather than fry.

Part Two

SEED PRODUCTION TECHNOLOGY

3 MILKFISH HATCHERY PRODUCTION SYSTEMS

There are two types of milkfish hatchery production systems being practiced in the top three milkfish producing countries. Hatchery operators in Taiwan use mainly the pond hatchery system (semi-intensive or outdoor system), while the Philippines and Indonesia are using both the tank production hatchery system (intensive or indoor system) and the semi-intensive system to produce milkfish fry. Large-scale milkfish hatchery operation usually include broodstock maintenance, spawning, and fry production while small scale (backyard) hatchery only produces fry with eggs or newly hatched larvae purchased from other hatcheries maintaining broodstocks.

4. PHYSICAL REQUIREMENTS

4.1 The Site

Proper site selection is required not only to ensure technical feasibility but also economic viability of the milkfish hatchery. Usually, remedial measures to beww undertaken in un-suitable sites are prohibitively expensive and impractical. Often, abandoning such hatchery is the only solution.

a) A milkfish hatchery should be situated in areas with favorable climatic condition that would permit year round and efficient operation. Warm climate and adequate sunshine throughout the year are ideal. The aspects to be considered are as follows:

   - Climatic type – Climatic type 3 (season not very pronounced, relatively dry from November to April and wet during the rest of the year) and type 4 (rainfall more or less evenly distributed throughout of the year) are preferred milkfish hatchery sites in the Philippines.
   - Minimal occurrence of typhoon

b) Elevation of the site should be given particular attention to prevent flooding of the hatchery and for proper water drainage.

c) The site should be far from population centers and free from possible impact of inland water discharges especially agricultural pesticides and domestic or industrial waste.

d) Seawater source from a bay or open sea rather than from a river or creek is preferred. Localities with rocky or coralline shorelines have good water quality relatively closer to the shore. This reduces cost of water intake installation and minimizes problems of clogging and maintenance.

e) Sites which are to be avoided are swamps, river mouths, tidal flats and muddy shores where water becomes turbid during heavy rains or strong winds.

f) Adequate freshwater supply for cleaning tanks and equipment, salinity adjustment for larval rearing and culture of food organisms and domestic consumption. Freshwater with high mineral contents such as iron (> 1 mg/l) or manganese (> 2 mg/l) is not suitable.

g) Reliable electric supply to provide the necessary power to run the life support system and equipment 24 hours a day.

h) The hatchery should be near available source of milkfish broodstocks, eggs or newly hatched larvae as this will greatly reduce transport stress and transport cost.

i) Accessibility.

- Accessible to both land and water transport for fast and convenient delivery of supplies and materials and marketing of fry.
- Adjacent or close to an airport so that the fry produced can be shipped with dispatch.
- Near centers of grow-out operation to minimize transport cost, reduce stress to fry and avoid mortalities.
- Have access to communication facilities for market information and to facilitate business transaction is necessary.

j) Peace and order situation in the locality is also an important factor in selecting a site.

4.2 Facilities

The number and capacities of different broodstock, larval, and food culture tanks/ponds are dependent on the production target of the hatchery. The basic facilities necessary are as follows:

a) Broodstock Maturation Tanks/Ponds (Figures 1 and 2)

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Figure 1. Milkfish broodstock tanks.

Kelley and Lee (1986)

Figure 2. Milkfish broodstock pond.

b) Holding/Quarantine Tanks/Ponds

c) Incubation Tanks

d) Larval Rearing Tanks/Ponds

e) Phytoplankton and Zooplankton Culture Tanks/Ponds

f) Laboratory - for water quality analyses, microscopic exam, weighing, and etc.

g) Indoor Algal Culture Room

h) Food Preparation Room - for refrigerator, freezer, a food preparation counter, etc.

i) Store Room

j) Machine and Generator Shed - for generators, water pumps, miscellaneous machines and etc.

k) Office

l) Dormitory - to serve as quarters for the technicians on duty

m) Workshop

n) Elevated Reservoirs

o) Overhead Sand Filter

p) Fry Packing Area

q) Aeration Supply System

r) Seawater and Freshwater Supply System

4.3 Machinery and Equipment

The operation of a milkfish broodstock and hatchery requires at the barest minimum water pumps and air blowers. However, due to the importance of ensuring continuous supply of energy generator set is always a necessity in order to have an uninterrupted life support. For large establishments, laboratory equipment to check for water quality, count density of microalgae and other monitoring activities are also advisable. However, backyard scale operation can make do without such equipment.

a) Electric Generator – as back up electricity supply

b) Water Pump for Seawater and Freshwater

c) Air Blower

d) Microscope (optional) – to observe development and health condition of larvae.

e) Refractometer

f) Thermometer

g) Hemacytometer – for counting algal density.

h) Drainers of varying types and mesh sizes

i) Harvesting box

j) Scoop Nets

k) Sorting Cups

l) Dipping Buckets

m) Basins

5. BROODSTOCK ACQUISITION AND MAINTENANCE

If milkfish broodstock is to be acquired, the source of breeders shall be identified, selected and arrangements made for their purchase and transport. Quarantine/ holding facilities should be constructed ahead together with the seawater system. The tanks should be thoroughly washed and conditioned before the arrival of broodstock. Although cages can be utilized for broodstock maturation, it was never used in commercial hatchery operation but it can be used as holding/conditioning facilities for the broodstock. The advantages of cages is the short installation time required and the low operating cost since it does not need pumps and aeration.

a) Broodstock selection shall be based on the following criteria:

- Age of broodstock is from 4 to 6 years old,
- Body weight not lower than 3 kg.

b) Conditioning of broodstock and transport protocols are as follows:

- Milkfish broodstock reared in ponds should be conditioned in a net pen inside the pond or adjacent supply canal 7 days prior to transport and should not be fed at least 2 days before transport. If broodstock is held in floating cages, the fish should be gradually concentrated in the upper 2 meters and allowed to rest and not fed at least 2 days before transport.
- On the day of transport, the broodstocks are transferred into a 4 x 4 holding net cage with a 1 cm knotless mesh to permit easy removal of individual fish.
- The fish are then individually scooped out of the holding cage and placed in 0.05 ton fiberglass tank containing chilled seawater (20-22°C) with 0.2 ml/L 2-phenoxyethanol.
- Anesthetized fish, as characterized by loss of balance (ventral side up), immobility, and rapid and shallow opercular movement are weighed and transferred to 1.0 ton fiberglass tank filled with seawater to recover normal swimming behavior.

- As soon as the fish recovers, it is placed in a double-lined (cylindrical shaped) plastic transport bag (2m long, 0.5m wide, and 0.006mm thick) containing 40 L of chilled seawater (20-22°C) and 0.125 ml/L 2-phenoxyethanol as a sedating dose. Fish weighing less than 3 kg are stocked at 2 fish/bag while those 3 kg and above are individually packed.

- Two transport bags are placed in each Styrofoam box measuring about 104 cm long, 53 cm wide and 66 cm high. A plastic bag containing 0.5 kg of crushed ice is placed against each transport bag to maintain low transport water temperature. The fish can be safely transported for 6-7 hours using this method. If transport time is more than 7 hours, change 50% of transport water every 6 hours.

- Upon reaching the hatchery, the transport bags are opened, fish are removed from the bags and placed into a 0.5 ton fiberglass tanks containing aerated seawater and having a temperature of 25°C to ease fish recovery.

- The fish are allowed to recover normal swimming behavior before stocking to quarantine tank.

c) The broodstock shall initially be released in the quarantine tank before transfer to maturation facilities for observation and disease treatment. This measure will minimize the potential for introducing diseases and parasites into the hatchery. The procedures while under quarantine and before transfer to maturation ponds/tanks are as follows:

- Milkfish are acclimated to the quarantine tank with the same water salinity as source of broodstock and transport container.

- Salinity is gradually changed the following day at a rate that does not exceed 5 ppt/day. The optimal salinity to maintain for faster recovery from handling and transport stress is 22 ppt.

- After two to three weeks in quarantine each fish undergo an initial check to obtain biological data such as weight, length and sex.

- The external appearance of the fish is also checked for injuries, discoloration, abnormalities and external parasites.

- Each fish is tagged (preferably by electronically encoded pit tag) so it can be identified individually.

- Those individuals with undetermined sex may be implanted with LHRH-a hormone during initial check to induce maturation for reliable sex determination later.

d) The broodstocks should be fed with commercial pelleted feeds containing 40% protein twice daily at 9 AM and 3 PM.

e) The recommended stocking density in the maturation tank/pond is 1 fish per 4 m^2 with a sex ratio of 2 females to 1 male.

6. BASIC ACTIVITIES IN HATCHERY OPERATION

6.1 Spawning

Spontaneous spawning of milkfish occurs at water temperatures of 26-34.5°C. Seawater and freshwater should have a minimum dissolved oxygen level of 5 mg/l and low un-ionized ammonia content < 0.05 mg/l. The optimal range for maturation appears to be 15-35 ppt. Spawning should be induced at salinities higher than 32 ppt to ensure that the eggs would float rather than sink and that the sperm will be completely activated. Milkfish can remature from 2 to 4 times in one spawning season and have asynchronous spawning behavior in captivity. Generally one female milkfish broodstock spawns 1 to 9 million eggs in one spawning season.

6.2 Egg Collection

Fertilized eggs are translucent with some yellowish tinge, while dead eggs are opaque. Egg quality is better when salinity is higher than 30 ppt. Egg collection becomes difficult at salinities lower than 26 ppt because the eggs tend to sink gradually at the bottom of the tank/pond a few hours after spawning.

a) The most common egg collection method is a net bag made of netting material with a mesh size of 0.8 mm that will prevent the spawned eggs (about 1.2 mm diameter) from going through. The outflow water goes into the bag that is placed in the harvesting pit.

b) Set nets may also be used for egg collection in large ponds or tanks in conjunction with paddlewheel or propeller driven aerator. Set nets should be constructed so that it shall not interfere with the swimming and spawning behavior of the broodstocks and should be portable for easy cleaning. It takes 1-3 hours depending on the shape of the pond or tank to collect 90% of the eggs.

6.3 Egg Incubation

Milkfish can be stocked as eggs or newly hatched larvae in the larval rearing tanks or ponds. However, since embryonic development takes about 30 hours, the eggs are incubated prior to stocking in order to separate out the eggs that die before hatching. Hatching can occur in salinities from 5-40 ppt but hatching is highest in salinities between 20 and 35ppt.

a) The incubation tanks are cylindrical and usually have a volume of 500-1000 liters (Figure 3). Optimum stocking density is 1,600 eggs/liter.

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Figure 3. Milkfish incubation tank.

b) Optimal salinity range for incubation in the hatchery is 30-40 ppt to facilitate separation of viable from nonviable eggs since poor quality milkfish eggs become negatively buoyant at salinities below 30 ppt.

c) The eggs are transferred to larval rearing tanks or ponds during the C embryo stage, which is more resistant to stress.

6.4 Egg and Larval Transport

It is possible to produce milkfish fry without having to develop and maintain broodstocks. Arrangements may be made to acquire milkfish eggs or newly hatched larvae from other hatcheries in the Philippines although the quality, quantity and time of availability cannot be guaranteed. The sensitivity of milkfish embryos to mechanical shock varies during development — the C-shaped eyed stage may be handled or transported with minimum risks or injury. Long distance travel of eggs could weaken the embryo and result to heavy mortality. Transport time for eggs should not be more than 12 hours. Newly hatched larvae are more tolerant to stress during transport. The following steps in packing and transport of eggs and larvae should be followed:

a) Swirl the water in the container at least once to concentrate dead eggs at the bottom. Siphon out dead eggs or weak larvae.

b) Set a double-lined plastic bag inside the “bayong” or box and fill it with about 5-l filtered seawater (28-32 ppt).

c) Scoop eggs/newly hatched milkfish larvae with fine mesh (0.6-0.8 mm) scoop net.

d) Take about 200-300 ml of eggs/larvae from the scoop net using a beaker and quickly transfer to the transport bag. About 60,000 eggs are contained in 100 ml.

e) The plastic bag with 5 liters of water and 8 liters of oxygen can accommodate 150,000 eggs/larvae.

f) Saturate each plastic bag with oxygen and seal tightly with rubber bands.

g) Keep the straw bags or boxes in the shade.

h) The bags may be placed on an ice bed to maintain water temperature at about 25-28°C throughout the transport.

7. NATURAL FOOD PRODUCTION

Even while awaiting the milkfish to spawn or for milkfish eggs or hatchlings to be acquired, steps shall already be taken to produce natural food. Outdoor food culture tanks are shown in Figure 4 and 5.

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Figure 4. Natural food culture tanks.

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Figure 5. Circular natural food culture tanks.

7.1 Indoor Chlorella *(Nannochloropsis sp.)* Culture

a) Sterilize containers/bottles (1 L)

b) Fill bottles with sterilized seawater

c) Fertilize using nutrient media (Conway medium)

d) Determine the density of Chlorella starter and compute for the volume of the starter inoculums to be added (initial densities are 10-20 million cells/ml).

e) Add sterilized seawater to fill the 1-liter volume

f) Cover the bottle with a piece of cotton with glass tubing on top. Connect the plastic tubing attached to the aeration line to the glass tubing.

g) Provide moderate aeration. The aeration system of indoor phytoplankton culture should be separate from the aeration system of outdoor culture facilities to prevent contamination.

h) Provide cultures with artificial light. Use two to three 40-watt fluorescent lamps.

i) Repeat above procedures to scale-up cultures in a 3-liter or 20-liter containers using the portion of the starter.

7.2 Outdoor Chlorella (*Nannochloropsis sp.)* Culture

a) Natural food culture tanks are filled with filtered seawater and Chlorella starter culture (initial density is 1-3 million cells/ml).

b) Dissolve the fertilizer in five liters of water and add in culture tanks.

c) Expose to continuous sunlight

d) Aerate the culture tanks vigorously throughout the culture period to prevent cells from clumping.

e) The peak bloom (when the density reaches 20 million cells/ml) is attained usually after 4-5 days under optimum environmental conditions.

f) Harvest the culture for use as starter for other algal tanks or to feed rotifers.

7.3 Rotifer Culture

a) Disinfect the culture tanks with 20ppm chlorine for 24-48 hours.

b) Wash the tanks with a mixture of detergent and chlorine using freshwater.

c) Culture Chlorella in rotifer tanks.

d) When the phytoplankton reaches the peak bloom, rotifers are added at a density of 10-20 individuals/ml.

e) Allow the density to increase for 3-5 days.

f) Harvest the rotifers partially or totally by siphoning the water using a hose.

g) Collect the rotifers in a 40-50 micron filter bag installed at the end of the hose. The harvested rotifers can be used as feed for the larvae or as starter for other tanks.

8. MILKFISH TANK HATCHERY PRODUCTION METHOD (INTENSIVE OR INDOOR SYSTEM)

8.1 Description

Generally tank size used in intensive larval rearing is from 5-20 m^3 and depth is from 1-1.3 m (Figures 6 and 7). Larval tanks are either made of concrete or canvas. Shade is also provided to prevent strong sunlight and rain from entering the larval rearing tank. The average yield is 10 fry per liter of rearing water.


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Figure 6. Rectangular larval rearing tank.


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Figure 7. Circular larval rearing tank.

The problems of low quality fry and deformities in intensive hatchery system have been addressed by providing adequate nutrition and vitamins and good water quality. The advantage of intensive system is that more fry can be produced in a limited area. Production schedule can be maintained even in unpredictable climatic conditions because environmental parameters in intensive tank being smaller are relatively easier to manipulate.

8.2 Larval Rearing Procedure

a) Stock milkfish larvae (Day 0) in concrete tanks (10 ton rectangular tank for intensive culture and 20 ton circular tank for semi-intensive) at a density of 30/l.

b) Maintain temperature at 25.6-31°C, salinity at 32-35 ppt and DO at 5.5 ppm.

c) Prepare enriched rotifers and Artemia by feeding them with HUFA booster diets supplemented with Vitamin C or microalgae with high HUFA content. Supplementation of rotifers with commercial larval feed (MBD, Norsan R-1) may be done to improve growth and survival of larvae.

d) On day 2 and thereafter, feed with rotifers supplied with Chlorella (Nannochloropsis sp.) Maintain a density of 7-8 rotifers/ml.

e) Starting day 7, feed with practical diet (particle size < 250 μm) at a rate of 8 g/ton rearing water/day. Feed four times a day at 09:00am, 11:00am, 1:00pm and 3:00pm. Increase the amount to 12 g/ton/day on Day 15 until harvest.

f) After two weeks, feed with Artemia nauplii at 0.5-1.0/ml.

g) Chlorella, Tetraselmis or Isochrysis are added to condition the water and serve as feed for rotifers.

h) Harvest after 21-23 days after hatching. Survival rate is 30%.

i) The protocol for milkfish tank hatchery operation is shown in Figure 8.

9. MILKFISH POND BASED HATCHERY PRODUCTION METHOD

9.1 Description

The optimum size for pond based hatchery production method or semi-intensive larval

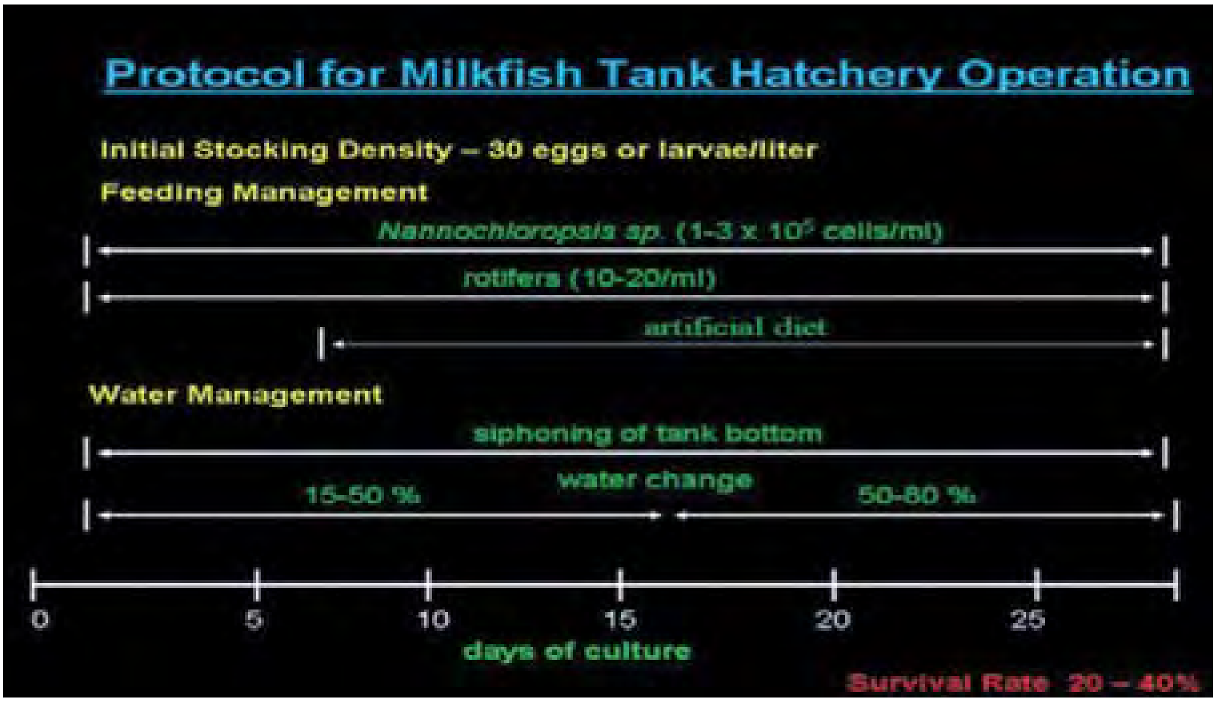

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Figure 8. Milkfish tank hatchery protocol (intensive or outdoor system).

rearing method is about 200-400 m^2 and the optimum depth 1-1.3 m. Pond of this size can be controlled easily and stocked with suitable density of larvae. The lower stratum of the pond bottom is paved with 20 cm of clay to prevent water seepage. The upper layer is covered with 30 cm of sand to keep water clear and for easy harvest of fry. One air stone is placed at about 2.5 meter interval to supply dissolved oxygen. Black plastic shade is used to cover the larval rearing pond to reduce the amount of sunlight going into the larval rearing pond before the larvae reach ten days old. Three water inlet pipes are provided in each pond, one for seawater, another for freshwater and another for green water.

9.2 Larval Rearing Procedure

a) Prior to hatching, transfer about 0.6-1.2 million fertilized eggs into the larval rearing pond. A suitable larvae density at the beginning of feeding is about 2-5 larvae/l.

b) Maintain optimum light intensity.

c) On Day 2, introduce green water (Nannochloropsis sp.) from the adjacent pond to regulate water transparency.

d) On Day 3 and thereafter, feed the larvae with oyster eggs to increase the survival rate of larvae.

e) On Day 5, feed larvae with rotifers.

f) Eel feed, fishmeal and micro pellet feeds maybe provided in addition to rotifers.

g) The protocol for milkfish pond hatchery method is shown in Figure 9.

10. COMPARATIVE ECONOMICS OF DIFFERENT TYPES OF MILKFISH HATCHERY OPERATION

Bio-technical assumptions, comparative investment requirements, and costs and returns of different types of milkfish tank hatchery operations are shown in Tables 1, 2 and 3.

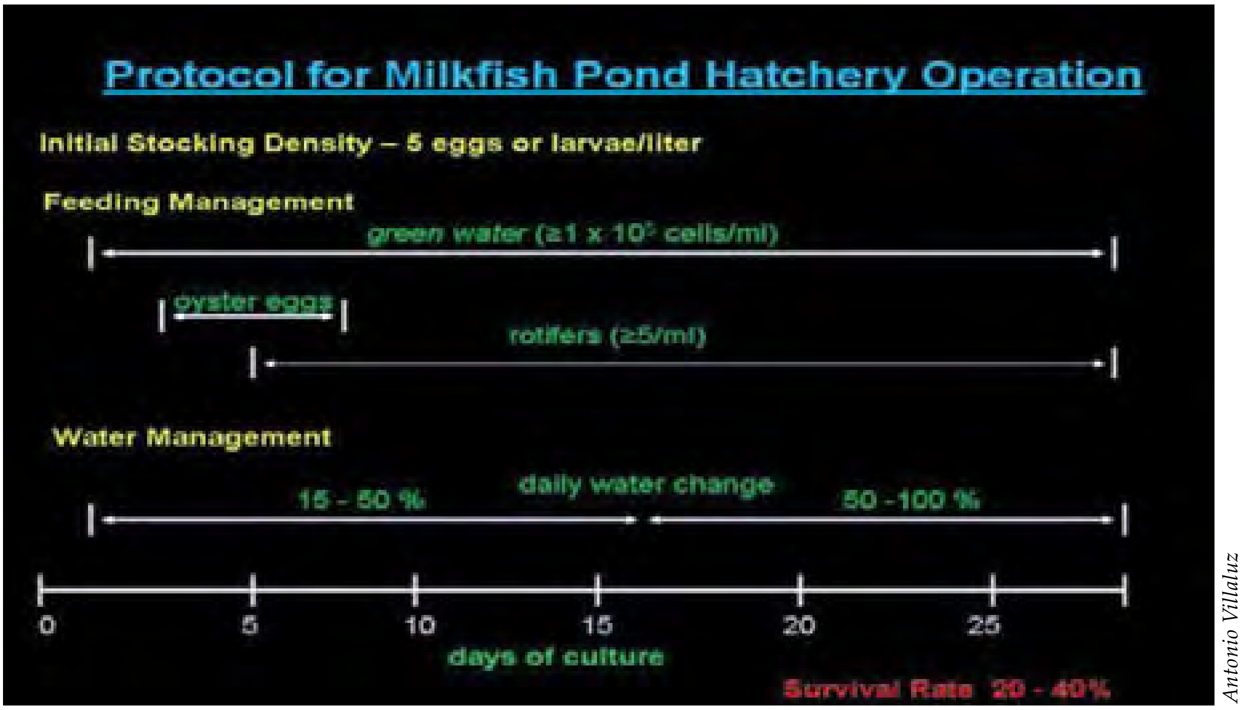

Figure 9. Milkfish pond hatchery protocol (semi-intensive or outdoor system).

Table 1. Bio-technical assumptions of different types of milkfish tank hatchery operations.			
Type of Hatchery Operation	**Backyard**	**Commercial w/o Broodstocks**	**Commercial with Broodstocks**
Stocking Density (pcs/liter)	30	30	30
Survival Rate (%)	30%	30%	30%
Size of fry at harvest (cm)	12 - 15	12 - 15	12 - 15
Culture Period (days)	21 - 28	21 - 28	21 - 28
Crops (per year)	6	7	7
Annual Fry Production	4,320,000	14,000,000	14,000,000
Farmgate Price (PhP/pc)	0.30	0.35	0.35
Interest Expense (%/yr)	16%	16%	16%
Sources of Capital			
Equity	20%	20%	20%

Table 2. Investment requirements of different types of milkfish tank hatchery operations.			
Type of Hatchery Operation	**Backyard**	**Commercial w/o Broodstocks**	**Commercial with Broodstocks**
Capital Outlay			
Hatchery Facilities	625,500	3,421,000	3,980,000
Equipment	321,000	1,669,200	1,850,000
Sub-Total	946,500	5,090,200	5,830,000
Working Capital	90,000	547,000	470,000
Cost of Broodstock			500,000
TOTAL	1,036,500	5,637,200	6,800,000

Table 3. Costs and returns of different types of milkfish tank hatchery operations.			
Type of Hatchery Operation	**Backyard**	**Commercial w/o Broodstocks**	**Commercial with Broodstocks**
Production	4,320,000	14,000,000	14,000,000
Sales	1,296,000	4,900,000	4,900,000
Less: Newly hatched larvae Feeds, fertilizers and chemicals Electricity, gas, lubricants Transportation & communication Salaries and allowances Repairs and maintenance Materials and supplies Subtotal	32,400 95,000 75,000 10,000 150,000 100,000 15,000 477,400	728,000 250,000 500,000 100,000 500,000 100,000 10,000 2,188,000	400,000 720,000 50,000 600,000 100,000 10,000 1,880,000
Fixed costs Depreciation Interest expense Broodstock replacement Subtotal	109,660 132,672 242,332	254,510 721,562 976,072	291,500 870,400 50,000 1,211,900
Total Costs	719,732	3,164,072	3,091,900
Net income before tax	576,268	1,735,928	1,808,100
Undiscounted Economic Indicators			
Unit cost of production	0.17	0.23	0.22
Return on investment	56%	31%	27%
Payback period	1.6	2.9	3.2

Part Three

BRACKISHWATER POND CULTURE PRACTICES

11. OVERVIEW

Several methods for producing milkfish in earthen ponds have been developed over the years, these include the following:

- Extensive,
- Modular or progression method
- Stock manipulation,
- Deep-water plankton,
- Polyculture, and
- High-density (semi and intensive) culture methods.

All of these culture methods apply common techniques in preparation such as complete drying, tillage, and fertilization. All methods also require proper acclimatization and stocking procedure as well as maintenance of water level and quality. Even harvesting procedures are common to all the methods. However it is in the scheduling of various activities, pond utilization, rate of stocking and cropping cycles where each method differs from the other.

12. SITES FOR MILKFISH FARMING

Milkfish farms in the Philippines have all been developed within intertidal areas, more often than not using mangrove swamps. This is so in order to take advantage of the natural inflow of tide making the use of pumps unnecessary. At the height of brackishwater fishpond development in the 1950s up to the early 1970s, mangroves were still considered practically as “wastelands” so that developing them into fishponds was considered one way of making them productive. Thus the site selection criteria during that time were as follows:

a) Ideal pond elevation ranges from 30-45 cm above mean sea level to allow best possible tidal exchange of water and assure that the pond bottom can be drained totally during low tide. Higher elevation than 30-45 makes the use of pumps necessary. It is important to determine the tidal characteristic of the area to ascertain the ideal pond elevation.

b) Generally clay, clay loam, silt-loam, loam, and sandy-clay loam are preferable types of soil. Sandy clay is ideal for dike construction while sandy loam is suitable for growing of natural food.

c) Avoid high acidic soil characterized by yellowish particles often becoming reddish when exposed. This soil type also requires heavy application of lime to neutralize acidity.

Nowadays there are no more new mangrove areas to develop since the law already protects what little remains. So the only areas are already existing development. Ideally the site should also have the following additional characteristics:

a) Adequate source of water year round that is free of pollution from sea, river or creek. The pond water is not liable to serious dilution during the rainy season. It is also beneficial to have a source of freshwater especially during a long dry season to prevent the rise in salinity.

b) Near source of seed stock and market for the produce.

c) Other factors. The site should have access to farm-to-market roads, power supply, telephone, available labor, construction materials and other necessary inputs. Also, consider the peace and order condition in the area.

13. PHYSICAL FACILITIES

Whatever the system or method used all brackish-water milkfish farms have the same basic facilities. Only the layout and design may differ. Even then a farm has to a certain extent some flexibility to shift from one system to another. Thus, the same farm maybe used for extensive, polyculture or for stock manipulation method if deep enough certain ponds within a farm may be operated and managed using the deep water plankton method or for high density methods. The only method which is not applicable to many farms is the modular or progression method because each pond has to be of definite size in relation to the others. But a modular arm can be used for all other methods as well.

The facilities required are as follows:

a) Culture Ponds

The culture ponds can be square or rectangular with independent sluice gates and provided with a central canal system for effective water control and ease in harvesting. Nursery ponds and transition/stunting ponds are required if the operation will start from fry stage but are unnecessary if the operation will use pre-grown fingerlings purchased from commercial nurseries. An ideal farm is shown in Figure 10.

b) Caretaker's House

A modest house is necessary for the caretaker and his family because of the irregular hours required in managing the entry or discharge of water depending upon the tidal fluctuation.

c) Warehouse or Storage Shed

A simple warehouse or storage shed is always necessary to store various inputs such as lime, fertilizer and supplemental feeds. For feed storage a rat proof but well ventilated area should be provided. The shed is also used to store farm implements and tools as well as various nets.

d) Equipment and Tools Required

A small dugout, chilling tanks and harvest containers and various kinds of nets for harvesting such as a gill net, a seine net and scoop nets are always handy to have. A water pump is not necessary but can be useful for emergency freshening or water change should there be an emergency. However for high density systems pumps and aerators are essential.

Figure 10.
A model milkfish earthen pond farm.

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14. INPUTS

Regardless of the method used, milkfish farming requires the same basic inputs. These include the following:

a) Good quality fry (or fingerlings)

b) Lime

c) Chicken manure

d) Inorganic fertilizer

e) Urea (45-0-0)

f) Ammonium sulfate (21-0-0)

g) Mono or diammonium phosphate (16-20-0 or 18-46-0)

h) Supplemental feeds if required can consist of rice bran or better still commercial feed.

15. BASIC POND PREPARATION PROCEDURE

The ponds should be prepared 1 to 1½ months ahead in order to obtain luxuriant growth of natural food prior to stocking of milkfish fry or fingerlings. The procedures are as follows:

a) Check and repair sluice gates and dikes for leaks and seepage.

b) Eradicate competitors and predators by applying either of the following:

- Tobacco dust. 300 to 400 kg per hectare of tobacco dust is spread over moist pond bottom and allow to stand for one week.

- Another method of pest eradication is the use of admixture of hydrated lime and ammonium sulfate fertilizer (21-0-0). Broadcast lime-ammonium fertilizer mixture at a ratio of 5:1 on wet areas of the pond bottom during sunny days. The reaction of the admixture of lime and ammonium sulfate fertilizer with the wet pond bottom releases heat and ammonia, which effectively kills the unwanted organisms.

c) Drain the pond, level the pond bottom and dry for 1-2 weeks until the soil cracks. Prolong drying is not advisable as it makes the soil hard, powdery and acidic.

d) Apply 1 ton/ha/yr (or higher depending on soil pH) agricultural lime and overturn soil by plowing.

e) Provide screen made of fine-meshed nylon netting to sluice gates to prevent the entrance of unwanted organisms.

f) Admit water to moisten the pond bottom. Apply chicken manure at 1 to 2 tons per hectare depending on soil quality and leave for 2 to 3 days.

g) Introduce new tidal water to a depth barely covering the pond bottom;

h) Apply 15 kg/ha Urea (45-0-0) by broadcasting after 2 days to accelerate decomposition of chicken manure.

i) After 3 days increase water depth by 3 to 5 cm and apply inorganic fertilizer (16-20-0) at 50 kg per hectare or 18-46-0 at 20 kg per hectare).

j) Subsequent applications of inorganic fertilizers (16-20-0 at 30 kg/ha or 18-46-0 at 10 kg/ha) at 1-2 weeks interval should be undertaken depending on lab-lab growth.

k) Apply inorganic fertilizers only after addition or replacement with new tidal water.

l) Avoid application of fertilizers during rainy days.

m) Increase water depth of the pond gradually by adding 3 to 5 cm at a time until it reaches 25 to 30 cm. An abrupt increase in water depth causes lab-lab to detach and float.

n) Install artificial net substrate to increase food production and provides additional feeding area for the fish.

- Net substrate is made of nylon netting (0.5 mm mesh) which is cut into strips measuring 30 cm wide with length depending on the size of the pond.
- The net strips are seeded with natural food organisms by dipping in lab-lab, mud and water mixture and air dried for 5 days.
- The net substrates are installed perpendicular to the sluice gate and

the lower edges are set about 5cm from the pond bottom to allow free movement of the fish.

- Net substrate surface area equivalent to 30% of surface area of the pond will give optimum result.

o) When lab-lab covers 75% of the pond bottom carefully flush the pond 2 to 3 times to get rid of highly saline water and/or toxic substances and maintain water level at 30 cm. The nursery pond is ready for stocking. This is usually within 30 to 39 days from the start of pond preparation.

16. NURSERY POND OPERATION AND MANAGEMENT

Nursery ponds are ideally small ranging from 1,000 to 4,000 m^2. Each pond should have access to fresh water supply. An ideal nursery pond layout is shown in Figure 11. They should also be well prepared before stocking so that natural foods are already abundant upon stocking. The pond preparation procedure for grow-out described earlier also applies.

Pangantihon-Kuhlmann, (1996)

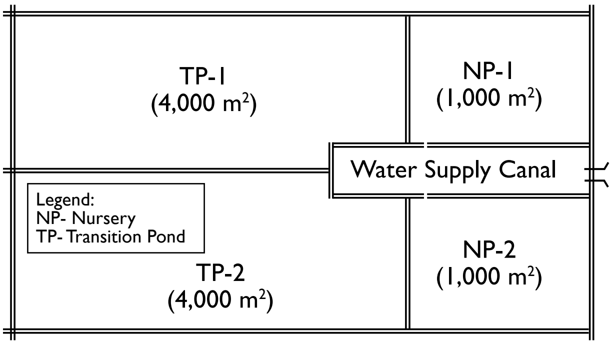

Figure 11. Ideal nursery pond layout.

16.1 Selecting Good Quality Fry

Fry quality is important in any species. To determine good quality fry the following should be noted while they are still in plastic basins for counting: They should have the following attributes.

- Move continuously along the wall of the basin in the same direction;
- Swim vigorously against the current if water in the container is stirred;
- React with quick downward or avoidance movement to moving shadows or when container is tapped.

For wild caught fry it is also the last chance to sort out extraneous (non-milkfish) species while they are still in the basin.

16.2 Stocking of Fry in the Nursery Pond

Milkfish fry are stocked at 30 to 50 fry per m^2. Stocking is done in the early morning or late afternoon to prevent temperature shock. It is important to check the temperature and salinity of the transport water and the nursery water. To minimize stocking mortality the following procedures should be followed:

a) If salinity and temperature of transport containers and nursery pond are approximately the same, stock the fry directly.

b) If the temperature difference is significant (can be felt even by hand) the transport containers should be allowed to float in the nursery pond for 15 to 30 minutes to equalize the temperature of the containers with the pond water.

c) If salinity difference between transport containers and nursery pond is above 5ppt, gradually add pond water to transport containers until salinity is equalized before releasing the fry.

d) Allow the fry to swim out of the containers.

16.3 Care of Stock in the Nursery

a) Maintain water depth at 30 to 40 cm.

b) Replace one half to one third of pond water every spring tide. Care should be taken in draining and flooding of the nursery pond as not to detach the lab-lab from the pond bottom.

c) Apply inorganic fertilizer (16-20-0 at 30 kg/ha or 18-46-0 at 10 kg/ha) every 2 weeks depending on lab-lab growth.

d) Application of fertilizer should only be done after replacement of about 1/3 to ½ of pond water.

- Do not apply fertilizer during rainy days.

e) Environmental factors affecting growth and survival of milkfish in the pond are as follows:

- Dissolved oxygen – optimum level is 3-10 ppm, below this level is harmful to the fish.
- Weather conditions – sudden change in weather condition causes oxygen depletion in ponds.
- Salinity – milkfish growth is retarded at 45 ppt salinity; frequent water exchange should be done during the summer months.
- Water temperature – affects metabolism of fish and consequently growth rates; optimum temperature is 25-32°C; growth is reduced at 23°C.
- pH – indicates the presence of metabolites, photosynthetic activity and fertility of pond water; high pH value indicates that the pond water is too fertile, therefore, there is a possibility of a plankton bloom; low pH means the water is infertile and plankton growth is slow; optimum range is 6.5-8.5; above or below this range, the water should be changed immediately.
- Hydrogen sulfide – the by-product of decomposition, produced by the chemical reduction of organic residues which accumulate at the pond bottom; the bottom soil turns black and smells like a rotten egg. It decreases dissolved oxygen and pH of water and fish will die at 2 ppm concentration; hydrogen sulfide concentration could be reduced by water exchange and draining the pond.

f) During rainy days, drain the uppermost freshwater layer in the water column to prevent sudden drop in salinity.

g) If fish is observed to be gasping or swimming in circles, replenish with new water from the river source and if not possible draw water from adjoining ponds. Pumps can be used in such emergency.

h) Supplemental feeds such as commercial fish feed, rice brand or bread crumbs should be provided if lab-lab is prematurely depleted due to overgrazing, poor water condition, or persistent inclement weather.

i) Harvest and transfer the fingerings from the nursery pond to the transition pond after 4 to 6 weeks (2-7 cm with average weight of 1-6 g).

16.4 Harvest and Transfer of Fingerlings

Harvest or transfer should be preferably done in the morning just after sunrise or late afternoon to avoid mass mortality and stress. Oxygen content of pond water is at its lowest before sunrise while water temperature increases considerably after 8:00 o'clock in the morning. There are several methods of harvesting or transfer of milkfish fingerlings depending upon the circumstances. The most ideal is to take advantage of the behavior of the milkfish which always try to swim against the current. But this is not always possible. So different methods may be employed as detailed below:

a) "Pasulang" or Freshening Method

- Initially decrease the pond water level in the morning or at noon time and admit new water to the nursery the following day. This induces the fingerlings to go against the water current and congregate to catching pond/canal or confinement net where they are held prior to transfer or packing.
- Return the gate screen when the required fingerlings have been confined in the catching pond or canal or confinement net if the fingerlings are to be transported for stocking in grow-out pond, pens, or cages.
- Allow water to flow continuously in the catching pond or canal or confining net while the fish are still being held.

- If the fingerlings are to be transferred to the transition/grow-out pond, open the gate screen of the transition/grow-out pond and carefully drive the fingerlings in the catching pond or canal with a seine net towards the gate of the transition/grow/out pond. Drain the nursery and transfer the remaining fingerlings to the transition/grow-out pond.

- Keep the fingerlings for at least 12 hours (1 to 2 days is recommended) in the holding pond or confinement net for conditioning and excretion of their gut contents before counting and packing if the fish are to be transported for long distance.

b) Seining Method of Harvesting

This method should be used only if "pasulang" or freshening method cannot be undertaken. It should be done between 6:00 to 8:00 in the morning. Although the effect of stress and injuries during seining may not be immediate, heavy mortality may occur after stocking in the transition pond, grow- out pond, pen or cage. The following are the steps involved:

- The seine net is spread on the far end of the pond and drag towards the catching basin or canal.

- The fingerlings are concentrated and transferred in holding canal/pond or net confinement using fine-meshed knotless seine.

- Repeat seining operation until the required number of fingerlings are caught;

- Follow draining procedure if total harvesting is to be done.

- Continuous water flow should be provided in catching basin or canal while the fingerlings are still being held to prevent stress and oxygen depletion.

- The confinement net where the fingerlings are held is carried slowly and closely to the pond where the fish are to be stocked if the transition or rearing pond is in the same farm.

- Keep the fingerlings for at least 12 hours (1 to 2 days is recommend) in the holding pond or confinement net for conditioning and excretion of their gut contents before counting and packing if the fish are to be transported for long distance.

c) Draining Method

- Start gradual draining of the nursery or transition pond at 2 to 3 pm and completely drain the pond before dark to prevent the fingerlings to jump and get stuck in the mud. Milkfish fingerlings are sensitive to light at nighttime.

- As the pond is being drained, the fingerlings are guided with the use of seine net towards the catching pond or confinement net and held them there until transfer or packing for transport.

- The holding pond or confinement net should have a continuous flow of water to avoid dissolve oxygen depletion and ammonia build-up.

- When the nursery pond is almost drained, admit water from the adjacent pond so that the remaining fingerlings will swim against the current. The process of draining and flooding is repeated 2 to 3 times until all the fish are collected.

- Keep the fingerlings for at least 12 hours (1 to 2 days is recommended) in the holding pond or confinement net so their gut contents are excreted before counting, packing, and transport to other farm.

16.5 Counting, Packing and Transport

Counting, packing and transport is preferably done early in the morning or late in the afternoon when water temperature is relatively cooler.

a) Counting Large Numbers of Fingerlings for Live Boat Transport

- Counting the approximate number of fingerlings is accomplished with the aid of a small-perforated plastic bucket. The capacity of the plastic bucket is from 500 to 2,000 fingerlings depending on the size of fish and bucket.
- Scoop three buckets full of fish and count the contents.
- The resultant average number of fingerlings per bucket is multiplied by the number of scoops to provide the total count of fish.
- Transfer the counted fingerlings with the use of plastic bag to the live boat for immediate transport or dip net while waiting for transport.
- The live boat can accommodate between 50,000 to 120,000 fingerlings depending on boat dimension, fingerling size and weather condition.

b) Counting and Packing for Transport in Plastic Bags

- Actual count is done for transport of small shipment of fingerlings.
- Do not use water taken directly from the pond for transport using plastic bag method.
- Use only clean water with a salinity of 5 ppt for freshwater stocking or 25ppt for stocking in cages in the sea to reduce stress.
- Clear and clean water taken from the pond or river or sea is place in a container and allowed to settle for about one day. The salinity of the transport water is then adjusted depending on where the fish would be stocked.
- Introduce 2 liters of prepared transport water into the plastic bag and stock the fingerlings directly into the bag.
- The number of fingerlings that can be packed in one plastic bag depends on the size as follows:
- 3-6 cm Fingerlings: 100 to 150 fish/bag (50-75 fish/liter of water)
- 7-12 cm Fingerlings: 50 to 75 fish/bag (25 to 37 fish/liter of water)
- Inflate plastic bag with approximately 2/3 of its capacity with oxygen.
- Place bag inside Styrofoam box and put about ½ kg ice (contained in plastic bag and wrapped in newspaper) on top of plastic bag containing the fish. Care should be taken so that water temperature would not fall below 25°C.

c) Transport Using Canvas or Fiberglass Tank

- This transport method is usually undertaken for post- fingerlings (40 to 100 g).
- The post-fingerlings that have been held for 1 to 2 days in the confinement net (5 x 10 m) are caught and placed in plastic bag at 100 fish per bag.
- The bags are then immediately brought to a ten wheeler truck provided with a canvas or fiberglass transport tank containing approximately 7 m^3 of water and having a depth of about ½ m with a freeboard of 1 meter.
- Oxygen passing through airstones is used to aerate the canvass transport tank.
- This method can transport 10,000 to 20,000 big size milkfish finger-lings (40 to 100 grams) per trip with no mortality for at least 3 hours.

17. TRANSITION/STUNTING POND OPERATION AND MANAGEMENT

The transition/stunting pond should be prepared 1 to 1½ months ahead of stocking fingerlings. Follow pond preparation procedures indicated in Section 10.2. Installation of artificial net substrate is optional.

a) Stocking rate is 10 to 15 fingerlings per m^2. If the fingerlings come from other source and salinity difference is over 5 ppt, acclimation should be done to prevent salinity shock. Follow acclimation procedure outlined in the Nursery Pond Section **(Section 10.3).**

b) Maintain water depth at 30 to 40 cm. Recommended mesh size for gate screen is 0.5 cm.

c) Replace one half to one third of pond water every spring tide. Care should be taken in draining and flooding of the transition pond as not to detach the lab-lab from the pond bottom.

d) Apply inorganic fertilizer (16-20-0 at 30 kg/ha or 18-46-0 at 10 kg/ha) every 2 weeks depending on lab-lab growth:

- Application of fertilizer should only be done after replacement of pond water.
- Do not apply fertilizer during rainy days.
- During rainy days, drain the uppermost freshwater layer in the water column to prevent sudden drop in salinity.

e) If fish is observed to be gasping or swimming in circles, replenish with new water from the river source and if not possible draw water from adjoining ponds. Pumps can be used in such emergency.

f) Supplemental feeds such as commercial fish feed, rice bran or bread crumbs should be supplied if lab-lab is prematurely depleted due to overgrazing, poor water condition, or persistent inclement weather.

g) Start harvest of fingerlings from the transition pond when they reach the desired size of 7 to 15 cm (10 to 25 g) for stocking in grow-out ponds, pens or cages.

h) Milkfish fingerlings can be held in the transition/stunting pond for 6 months to one year with minimal mortality if necessary.

i) If post-milkfish fingerlings (40 to 80 g) are desired, the fish from the transition pond can be thinned out or transferred to a bigger pond (formation pond) at a stocking density of 7 to 10 fingerlings per m^2 for faster growth. Pond preparation, fertilization, and harvesting procedures in the formation pond are the same as in the nursery/transition phase except no artificial substrate is provided.

18. GROW-OUT OPERATION AND MANAGEMENT

18.1 Extensive or Straight-Run Method

Extensive or straight-run system is the traditional and most widely practiced milkfish culture method in the Philippines and is also known as "stock and wait method". The fish stays in the same grow-out pond from the time they are stocked to the time they are harvested. Basic ponds required are shown in Table 4 and Figure 12 shows a typical layout. The fish feed mainly on benthic algae (lab-lab) and filamentous green algae. Water management is purely tidal. This extensive method of milkfish production usually starts in the nursery pond where fry are stocked at a rate of 30 to 50 fry per m^2. The fry are reared in the nursery for 1 to 2 months and grow to about 5-8 cm (3-5 grams) fingerlings. The fingerlings are then transferred either directly to the rearing pond or to the transition/stunting pond at the rate of 15 to

Table 4. Size ranges of each farm component and ideal percentage area allocation based on total farm area.

Farm Components	Area	Percentage Area Allocation Based on Total Farm Area
Nursery ponds	500 - 5,000 m^2	2%
Transition ponds	1,000 – 20,000 m^2	8%
Rearing ponds	1 to 50 hectares	80%
Dikes & canals		5%

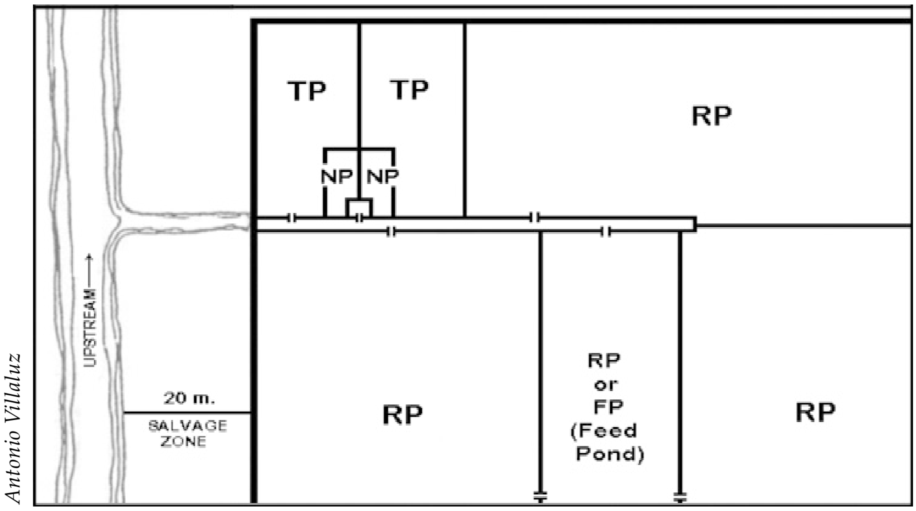

Figure 12. Typical layout of traditional milkfish farm.

25 fingerlings per m^2 for further growing to post-fingerlings. Stocking density of milkfish fingerlings or post-fingerlings in the rearing pond ranges from 1,000 to 3,000 per hectare depending on the availability of natural food in the pond and the target size at harvest (200 to 500g per fish). Harvesting of the fish is usually done at one time. Milkfish production for this method varied from 300 to 900 kg per hectare per crop or an annual production of 600 kg to 1,800 kg per hectare.

The growing of the milkfish follows the following procedure:

a) The rearing pond should be prepared 1 to 1½ months ahead of stocking fingerlings.

b) Follow pond preparation procedures indicated in **Section 13** but installation of artificial net substrate is omitted.

c) Stocking rate is from 1,000 to 3,000 per hectare depending on the availability of natural food in the pond and the target size at harvest (200 to 500g per fish).

d) Maintain water depth at 30 to 40 cm. Recommended mesh size for gate screen is 1.5 cm.

e) Replace one half to one third of pond water every spring tide. Care should be taken in draining and flooding of the grow-out pond as not to detach the lab-lab from the pond bottom.

f) Environmental factors affecting growth and survival of milkfish in the pond are as follows:

- Dissolved oxygen – optimum level is 3-10 ppm, below this level is harmful to the fish; during sudden rains, drain water from the surface or admit water to prevent sudden drop in salinity and temperature; during summer, closely monitor the water level and admit water frequently. When fish are observed gasping at the surface or swimming in circles, replenish with new water and if not possible draw water from adjoining ponds. Pumps can be used in such emergency.

- Weather conditions – sudden change in weather condition causes oxygen depletion in ponds:

- During sudden rains, drain water from the surface or admit water to prevent sudden drop in salinity and temperature;

- During summer, closely monitor the water level and admit water frequently.

- When fish are observed gasping at the surface or swimming in circles, replenish the water to agitate the pond water.

- Salinity – milkfish growth is retarded at 45 ppt salinity; frequent water exchange should be done during the summer months.

- Water temperature – affects metabolism of fish and consequently growth rates; optimum tempera-ture is 25-32°C; growth is reduced at 23°C.

- pH – indicates the presence of metabolites, photosynthetic activity and fertility of pond water; high pH value indicates that the pond water is too fertile, therefore, there is a possibility of a plankton bloom; low pH means the water is infertile and plankton growth is slow; optimum range is 6.5-8.5; above or below this range, the water should be changed immediately.

- Hydrogen sulfide – the by-product of decomposition, produced by the chemical reduction of organic residues which accumulate at the pond bottom; the bottom soil turns black and smells like a rotten egg. It decreases dissolved oxygen and pH of water and fish will die at 2 ppm concentration; hydrogen sulfide concentration could be reduced by water exchange and draining the pond.

g) Apply inorganic fertilizer (16-20-0 at 30 kg/ha or 18-46-0 at 10 kg/ha) every 2 weeks depending on lab-lab growth.

h) Application of fertilizer should only be done after replacement of pond water.

- Do not apply fertilizer during rainy days.

i) Supplemental feeds such as commercial fish feed, rice bran or bread crumbs should be supplied if lab-lab is prematurely depleted due to overgrazing, poor water condition, or persistent inclement weather.

j) Start harvest when natural food in the rearing pond becomes in short supply and/or the target size of 200g to 500g is attained.

k) Harvest when fish are scarce in the market to maximize profit. This is usually during full moon nights when not much fish are caught in the sea.

18.2 Modular or Progression Method

The modular method is a more complicated but highly productive type of culture technique. It takes maximum advantage of the growth of natural food in the pond, time and space. It is so called because large areas are subdivided into production modules. Each module consists of three pond compartments with a ratio either or 1: 2: 4 or 1: 3: 9. As shown in Figure 13. A continuous program of pond preparation, stocking, transfer and harvest characterize this method.

Fish rearing comprises of three production stages and takes about 30 to 45 days for each stage. The fish are moved from a smaller to a larger compartment as they grow. Modifications in stocking rate can be made where pond compartment ratios vary considerably. About 6-10% of the total farm area is allocated to nursery and transition ponds if these 2 components are incorporated in the farm. This method allows 4 to 8 crops per year with an annual yield ranging from 2,000 to 4,000 kg/ha.

A modification of this method employs a two stage production system wherein the grow - out ponds (formation and rearing pond) have a ratio of 1:2. It allows 4 cropping per year with an annual production of 2,000 to 4,000 kg/ha. The first crop is grown in the formation and rearing ponds for 85 days while the rest of the crops were grown for 70 days.

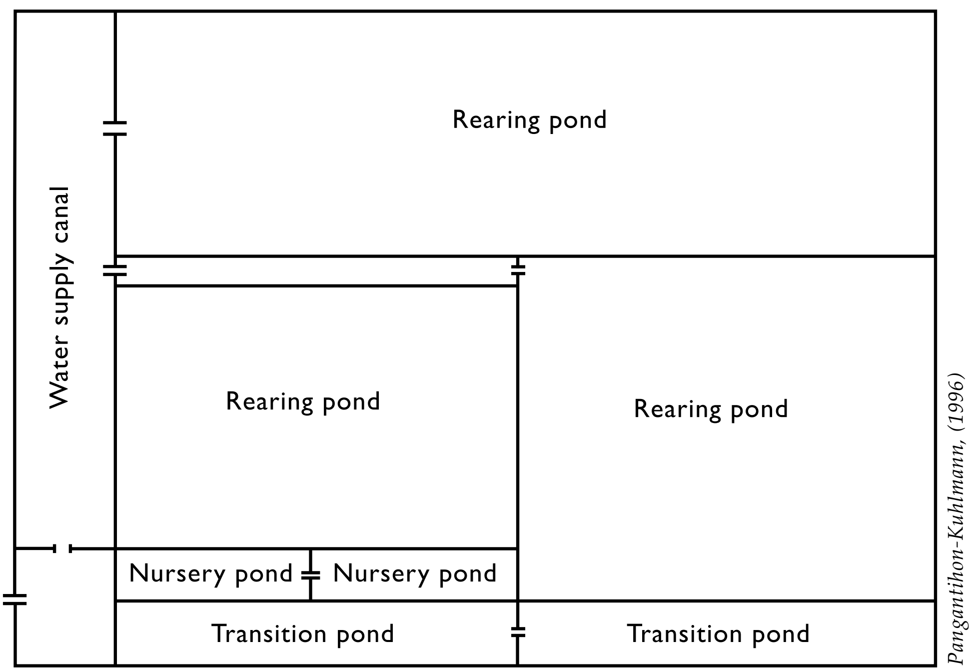

Figure 13. Pond lay-out for one milkfish production module.

It is very important that immediately upon fish transfer or harvest; the compartments are immediately prepared to attain the production schedule of 4 to 8 crops per year. A typical production schedule is shown in Table 5. If the farm intends to use milkfish fry and grow these to fingerlings then the nursery procedure in Section 14 and the procedure for transition and stunting in Section 15 is followed. Otherwise each module is operated and managed as follows:

a) Follow water and fertilization management as well as care of stock as outlined in the Extensive Method **(Section 16.1)**;

b) The milkfish fingerlings to be stocked in the grow-out module are either reared in the farm or acquired from commercial nurseries (cost of producing own fingerlings and buying outside is almost the same but regular supply and quality are not guaranteed). If the fingerlings come from other source acclimation should be done to prevent temperature and salinity shock as follows:

- Let the transport containers float in the grow-out pond for 15 to 30 minutes to equalize the temperature of the containers with the pond water;
- If salinity difference between transport containers and grow-out pond is above 5ppt, gradually add pond water to transport containers until salinity is equalize before releasing the fingerlings;
- Allow the fingerlings to swim out of the containers.

Table 5. Production schedule of modular culture method

	TRANSITION POND		FORMATION POND		REARING POND	
1st Crop	PP	Feb 13 – Mar 14	PP	Mar 14 - April 15	PP	Apr 15 - May 16
	S	15-Mar	S	16-Apr	S	17-May
	CP	Mar 15 - Apr 15	CP	April 16 - May 16	CP	May 17 - Jun 17
	T	16-Apr	T	17-May	H	18-Jun
2nd Crop	PP	Apr 17 - May 2	PP	May 18 - Jun 3	PP	Jun 19 – Jul 6
	S	3-May	S	4-Jun	S	6-Jul
	CP	May 3 - Jun 3	CP	Jun 4 - Jul 5	CP	Jul 6 - Aug 6
	T	4-Jun	T	6-Jul	H	7-Aug
3rd Crop	PP	Jun 5 - Jul 5	PP	Jul 7 - Aug 8	PP	9-Sep
	S	6-Jul	S	8-Aug	S	9-Sep
	CP	Jul 6 - Aug 7	CP	Aug 8 - Sep 8	CP	Sep 9 - Oct 9
	T	8-Aug	T	9-Sep	H	10-Oct
4th Crop	PP	Aug 9 - Sep 9	PP	Sep 10 - Oct 10	PP	Oct 11 - Nov 11
	S	10-Sep	S	11-Oct	S	12-Nov
	CP	Sep 10 - Oct 10	CP	Oct 11 - Nov 11	CP	Nov 12 - Dec 13
	T	11-Oct	T	12-Nov	H	14-Dec
5th Crop	PP	Dec 15 - Jan 15	PP	Jan 17 - Feb 16	PP	Feb 18 - Mar 18
	S	13-Nov	S	14-Dec	S	16-Jan
	CP	Nov 14 - Dec 13	CP	Dec 14 - Jan 15	CP	Jan 16 - Feb 16
	T	14-Dec	T	16-Jan	H	17-Feb
6th Crop	PP	Dec 15 - Jan 15	PP	Jan 17 - Feb 16	PP	Feb 18 - Mar 18
	S	16-Jan	S	17-Feb	S	19-Mar
	CP	Jan 16 - Feb 16	CP	Feb 17 - Mar 18	CP	Mar 19 - Apr 13
	T	17-Feb	T	19-Mar	H	14-Apr

LEGEND:
PP - Pond Preparation
S - Stocking
CP - Culture Period
T - Transfer
H - Harvest

Source: Baliao et al., 1999. The Modular Method. Milkfish Pond Culture. AEM No. 25 SEAFDEC Aquaculture Dept.

c) If the fingerlings come from the farm, use "pasulang" or freshening method in transferring fish from one pond to another to minimize stress. Follow transfer procedures stated in **Section 14.4).**

d) Stock milkfish fingerlings (at least 25 grams each) in the first compartment at 3,000 pieces per hectare based on the area of the last module. For example, under a 1: 2: 4 module, the first compartment is stocked at the rate of 12,000 fingerlings per hectare.

e) After 30 or 45 days of culture, the fish are transferred to the second compartment thereby effectively decreasing the stocking rate to 6,000 fish/ha.

f) In another 30 to 45 days, the fish are then again transferred to the last compartment with a final density of 3,000 fish/ha.

g) In case the set of grow-out module is not regular, for instance 1: 3: 5 pond proportions, the rule is to get the total area of the module (1+3+5) which is equivalent to 9 hectares in this particular set. A factor of 1,714 is multiplied by 9 hectares to obtain a total of 15,426 fingerlings to be stocked in the first compartment.

h) Supplemental feeds such as commercial fish feed, rice brand or bread crumbs should be supplied if lab-lab is prematurely depleted due to overgrazing, poor water condition, or persistent inclement weather.

i) Harvest after 30 to 45 days in the last compartment when natural food in the rearing pond becomes overgrazed and/or the target size of 200g to 350g is attained.

18.3 Deep Water-Plankton Method

The plankton method of milkfish culture utilizes deeper ponds (at least 1 meter in depth) in rearing milkfish at higher density using primarily plankton as food. Deeper pond water increases water volume per unit area and therefore more space is available to the fish and natural food production. This method was developed when it was observed that milkfish can utilize phytoplankton and zooplankton in the water column as food source. About 3 to 4 crops can be attained in a year with a production of around 800 kg/crop and an annual yield between 2.5 to 3 tons of milkfish per hectare. The procedural steps for this method are as follows:

a) Initially follow the water and fertilization management as outlined in Section 13.

b) Stocking rate is from 4,000 to 6,000 fingerlings per hectare depending on the availability of natural food in the pond and the desired size of fish at harvest.

c) The milkfish fingerlings to be stocked in the grow-out module are either reared in the farm or acquired from commercial nurseries (cost of producing own fingerlings and buying outside is almost the same but regular supply and quality are not guaranteed). If the fingerlings come from other source, acclimation should be done to prevent temperature and salinity shock as follows:

- Let the transport containers float in the grow-out pond for 15 to 30 minutes to equalize the temperature of the containers with the pond water.
- If salinity difference between transport containers and grow-out pond is above 5 ppt, gradually add pond water to transport containers until salinity is equalized before releasing the fry.
- Allow the fingerlings to swim out of the containers.

d) If the fingerlings come from the farm, use "pasulang" or freshening method in transferring fish from one compartment to another rearing compartment to minimize stress. Follow transfer procedures stated in **(Section 14.4).**

e) The fish initially feed on lab-lab but when lab-lab starts to deteriorate or get overgrazed; gradually increase the water level to 75-100 cm.

f) Apply inorganic fertilizer (18-46-0 or16-20-0) at 50 kg/ha divided in small doses every 12-15 days. Application of fertilizer is done either by directly broadcasting the fertilizer to the water or placing the fertilizer on a submerged platform placed 12 to 20 cm below the surface. Planktons should bloom after a few days which are characterized by a rich green water.

g) Closely monitor plankton growth and adjust fertilizer dosage and frequency of application to keep secchi disk reading between 20 and 30 cm. Reapply fertilizer if plankton does not bloom but if secchi reading is less than 20 cm stop fertilization and replace about ¼ of volume of pond water. A combination of regular water exchange and fertilization will maintain good plankton blooms. Water transparency of less than 20 cm indicates plankton over bloom and leads to plankton die-offs. Plankton die-offs reduce dissolved oxygen of pond water.

h) Supplemental feeds such as commercial fish feed, rice brand or bread crumbs should be supplied if the plankton prematurely collapsed due to poor water condition or persistent inclement weather.

i) Start harvest when natural food in the rearing pond becomes in short supply and/or the target size of 200g to 350g is attained.

j) Harvest when fish are scarce in the market to maximize profit. This is usually during full moon nights when not much fish are caught in the sea.

18.4 Stock Manipulation or Multi-Size Group Method

The stock manipulation method aims to maintain a balance between the fish population and natural food supply by periodic stocking of multi-size fish and partial harvesting. Under this technique of periodic stocking and partial harvesting, fish biomass in the pond fluctuates between 250 kg/ha to a maximum of 750 kg/ha until each harvest. The carrying capacity of brackishwater pond is from 700 to 800 kg /ha. Annual fish yield using this method is 2,000 to 3,000 kg/ha. This method was developed and popularly practiced in Taiwan. The steps involved are as follows:

a) Follow water and fertilization management as well as care of stock in the nursery and transition ponds as outlined in Sections 13, 14, 15).

b) Stock milkfish fingerlings of assorted sizes (5 to 100g) at 4,000-5,000 per hectare in the grow-out pond preferably during the month of April.

c) Acclimate the fish to pond environment before stocking:

- If salinity and temperature of transport containers and nursery pond are approximately the same, stock the fish directly.
- If not let the transport containers float in the nursery pond for 15 to 30 minutes to equalize the temperature of the containers with the pond water.
- If salinity difference between transport containers and nursery pond is above 5ppt, gradually add pond water to transport containers until salinity is equalized before releasing the fish.
- Allow the fry to swim out of the containers.

d) If the fingerlings come from the farm, use “pasulang” or freshening method in transferring fish from one compartment to another rearing compartment to minimize stress. Follow transfer procedures stated in Extensive Method (Section A. 7. 3).

e) Stock milkfish fry at 5,000 to 8,000 per hectare from May to August.

f) Provide rice bran as supplemental feed at 30 to 50 kg/ha daily or every two days to avoid overgrazing of natural food.

g) Begin selective harvesting at the end of May so that the smaller fish can grow more rapidly:

  - Selective harvesting is carried out with various mesh-size gill nets depending on the market demand.
  - Fish farmers usually empty the digestive tracts of the fish by exciting them before harvest.

h) Two or three more harvests to be undertaken in June and July to keep the fish biomass at optimum level.

i) Harvest once a month starting August when fish biomass reaches between 600 to 700 kg/ha.

j) Total harvest in mid-November.

18.5 Polyculture Method

Polyculture is also known as multi-species or composite fish culture. Two or more species with complementary feeding habits and behavior are grown together to enhance overall production and lessen financial risk in case one of the species undergoes crop failure. Milkfish maybe reared with shrimps, mudcrab, rabbitfish, seabass, tilapia, seaweeds, mollusks, and many other fish species either as primary or secondary crop. The polyculture of milkfish with shrimps or with crabs however, are the most popular and profitable. They compliment each other in terms of habitat and food requirements. Annual yield of milkfish as the primary stock when grown together with shrimp ranges from 1,200 to 1,800 kg/ha while annual shrimps production is from 100 to 200 kg/ha. On the other hand, about 550 kg per ha of milkfish and 1,500 kg/ha of crabs per crop can be attained using the polyculture method. Generally a minimum of 2 crops per year can be undertaken when milkfish is polycultured with either shrimps or crabs.

The procedure involved is as follows:

a) Initially follow the water and fertilization management as outlined in the Extensive Method (Section 10.6).

b) Stocking rates are from 1,000 to 3,000 milkfish fingerlings per hectare and 3,000 to 5,000 shrimp fry for milkfish-shrimp polyculture while for combination milkfish-crab culture stocking rates are 1,500 milkfish fingerlings and 10,000 juveniles for milkfish and crabs respectively.

c) Stock shrimp fry or crab juveniles while still growing natural food;

d) The milkfish fingerlings to be stocked in the grow-out module are either reared in the farm or acquired from commercial nurseries (cost of producing own fingerlings and buying outside is almost the same but regular supply and quality are not guaranteed). If the fingerlings come from other source, acclimation should be done to prevent temperature and salinity shock as follows:

  - If salinity and temperature of transport containers and nursery pond are approximately the same, stock the fish directly.
  - If not let the transport containers float in the nursery pond for 15 to 30 minutes to equalize the temperature of the containers with the pond water.
  - If salinity difference between transport containers and nursery pond is above 5ppt, gradually add pond water to transport containers until salinity is equalized before releasing the fish.
  - Allow the fry to swim out of the containers.

e) Follow the same acclimation and stocking procedures for shrimp fry or crab juveniles.

f) Maintain water depth at 40 to 50 cm. Recommended mesh size for gate screen is 1.5 cm.

g) Replace one half to one third of pond water for 3 to4 days every spring tide. Care should be taken in draining and flooding of the transition pond as not to detach the lab-lab from the pond bottom.

h) Apply inorganic fertilizer (16-20-0 at 30 kg/ha or 18-46-0 at 10 kg/ha) every 2 weeks depending on lab-lab growth.

- Application of fertilizer should only be done after replacement of pond water.
- Do not apply fertilizer during rainy days.
- During rainy days, drain the upper-most freshwater layer in the water column to prevent sudden drop in salinity.
- If fish is observed to be gasping or swimming in circles, replenish with new water from the river source and if not possible draw water from adjoining ponds. Pumps can be used in such emergency.
- Supplemental feeds such as commercial fish feed, rice brand or bread crumbs should be supplied if lab-lab is prematurely depleted due to overgrazing, poor water condition, or persistent inclement weather.

i) Feed the crabs with trash fish or mussel meat at about 10% of crab biomass per day if crab is grown with milkfish. Provide supplementary feeds occasionally in the form of trash fish, mollusks, or formulated diet to the shrimp particularly towards the end of the culture period if shrimps are grown with milkfish.

j) Start selective harvest of marketable crabs (≥ 150 g for female and ≥ 250 g for males) after 45 to 60 days of rearing. This is done by freshening and lift-net methods.

k) Start harvest of milkfish when natural food in the rearing pond becomes in short supply and/or the target sizes of 200 g to 500 g are attained. Use freshening method for partial harvest of all species being polycultured and total drainage to harvest all the stocks in the pond.

l) Harvest when fish are scarce in the market to maximize profit. This is usually during full moon nights when not much fish are caught in the sea.

18.6 Semi-Intensive Pond Culture Method

Semi-intensive culture method is characterized by smaller pond size of 1 to 5 hectares, at least 1 meter depth of water, and an increased stocking rate of 8,000 to 12,000 fingerlings per hectare in the rearing pond. Widening the gate, provision of separate drain gate and using water pump enhances water exchange. Oxygen supply is improved by providing paddlewheel aerators and maintaining good phytoplankton growth later in the growing period. Natural food, mainly lab-lab, is grown and used as food in the first 45 to 60 days of culture in the grow-out ponds and commercial formulated diet with at least 27% protein is supplied thereafter. Production is 2,000 – 2,500 kg/ha/crop. This method allows 2 to 3 crops and yields of 5,000 to 7,500 kg/ha/per year.

a) Initially follow the water and fertilization management as outlined in Section 16.1 for the Extensive Method

b) Stocking rate is from 8,000 to 12,000 fingerlings per hectare with an initial average weight of at least 60 grams to obtain lower FCR.

c) The milkfish fingerlings to be stocked in the grow-out module are either reared in the farm or acquired from commercial nurseries (cost of producing own fingerlings and buying outside is almost the same but regular supply and quality are not guaranteed). If the fingerlings come from other source, acclimation should be done to prevent temperature and salinity shock as follows:

- If salinity and temperature of transport containers and nursery pond are approximately the same, stock the fish directly.
- If not let the transport containers float in the nursery pond for 15 to 30 minutes to equalize the temperature of the containers with the pond water.
- If salinity difference between transport containers and nursery pond

is above 5 ppt, gradually add pond water to transport containers until salinity is equalized before releasing the fish.

- Allow the fry to swim out of the containers.

d) If the fingerlings come from the farm, use "pasulang" or freshening method in transferring fish from one compartment to another rearing compartment to minimize stress. Follow transfer procedures stated in Extensive Method (Section A. 7. 3).

e) The fish initially feed on lab-lab but when lab-lab starts to deteriorate or get overgrazed (usually in about 45 to 60 days of rearing); gradually increase the water level to 80-100 cm.

f) Install or operate water pump for efficient water exchange and to prevent mortality due to low dissolved oxygen (≤ 1 ppm) particularly early in the morning or after sudden rain during the summer.

g) Apply inorganic fertilizer (18-46-0 or16-20-0) at 50 kg/ha divided in small doses every 12-15 days. Application of fertilizer is done either by directly broadcasting the fertilizer to the water or placing the fertilizer on a submerged platform placed 12 to 20 cm below the surface.

h) Closely monitor plankton growth and adjust fertilizer dosage and frequency of application to keep secchi disk reading between 30 and 50 cm. A combination of biweekly water exchange and fertilization will maintain good plankton blooms and maintain safe ambient oxygen level in the pond.

i) Commercial pellets (usually with 23-27% crude protein) are given when natural food becomes insufficient or prematurely collapsed due to poor water condition or persistent inclement weather.

j) Do not feed when dissolved oxygen level is below 1.5 ppm because the

Table 6. Feeding guide for milkfish at various body weights.

Feed Type	Fry Mash	Starter Crumble	Starter Pellet	Grower	Finisher
Fish Weight (g)	Fry - 5	5 - 70	50 - 150	150 - 250	250 - up
Feed Rate (%)	8 -10	3.5 - 5	3 - 3.75	2.5 – 3.25	2 – 2.75
Feeding frequency	1 – 2 x	2 – 3 x	3 – 4 x	3 – 4 x	3 – 4 x

Source:Cruz,1996

Table 7. Recommended feeding frequency and feeding schedule for milkfish.

Natural Food Availability	Feeding Frequency	Feeding Schedule and Ration Distribution			
		1st	2nd	3rd	4th
High	1x	3 pm (100%)	-	-	-
	2x	9 am (30-40%)	3 pm (60-70%)	-	-
Low	3x	8 am (20-30%)	12 pm (35-40%)	4 pm (35-40%)	-
	4x	8 am (10-25%)	11 am (25-30%)	2 pm (25-30%)	5 pm (25-30%)

Source: Cruz, 1996

Table 8. Suggested feeding management based on weather conditions

Water Temperature (^{0}C)	Feeding Quantity
25-30	Feed at 100% of calculated daily feed ration
20-24	Feed at 80% of calculated daily feed ration
16-20	Feed at 60% of calculated daily feed ration
30-32	Feed at 80% of calculated daily feed ration

Source: www.tateh.com

fish would not eat and the formulated feed will only go to waste.

k) Feeding guide at various body weights, feeding frequency and ration distribution for high density culture is provided in Tables 6, 7 and 8. The feeding schemes indicated should be only used as a guide and should be regularly evaluated and adjusted as necessary. Actual feed consumption vary depending on prevailing environmental conditions particularly dissolved oxygen, temperature, and availability of natural food.

l) Feeding Method

There are currently 3 feeding methods that are being employed in semi-intensive culture system:

- Hand feeding
  - Food ration is broadcasted by hand for 15-30 minutes at fixed areas of the pond.
  - Feeds are usually given at 8 am, 12 noon and 4 pm.
  - This method allows uniform feeding and observation of appetite and feed response but costly and labor intensive.
  - Feeding tray
  - Designed for use with sinking pellets.
  - Feed ration is placed on a 1 x 1m or 1 x 2 m fine meshed net situated 15-20 cm below the water surface.
  - Low cost and simple to use.
  - Its use is being discouraged due to feed losses resulting from nutrient leaching and feed disintegration caused by the low stability of fish feeds.
- Demand Feeder
  - Feed release mechanism triggered by fish on demand.
  - Cost and labor efficient; reflects on appetite and condition of fish.
  - Should be used strictly with a maximum feeder: fish ratio to ensure uniform feeding; cannot be used for smaller than 20 g fish.

m) Install 2 units paddlewheel aerators and operate between 2 am to 8 am when biomass of the milkfish in the pond wreached 800 to 1,300 kg to maintain safe dissolved level of not less than 3 ppm in the pond water.

n) Replace at least 50% of water volume once a week on the last month of culture to flush out toxic metabolites.

o) Start harvest when the target size of 200 g to 300 g is attained.

p) Harvest when fish are scarce in the market to maximize profit. This is usually during full moon nights when not many fish are caught in the sea.

18.7 Intensive Method

The intensive milkfish culture method employs high levels of inputs such as seed stocks, formulated feeds, water, and energy in small (0.1-1 hectare) but deeper (1-2 m) grow-out ponds. It requires enormous capital investments, large working capital, and technical proficiency. This type of culture allows 2 to 3 crops a year and produces a high yield of 8,000 to 12,000 kg/ha/yr but is considered a high-risk venture. Mass mortality is a constant treat due to accumulations of toxic metabolites such as ammonia and sulfides, oxygen depletion, and diseases. Procedures in pond preparation, maintaining good water quality, feeding and care of stocks are very similar with semi-intensive method but with more material and technical inputs.

The procedure involved is as follows

a) Initially follow the water and fertilization management as outlined in Section 16.1 for the Extensive Method.

b) Stocking rate is from 20,000 to 30,000 fingerlings per hectare with an initial average weight of at least 25 grams to obtain lower FCR.

c) The milkfish fingerlings to be stocked in the grow-out module are either reared in the farm or acquired from commercial nurseries (cost of producing own fingerlings and buying outside is almost the same but regular supply and quality are not guaranteed). If the fingerlings come from other source, acclimation should be done to prevent temperature and salinity shock as follows:

- If salinity and temperature of transport containers and nursery pond are approximately the same, stock the fish directly.
- If not let the transport containers float in the nursery pond for 15 to 30 minutes to equalize the temperature of the containers with the pond water.
- If salinity difference between transport containers and nursery pond is above 5ppt, gradually add pond water to transport containers until salinity is equalized before releasing the fish.
- Allow the fry to swim out of the containers.

d) If the fingerlings come from the farm, use "pasulang" or freshening method in transferring fish from one compartment to another rearing compartment to minimize stress. Follow transfer procedures stated in Extensive Method **(Section 10.4.4).**

e) The fish initially feed on lab-lab but when lab-lab starts to deteriorate or get overgrazed (usually in about 15 to 30 days of rearing); gradually increase the water level to 100-120 cm and start feeding with commercial pellets.

f) Install or operate water pump for efficient water exchange and to prevent mortality due to low dissolved oxygen (≤ 1 ppm) particularly early in the morning or after sudden rain during the summer.

g) Closely monitor plankton growth and adjust fertilizer dosage and frequency of application to keep secchi disk reading between 30 and 50 cm. A combination of water exchange and fertilization will maintain good plankton blooms and maintain safe ambient oxygen level in the pond.

h) It is recommended that high protein formulated diet containing 27-31% protein be utilized in feeding the milkfish in intensive ponds. Training of the milkfish to feed on artificial diet is necessary for 2 to 3 days.

i) Commercial formulated pellets are expensive and, therefore, good feeding practice should be followed to obtain fast growth rate of fish, low feed conversion and at the same time prevent pollution of water and deterioration of pond soil. The following are the feeding methods used in milkfish intensive farms:

- Hand feeding
  - Food ration is broadcasted by hand for 15-30 minutes at fixed areas of the pond.
  - Feeds rations are consumed as these are broadcasted.
  - This method allows uniform feeding and observation of appetite and feed response but costly and labor intensive.
- Feeding tray
  - Designed for use with sinking pellets.
  - Typically 1- 4 m^2 platforms which maybe made of either fine meshed net, canvas, plastic or marine plywood and positioned 15-20 cm below the water surface.
  - Low cost and simple to use.
  - It is low cost and simple to use but its use is being discouraged due to feed losses resulting from nutrient leaching and feed disintegration caused by the low stability of fish feeds.
- Feeding Ring
  - It is specifically utilized for floating feeds and usually made of buoyant bamboo frame to prevent the

feed from drifting outside the feeding area.

- Like the feed tray it is both cost effective and labor saver but would encourage competition among the fish which in turn would lead to uneven sizes.
- Setting up of several small feeding areas using feeding rings around the pond instead of only a few large ones will be advantageous.

• Demand Feeder

- Feed release mechanism triggered by fish on demand.

Table 9. Recommended size range and number of fish per demand feeder.	
Size range	**Number of fish/feeder**
20-80 g	5,000-7,000 fish/unit
80-150 g	3,500-4,500 fish/unit
>150 g	2,000-3,000 fish/unit

- Cost and labor efficient; reflects on appetite and condition of fish.
- Should be used strictly with a maximum feeder: fish ratio to ensure uniform feeding; cannot be used for smaller than 20 g fish. See Table 9 for recommended number and size range of fish per demand feeder.

j) Recommended feeding rates at various body weights, feeding frequency and ration distribution for high density culture is provided in Tables 7, 8 and 9. The feeding schemes indicated should be only used as a guide and should be regularly evaluated and adjusted as necessary. Actual feed consumption vary depending on prevailing environmental conditions particularly dissolved oxygen, temperature, and availability of natural food.

k) Do not feed when dissolved oxygen level is below 1.5 ppm because the fish would not eat and the formulated feed will only go to waste.

l) Install 2 units paddlewheel aerators and operate between 2 am to 8 am when biomass reached 800 to 1,500 kg and between 12 midnight to 9 am when the biomass exceed 1,500 kg to maintain safe dissolved level of not less than 3 ppm.

m) Replace at least 50% of water volume once a week starting on the 45th day of culture to flush out toxic metabolites, promote healthy plankton bloom, and maintenance of optimal dissolve oxygen (> 3 ppm) in water.

n) Start harvest when the target size of 200 g to 300 g is attained.

1. Harvest when fish are scarce in the market to maximize profit. This is usually during full moon nights when not much fish are caught in the sea.

19. HARVEST OF MARKETABLE MILKFISH

Complete and partial harvesting is both practiced but total harvesting by draining lowers the quality of fish. Harvesting of marketable milkfish is undertaken using the following methods:

19.1 By "Pasulang" or Freshening

a) Harvest at night or early in the morning by inducing the milkfish to go against the water current during the spring tide and congregate the fish to the catching pond or canal.

b) Collect the fish concentrated in the catching pond or canal system using drag seines or scoop net.

c) Totally drain the pond and handpick the remaining fish when the pond is totally drained.

19.2 By Total Drainage

As the name indicates, the pond water is totally drained and the fish are handpicked. One disadvantage of this method is the muddy smell and taste because of the mud that adheres to the body and gills of fish.

19.3 By Gill Net

This method is use for partial harvesting in ponds and in fish pens. A gill net of appropriate mesh size is used to catch the fish.

19.4 By Seining

A seine net is dragged across the pond to catch the fish. This method is used for partial harvesting in ponds and fish pens.

19.5 By Stationary Fish Corral

This is used in small-sized ponds to catch small quantity of fish. Water is admitted to make the fish swim towards the corral installed near the main gate. The fish are then scooped or seined from the corral.

20. POST-HARVEST HANDLING OF MARKETABLE MILKFISH

a) Wash the fish with pond water prior to icing and sort according to size.

b) Prevent the fish from loosing scales by placing a bamboo screen or seine over the still alive fish until they stop flipping.

c) Pre-chill the fish to 40°C immediately after harvest using chilling tank or box to maintain quality of harvested fish. The container is usually made of wood, fiberglass or permanent concrete tank constructed near the catching pond. Maintain 1:1 ratio of ice to a kg of fish or two blocks of ice for each ton of fish.

d) Keep the temperature at 0°C to slow down enzymatic activities and delay spoilage.

e) Minimize contact of fish with dirty surfaces and handlers.

f) Prevent physical damage to fish (bruises, cuts, etc.).

g) Dip the fish in iced water before packing to prevent fish from loosing more scales and to further remove blood, slime, dirt and bacteria from the skin of the fish.

h) Milkfish are packed in wooden boxes or metal container (“bañera”) or bamboo wicker baskets (“kaings”).

i) If the fish will be immediately sold, they can be packed heads up (vertically) in slatted baskets that are well ventilated and well drained.

j) If the fish will not be sold locally and transported by land, a 1:2 ratio of ice to fish (weight basis) is needed for 1 ½ hours of travel and a 1:1 ratio for 3 hours of travel is recommended.

k) Shipping milkfish through commercial cargo vessels requires the use of rigid wooden containers using the following procedure:

- Spread a layer of crushed ice 15 cm thick at the bottom of the transport box. Make sure the ice is compact to minimize thawing and to cushion the fish.
- Lay the fish on top of the crushed ice. Arrange the fish alternately head and tail in rows or parallel to each other;.
- Spread another layer of crushed ice 5 cm thick on top of the fish;
- Repeat the two preceding steps above until the last layer of fish is 15 cm below the top of the box.
- Place the last layer of crushed ice 15 cm thick on top of the last layer of fish. The bottom and the top layers of ice should always be 15 cm thick.
- Do not remove fish from the box until it reaches the market place because fish can stay fresh in the box for more than12 hours.
- Add ice to the top layer of the fish in the box if the fish cannot be sold within 24 hours.

21. COMPARISON BETWEEN PRACTICES AND ECONOMICS

21.1 Comparative Culture Practices of Milkfish in Earthen Ponds

The different milkfish culture practices in earthen ponds are summarized in Table 10.

Table 10. Milkfish culture practices in earthen ponds.

Culture System	Stocking Density (fish/ha)	Food Supply	Pond Size (ha)	Pond Depth (cm)	Water Mgt.	Crops (yr)	Yield (kg/ha/yr)
Extensive	1,000-3,000	Natural food	1-50	40-50	Tidal	2	600-1,800
Modular	3,000-	Natural food	1-10	40-50	Tidal Pumping	4-8	2,000-4,000
Plankton	4,000-6,000	Natural food supl. feeding	1-10	≥100	Tidal Pumping	2-3	2,500-3,000
Multi-Sized Group	10,000 -12,000	Natural food Supplemental Feeding	1-10	40-50	Tidal	Selective Harvest	2,000-3,000
Semi-Intensive	8,000-12,000	Natural food supl. feeding	1-5	40-50 75-120	Tidal Pumping Aeration	2-3	5,000-7,500
Intensive	> 20,000	Commercial feeds	0.1-1	40-50 75-200	Tidal Pumping Aeration	2-3	8,000-12,000

Table 11. Three types of management programs of milkfish ponds in accordance with the four types of climatic conditions (Source: Tang, 1967).

Type of Management Program		Period for conditioning the pond bottoms	Period for rearing the fish	Type of weather	Region
Type I	1st fish rearing season	Nov	Dec to Apr	1st type: 2 pronounced seasons, dry from Nov to May, wet during the rest of the year	The western part of North and central Luzon and of Mindoro, Panay, Negros and Palawan
	2nd fish rearing season	May	Jun to Oct		
Type II	1st fish rearing season	Oct	Nov to Mar	2nd & 3rd types: Seasons not very pronounced, relatively dry from Nov to April or with maximum rainfall from Nov to Jan	The eastern part of South Luzon, Samar, Leyte, Panay, Negros, Palawan and Mindanao; the western and central part of Mindanao; and the whole island of Masbate and Cebu.
	2nd fish rearing season	Apr	May to Sep		
Type III	1st fish rearing season	Feb	Mar to May	4th type: Rainfall more or less evenly distributed throughout the year.	The western part of South Luzon, Samar, Leyte and Mindoro; the eastern part of North and Central Luzon; and southern part of Mindanao; and the whole island of Bohol.
	2nd fish rearing season	Jun			

21.2 Management Programs of Earthen Milkfish Ponds Based on Four Types of Philippine Climatic Conditions

Some 85 percent of milkfish production in the Philippines comes from brackishwater fishponds. As such most of the milkfish produced in the country relies on natural feed, largely lablab, the blue-green algal complex and to a certain extent "lumot" or filamentous green algae. With such feed it is obvious that milkfish production in the Philippines is weather-dependent. Long periods of sunshine favor algal production and therefore milkfish production. It is not surprising that the major milkfish producing regions where average annual production always exceed one metric ton consist of Ilocos, Central Luzon and Iloilo. Pond management programs based on the 4 climatic types of the Philippines are indicated in Table 11.

21.3 Tidal Fluctuations and Frequency of Flood and Ebb in the Seven Reference Stations of the Philippines

Milkfish ponds in the Philippines depend on tidal flow for initial filling and for water change. Harvests have to be scheduled to coincide with an ebb tide preferably during spring tides. Knowing the exact time when the sea rises or fall is therefore an important factor for successful fishpond operation. Daily tidal information is contained in a Tide Table which is issued annually by National Mapping and Resource Information Authority (NAMRIA).

Tidal fluctuations in the Philippines vary from place to place. For this reason, the NAMRIA maintains 7 tidal reference stations located in strategic locations from the north to the south of the country. Based on the typical tide curves in these reference stations, frequency of rise and fall is either semi-diurnal or diurnal and the tidal ranges vary from about 0.75 m to 1.75 m as shown in Table 12.

The time of rise and fall in specific locations outside the reference stations are computed using correction factors for height and for time that is provided for various localities in the Tide Table. While such exact information maybe important for navigation purposes, a few more minutes plus or minus and a few more centimeters higher or lower are tolerable in fishpond operation. Most fishpond caretakers therefore merely rely on the daily tide information provided in some calendars. This information is often based on the Reference Station nearest the publisher of the calendar. Experienced caretakers also often can already predict the time of rise and fall based on the lunar phase

21.4 Comparative Investment Requirements and Costs and Returns

Bio-technical assumptions, investment requirements, and costs and returns of principal milkfish culture systems in earthen ponds are shown in Tables 13, 14 and 15.

Table 12. Tidal ranges in the seven reference stations of the Philippines.

		Tidal Elevation (meters from zero datum)*		
Reference Stations	Frequency of flood and ebb	Lowest Tide	Highest Tide	Tidal Range (m)
San Fernando Harbor	Diurnal	-0.125	0.625	0.750
Manila	Diurnal	-0.200	1.000	1.200
Legaspi Port	Semi-diurnal	-0.250	1.500	1.750
Cebu	Semi-diurnal	-0.200	1.650	0.850
Jolo	Diurnal	0.000	1.000	1.000
Davao	Semi-diurnal	-0.300	1.650	1.950
Tacloban	Semi-diurnal	0.050	0.750	0.800

*Approximated from typical tidal curve given in NAMRIA tide table.

Table 13. Bio-technical assumptions of major culture methods in earthen ponds.

	Extensive	Modular	Semi-Intensive	Intensive
Production Area	1 ha	1 ha	1 ha	1 ha
Stocking Density	3,000	1,714	12,000	20,000
Survival Rate (%)	90%	90%	90%	90%
Culture Period (days)	135	90	135	135
Crops (per year)	2	6	2	2
Ave. Harvest Size (g)	333	250	333	333
Ave. Yield per Crop	900	386	3,596	5,994
FCR			1.5	1.8
FarmGatePrice (PhP/pc/kg)	75	70	75	75

Table 14. Comparative investment requirements of major culture methods in earthen ponds.				
Culture System	**Extensive**	**Modular**	**Semi-Intensive**	**Intensive**
Capital Outlay				
Improvements	20,000	40,000	55,000	55,000
Equipment	2,000	2,000	125,000	195,000
Sub-Total	22,000	42,000	180,000	250,000
Working Capital	45,500	28,737	173,676	348,695
TOTAL	67,500	70,737	353,676	598,695

Table 15. Comparative costs and returns of different culture methods in earthen ponds.				
Item	Extensive	Modular	Semi-Intensive	Intensive
Production	1,800	2,314	7,193	11,988
Sales	134,999	161,973	539,460	899,100
Less:				
Variable costs				
Milkfish fingerlings	10,800	18,511	43,200	72,000
Lime	3,750	3,750	3,750	3,750
Chicken manure	4,000	3,960		
Supplemental feed	4,200		226,573	453,146
21-0-0	1,950	3,900	1,950	390
45-0-0	2,700	2,160	2,700	540
16-20-0	11,200	19,200	5,600	1,600
Direct Labor	3,000	9,000	3,000	3,000
Gasoline & oil			20,000	80,000
Caretaker	12,000	12,000	12,000	12,000
Repairs & maintenance	2,000	3,000	5,000	5,000
Harvesting cost	5,400	6,942	21,578	35,964
Caretaker's incentive	32,171	32,967	32,211	38,679
Subtotal	93,171	115,390	377,562	706,069
Fixed costs				
Depreciation	4,400	8,400	36,000	50,000
Pond rental	15,000	15,000	15,000	15,000
Subtotal	19,400	23,400	51,000	65,000
Total Costs	112,571	138,790	428,562	771,069
Net income before tax	22,428	23,183	110,898	128,031
Undiscounted economic indicators				
Unit Cost of Production	62.54	59.98	59.58	64.32
Return on Investment	33%	33%	31%	21%
Payback Period	3	3	3	5

Part Four

CULTURE IN PENS AND CAGES

22. MILKFISH PEN AND CAGE PRODUCTION SYSTEMS

Farming in pens and cages of milkfish is the most favorable solution in increasing fish production without further conversion of wetlands and mangroves into aquaculture ponds. Pens and cages are high production systems, relatively simple and less expensive to construct but would require a large amount of working capital due to high cost of commercial feeds in sites where feeding is needed. These two culture methods have high returns but can be considered high risk on account of natural calamities such as typhoons, drought, and fish kills due to pollution, dissolved oxygen depletion, and plankton blooms.

23. PEN CULTURE METHOD

23.1 Description of the Pen Culture Method

23.1.1 Pen Culture in Eutrophic Freshwater Lakes

The farming of milkfish in pens is undertaken in freshwater lakes, brackishwater areas, and in shallow coastal marine waters. In eutrophic (plankton-rich) lakes and bays the milkfish feed mainly on plankton and also forage for food at the bottom. However, there are times that supplementary feeding may be required especially when stocked at higher densities or natural food becomes depleted. Pen operators in Laguna de Bay (pen area ranges from 1-400 ha with an average water depth 3 meters) stock 30,000 to 50,000 fingerlings per hectare which equals 1 fish per m^3. The fish grow to market size (250-300 g) in 4 to 8 months with survival of 60-80% and yield from 4,000 kg/ha to as high as 10,000 kg/ha.

23.1.2 Pen Culture in Marine and Brackishwater pens

Marine and brackishwater pens are generally smaller in size (500–1,600 m^2). The depth, area and speed of the water current at the culture grounds determine the culture density (6–12) fingerlings per m^2. Commercial formulated diet containing 27-31% protein is fed daily at 3-4 times a day starting from stocking till harvest.

The fish reach harvest size of 250-275 g in 4-5 months with a survival rate of 80-90% and production of 1.5-5 kg/m^2.

23.2 Physical Requirements

23.2.1 The Site

The site of the aquaculture project is perhaps the most significant factor that determines the culture method and level of viability of an aquaculture operation. Fish pens should be located in areas that will provide optimum water quality; minimize conditions that may induce stress, decrease growth or predispose the fish to diseases; and reduce cost of operation.

a) Fish pens should be situated in protected shallow bays, sheltered coastal areas, enclosed lagoons, estuaries, tidal rivers and fresh-water lakes having the following characteristics:

- Sheltered from intense wind and destructive wave action.
- Water current speed of 10-20 cm/sec in order to maintain good water quality. Areas with strong current (> 40 cm/sec) should be avoided.
- Firm but deep mud. Sites with hard and sandy or gravelly bottom to be avoided;
- Far from water run-off which will cause high turbidity, abrupt salinity fluctuations that may last from 3 to 6 days. This may disrupt feeding, irritate gills and cause diseases, and possible destruction of pens caused by run-off debris.
- Water is relatively free of heavy loads of domestic, agricultural and industrial effluents.
- Good water exchange brought about by wind generated waves, currents, tidal flows and unimpeded water flow.
- High and stable dissolved oxygen level of water (5-7 ppm). Avoid sites that are strongly stratified or with algal blooms because these will give poor oxygen condition.
- Water pH should be 6.5-8.5. High pH can damage gills and cause death of fish. It could also affect the toxicity of several common pollutants and heavy metals.
- Water depth should not be less than 1.5 m at the lowest water level.

b) Sites which are overcrowded should be avoided.

c) Near reliable source of milkfish fingerlings of at least 25 g and market for the harvested milkfish.

d) Other factors. The site should have access to farm-to-market roads, power supply, telephone, available labor, construction materials and other necessary inputs. Also, consider the peace and order condition in the area.

23.2.2 Facilities, Equipment and Tools

a) Net Pens

Fishpens are constructed in various sizes and shapes: square, circular or rectangular and may contain a nursery compartment (200-1,000 m^2) within the grow-out pen. Sizes of the fishpen range from 500 m^2 to 100 ha or more. A common rectangular brackishwater/marine pen is 20 x 80 x 6 m (1,600 m 2 x 6 m) which is made up of 2 rolls of net, each roll measuring 100m in length and 3 meters wide. Nets (net mesh sizes 5-15 mm) are used for the enclosure of nursery and grow-out pens respectively. The largest mesh size that will prevent the stocked fish from escaping but small enough to prevent entry of predators is recommended as netting material to allow good water flow and diminish fouling.

Antonio Villaluz

Figure 14. Fishpens in tidal river.

Antonio Villaluz

Figure 15. Fishpens in lagoon.

Fishpens are commonly set where water depth is from 2 to 5 m in tidal rivers (Figue 14) and lagoons (Figure 15) but in shallow protected bays and freshwater lakes (Figure 16) from 3 to 7 meters deep.

Summary of materials required in constructing fishpens:

- Framework – Bamboo poles
- Pen net enclosure – Polyethylene net, CC-net, 17 knots, knotless
- Barrier net enclosure (optional) - Polyethylene net, 7 knots, knotted
- Nursery net enclosure - Polyethylene net, V-net size 8-12
- Rope for tying and netting - Polyethylene rope, 5mm
- Twine for net/barrier assembly – Polyethylene twine, 1mm
- Sinker stone – 1 inch thick, 5 inch diameter
- Bamboo stakes

b) Caretaker's Hut or Guard House

c) Equipment and Tools Required

- Various kinds of nets
- Water pump
- Paddlewheel aerators
- Automatic/demand feeders
- Motorized boat

Liao and Chen (1986)

Figure 16. Fishpens in lake.

- Flat boat (for hauling feed and harvest)
- Scuba gear
- Chilling tanks and harvest containers

23.3 Inputs

a) Good quality milkfish fingerlings of at least 25 grams in weight

b) Commercial feed pellets

c) Supplementary feeds such as rice bran or bread crumbs in eutrophic lakes (i.e. Laguna de Bay)

23.4 Fish Pen Operation and Management

23.4.1 Fish Pen Nursery Compartment

A pen nursery varies from 200–1,000 m2 in which the small-sized fingerlings (5-25 g) will be raised until they are large enough (40-50 g) to be released into the grow-out compartment.

a) Milkfish fingerlings are either transported by live-fish boat ("petuya") or oxygenated plastic bags from the nurseries to the culture pens. Delivery of seeds is done in calm days as a preventative measure to minimize stress.

- If the fingerlings are transported using live-fish boat, gradual acclimation to pen environment is undertaken during transport.
  - Acclimation is done by pumping out partially at interval the original water from the source of fingerlings. Simultaneous with this is the removal of a hole plug in the boat to allow water from the lake, river, or sea to come in;
  - As soon as fish pen is reached, the fingerlings are seined out and transferred carefully into the pen nursery.

b) If the fingerlings are transported using oxygenated plastic bags, the following acclimation procedures should be made to prevent temperature and salinity shock.

- Let the plastic transport containers float in the nursery pen for 15 to 30 minutes to equalize the temperature of the containers with the surrounding water.
- If salinity difference between transport containers and nursery pen is above 5 ppt, gradually add pen water to transport containers until salinity is equalized before releasing the fingerlings.
- Allow the fingerlings to swim out of the containers into the pen nursery.

c) While in the pen nursery the fingerlings, depending on the abundance of natural food, should be fed with fine rice bran or commercial feed pellets at about 3 to 5 percent of the extrapolated fish biomass.

d) Control of predators in the nursery compartment is done using peated netting.

e) The stocks stay in the nursery for one to two months depending on the desired grow-out stocking size or until such time that it is no longer possible for them to pass through the grow-out net enclosure.

23.4.2 Fish Pen Grow-out

a) Elimination of predators and competitors in the grow-out compartment should be undertaken using peated netting before stocking.

b) Fingerlings are released to the grow-out compartment by lowering one side of the nursery net.

c) The main cause why the growth potential of appropriately fed fish is not fully achieved is that stocking density has exceeded the carrying capacity of the system. An optimum density and proper feeding are required for economical fish pen operation.

d) Stocking rates depends on the location of the pens and abundance of natural food.

- Laguna de Bay – 3 to 5 fish per m^2
- Marine and brackishwater environments – 6 to 12 fingerlings per m^2

e) No feeding or just supplementary feeding is required in pens located in areas with abundant natural food such as Laguna de Bay but in areas with insufficient natural food (marine and brackishwater) and high stocking densities feeding of high protein formulated diet (27-31% protein) is essential.

f) Commercial formulated pellets are expensive and, therefore, good feeding practice should be followed to obtain fast growth rate of fish, low feed conversion and at the same time prevent pollution of water and deterioration of the pen bottom.

g) Training of the milkfish to feed on artificial diet is necessary for 2 to 3 days. The following are the feeding methods used in milkfish pen culture:

- Hand Feeding
    - Food ration is broadcasted by hand at fixed areas of the pen.
    - Rations are consumed as these are broadcasted.
    - Allows uniform feeding and observation of appetite and feed response but costly and labor intensive.
- Feeding Ring
    - It is specifically utilized for floating feeds and usually made of buoyant bamboo frame or net to prevent the feed from drifting outside the feeding area.
    - Like the feed tray it is both cost effective and labor saver but would encourage competition among the fish which in turn would lead to uneven sizes.
    - Setting up of several small feeding areas using feeding rings around the pen instead of only a few large ones will be advantageous.

- Demand Feeder
    - Feed release mechanism triggered by fish on demand.
    - Cost and labor efficient; reflects on appetite and condition of fish.
    - Should be used strictly with a maximum feeder: fish ratio to ensure uniform feeding; cannot be used for smaller than 20 g fish. See Table 10 for recommended size range and number of fish per demand feeder.

h) Recommended feeding rates at various body weights, feeding frequency and ration distribution for high density culture is provided in Table 7, 8 and 9. The feeding schemes indicated should be used only as a guide and should be regularly evaluated and adjusted as necessary. Actual feed consumption vary depending on prevailing environmental conditions particularly dissolved oxygen, temperature, and availability of natural food. The daily feed ration is computed for a period of 1-2 weeks based on projected daily increase in biomass as determined from the routine sampling of average body weight and observed mortality.

i) Do not feed when dissolved oxygen level is below 1.5 ppm because the fish would not eat and the formulated feed will only go to waste.

j) If fish pens are set up in areas which has constricted water flow, shallow, or overcrowded install paddlewheel aerators and operate them when fish are observed to be gasping or swimming in circles to maintain safe dissolved level of not less than 1.5 ppm.

k) Routine management measures to be undertaken

- Monitoring of growth and mortalities in order to determine accurate fish biomass which form as basis in computing feed ration and projected harvest.
- Daily inspections of framework perimeters and cleaning and repairing of nets.
    - Provide security against poaching.

l) "Earthy-muddy" taste in milkfish is minimized by feeding daily with stale bread, rice bran, or commercial feed pellets for two weeks.

m) Start harvest when the milkfish stock is already of a suitable market size.

- Monitor fluctuations in market price to determine the best time to harvest and realize maximum profit.
- In the event of an impending strong typhoon, however, it becomes necessary to harvest prematurely even at low price.
- The quantity of fish per harvest is also regulated to prevent oversupply in the market. Hence, harvest for one season crop may last for several months.
- The common method of harvest is by using purse seine or gill net.

n) Proper handling should be observed during harvest to maintain good quality fish. If the fish are stressed during harvest, they turn reddish. This is caused by overcrowding of fish inside the bag seine and can be prevented by the following:

- Returning part of the harvest to the fish pen.
- Transferring part of the harvest to a much bigger bag seine.
- Haul part of the catch immediately.
- Haul in the contents of the bag seine section by section and avoid compressing it.

23.5 Post-Harvest Handling

a) Live-fish boat or similar type flat boat is used to pre-chill the fish immediately after harvest and transport to shore for packing or directly carry the fish to fish port. The boat contains 20–25 cm deep of water with crushed ice to chill the fish to death. Two to three blocks of ice per ton of fish is sufficient to maintain good quality fish.

b) If transport time to market takes a long time and live-boat is utilized for transport, the melted ice with fish blood is pumped out of the live-boat and at the same time crushed ice is added.

c) Upon arrival at the fishing port or shore, the milkfish is unloaded in tin trays or "banyera", wooden boxes, or bamboo wicker baskets and classified according to size or weight.

d) If the fish will be immediately sold, they can be packed heads up (vertically) in slatted baskets that are well ventilated and well drained.

e) If the fish will not be sold locally and transported by land, a 1:2 ratio of ice to fish (weight basis) is needed for 1 1/2 hours of travel and a 1:1 ratio for 3 hours of travel is recommended.

24. CAGE CULTURE METHOD

24.1 Description of the Cage Culture Method

Milkfish culture in cages in the Philippines is undertaken in freshwater lakes, estuarine areas, and coastal marine waters using different cage designs and sizes. The depth, area and speed of the water current at the culture grounds determine the culture density. Very high stocking densities can be accommodate using this culture method because the free flow of water current brings in new water and removes metabolic wastes, excess feed, and fecal matter. This culture method has a high level of production but would also require a considerable investment primarily due to huge formulated feed requirements. It is a high risk venture and labor intensive operation.

Feeding of complete formulated diet (27-31% protein) is essential from stocking of the fish to harvest. Small-sized fingerlings (5-10 grams) are initially stocked at higher density in cages with nets having small mesh size for 1-2 months before being transferred at desired density to grow-out cages. Stocking density depends on the carrying capacity of the cage and the environment. Typical stocking densities in floating and stationary cages are from 10-40 pcs/m^3 with a survival rate ranging from 70-90% and yield of 3-20 kg/m^3. Offshore cages can be stocked with 40-100 pcs/m^3 with a yield from 20-35 kg/m^3. Culture period at harvest size of

200-500 grams is usually from 6-8 months if 5-10 grams fingerlings are initially stocked.

24.2 Advantages and Disadvantages of Cage Culture Method

a) Advantages:

- Simple to construct and requires smaller financial investment.
- Easily managed e.g. fish stock are easily observed, fed and harvested.
- Transferable to sites with better environmental conditions.
- Can be stocked with fish at higher densities than ponds.
- Offers high production per unit area or volume.
- Greater opportunity for expansion.
- Allows the use for aquaculture of existing water bodies.

b) Disadvantages:

- Crowded condition of fish may lead to incidence of diseases.
- High feeding cost.
- Vulnerability to adverse weather condition.
- Vulnerability to the effects of pollution.
- Attractive to poachers and vandals.
- Wastes have negative impact on the aquatic environment.
- Disrupt navigation and reduce landscape value of a site.
- Wastes may stimulate primary production adversely affecting water quality of site and surrounding environment.

24.3 Physical Requirements

24.3.1 The Site

a) Fish pens should be situated in protected shallow bays, sheltered coastal areas, enclosed lagoons, estuaries, tidal rivers and freshwater lakes having the following characteristics:

- Sheltered from intense wind and destructive wave action.
- Tidal flows, wind generated waves, and sufficient current are desired for good water exchange for replenishment of oxygen and removal of waste metabolites. Excessive current (> 10 m/sec), however, may lessen the volume of the cage, add weight to the supporting structures and moorings and may contribute to feed loss.
- Water depth should be 2-3 meters for freshwater. In marine environment, deeper sites for sufficient water circulation. Water depth should allow a minimum distance of 1 meter between the cage and bottom sediment. This allows water flow through the cage and minimizes contact of stock with bacteria in the sediment.
- Bottom should be well clear of substrate (from rocky to muddy). Rocky substrate is advantageous only for off shore cages as it indicates good bottom current thus reducing wastes build up.
- Far from water run-off which will cause high turbidity, abrupt salinity fluctuations that may last from 3 to 6 days. This may disrupt feeding, irritate gills and cause diseases, and possible destruction of pens caused by run-off debris.
- Water is relatively free of heavy loads of domestic, agricultural and industrial effluents and far from navigational routes.
- Good water exchange brought about by wind generated waves, currents, tidal flows and unimpeded water flow.

- High and stable dissolved oxygen level of water (7-8 ppm). Avoid sites that are strongly stratified or with algal blooms because these will give poor oxygen condition.
- Water pH should be 6.5-8.5. High pH can damage gills and cause death of fish. It could also affect the toxicity of several common pollutants and heavy metals.

b) Near reliable source of milkfish fingerlings of at least 25 g and market for the harvested milkfish.

c) Sufficient land area must be available for office, tool and feed storage and labor/security house.

d) Other factors. The site should have access to farm-to-market roads, power supply, telephone, available labor, construction materials and other necessary inputs. Also, consider the peace and order condition in the area and conflict with traditional fishing activities.

24.3.2 Cages and Other Facilities

a) Sea base should have:

- Personnel accommodation
- Small working area
- Small area for storing feeds
- Means of communication
- Power source (i.e. solar panels)

b) Land base should be/have:

- Readily accessible
- Means of communication
- Electric power source

c) Workboat (towable or self-propelled) for the following activities:

- Hauling of feeds
- Transport of fry
- Harvesting
- Maintenance of mooring

d) Net Cages

- Considerations in the design and construction of fish cages:
  - The fundamental design of the fish cage is determined by the environmental conditions of the site and the species to be cultured. Accessibility for feeding, ease of maintenance, cost and safety of the complete system should also be taken into account.
  - The design and engineering of sea cage production systems should give consideration to the following five principal components: the net or cage bag; frames; collars and supports; linkages and groupings; and mooring systems.
  - The net cage should be able to retain the fish while permitting sufficient water exchange.
  - Frames must be strong.
  - Materials should be corrosion resistant and durable (aluminum, wooden beams, bamboo poles, galvanized pipes, steel and flexible rubber hoses).
  - Materials should be light in weight and able withstand the wave forces.
  - Cage netting materials should not cause abrasion to the fish stock.
  - Floaters should support the weight of the frame, workers, and net with stock. Float and pontoons may be made of empty oil drums, plastic containers, Styrofoam or especially designed air or foam-filled plastic floats.
  - Use strong anchors that can hold the cage in position.

The weight and number of anchors should be related to the weight and sizes of cages, nature of bottom, tide, current, wind and wave.

- The rule of the thumb is that cage depth should not be more than its width. The maximum recommended depth is 10 m.

• Types of cage

- Stationary (Fixed) cage (Figure 17)

Figure 17. Stationary fish cage.

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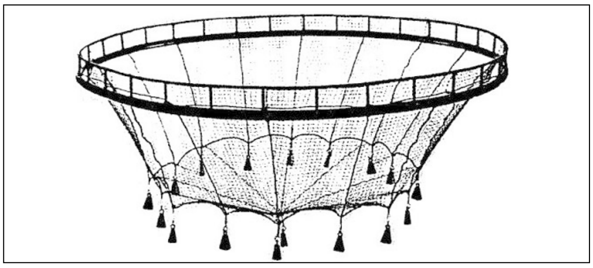
Fix cages consist of a square or rectangular net with corners supported by bamboos or wooden poles staked at the bottom.They are usually constructed near the shore (no more than 6 meters in depth during high tide). This type of cage requires well-sheltered areas such as river and coves because strong waves and currents easily damage the fixed cages. Sizes range from 600 m^3 (10 x 20 x 3 m) to 6,000 m^3 (20 x 50 x 6 m).

- Floating cage (Figures 18 & 19)

Floating cages may be square, rectangular, or circular in shape and is constructed using polyethylene net and wooden or GI pipe frames. A floating frame made of bamboo, wood, metal, styrofoam or plastic keeps the cage afloat and is held in position by concrete weights

Wilfredo Yap

Figure 18. Floating cages.



Rosario 1998

Figure 19. Norwegian type floating cage.

or by anchoring the corners of the cage to the bottom. Sizes range from 27 m^3 (3 x 3 x 3 m) to 1,800 m^3 (15 x 20 x 6 m) for square and rectangular shaped cages and 10-20 m in diameter with depth of 6-10 m for circular cages.

There are several modifications in cage structures and set-ups that have been developed for floating cages. One of them is the modular steel cages (i.e. Aquaranch Sea Cage System) consisting of 4 units of 4 x 4 m cages per module which can be converted to 2 units of 4 x 8 m cage or 1 unit 8 x 8 m cage. Cage float has an inner and outer foam-filled circular polyethylene tubes which are held together by braces. This modified floating cage can produce 20 kg/ m^3/crop. Another modification is the Polar Circle Cages from Norway which is made of PE pipes and usually set offshore. The cage sizes are 12 m diameter x 8 m depth and 19 m diameter x 12m depth. The cages are fitted with polyethylene net with mesh sizes from #12 to #17.

The advantages of floating cages are:

- Availability of working area which makes feeding, changing of nets and harvesting convenient;
- Ease in controlling predators;
- Stocks can be transferred easily when necessary;
- Sites not limited by water depth;
- More tolerant to wave and current action compared to fixed cage.
- Ease of movement and relocation of cages

- Submersible Cage Figure 20.

Figure 20. Submersible cage.

This type of cage is designed for deep waters to overcome strong waves and rough sea. Submersible cage has no collar and the bag rests on a frame to maintain its shape. Ocean Spar Technologies Sea Station Cage exemplifies this type. The cage has tightly framed webbing supported by a central floating spar, a submerged steel rim. The spar is made from either galvanized or marine-coated steel and the net is constructed of knotless nylon. The length of the cage is 15 m in length and approximately 80 m in circumference. Efficient feeding management and net maintenance are major problems.

24.3.3 Equipment, Tools and Materials Required

a) Various kinds of nets

- Polyethylene (usually color green) – 17K (17 knots, approx. 1.9 cm when stretched), 12K (approx. 3 cm) and 10K (approx. 3.4 cm). Additional 8K mesh (approx. 4.4 cm) can be used towards the end of culture to improve water quality in the cage. It is best to use a minimum of 9 strands for 17K, 12 strands for 12K and 18 strands for 8K-10K. For nursery, 25K-40K knotless nylon (depending on fingerling size) is highly recommended. Square mesh is preferred than diamond mesh. The cut should be tapering towards the bottom and heavy net weights should be used. Net weights (15-40 kg) are installed every 4-5 meters depending on net depth, mesh size and water velocity.
- Nylon (usually color maroon or dark brown).

b) Mooring system

- In sheltered areas - consists of a simple anchor weight and rope directly tied to the cage.
- In exposed sites – consists of heavy anchors, chains weights (to keep a constant tension on the ropes during low or high tide) and cushions floats or spring buoys (soften the jerking forces on the anchor and the cage structure during rough sea conditions).
- A four-point mooring system is used for single or module of small cages and a grid-type design is used for multiple cages.

c) Service boat and work boat used for:

- Hauling of feeds
- Transport of fry

- Harvest
- Maintenance of moorings

d) Automatic feeder

- Demand feeder – for small cages
- Feed spreader or feed blower – for bigger cages

e) Scuba gear

f) Motorized boat

g) Flat boat (for hauling feed and harvest)

h) Staff Quarters

24.4 Inputs

a) Good quality fingerlings of at least 25 grams in weight.

b) Commercial feed pellets for high density stocking

24.5 Fish Cage Operation and Management

a) Milkfish fingerlings are either transported by live-fish boat ("petuya") or oxygenated plastic bags from the nurseries to the fish cages. Delivery of seeds is done in calm days as a preventative measure to minimize stress.

- If fingerlings are transported using live-fish boat, gradual acclimation to cage environment is undertaken during transport.
  - Acclimation is done by pumping out gradually at interval the original water from the source of fingerlings. Simultaneous with this is the removal of a hole plug in the boat to allow water from the lake, river, or sea to come in;
  - As soon as fish cage is reached, the fingerlings are seined out and transferred carefully into the fish cage.
- If the fingerlings are transported using oxygenated plastic bags, the following acclimation procedures should be made to prevent temperature and salinity shock.
  - Let the plastic transport bags float in the fish cage for 15 to 30 minutes to equalize the temperature of the containers with the surrounding water.
  - If salinity difference between transport containers and the fish cage is above 5 ppt, gradually add water coming from the fish cage to transport containers until salinity is equalize before releasing the fingerlings.
  - Allow the fingerlings to swim out of the containers into the fish cage.

b) The small size fingerlings (≤ 25g) are initially stocked in smaller cages from 1-2 months until the preferred sizes (usually 40-50 g) is attained. In some areas the desired stocking sizes is from 80-100 g which greatly reduce feed conversion ratio (FCR) and therefore, save on feed cost.

c) It is recommended that high protein formulated diet containing 27-31% protein be utilized in feeding the milkfish in cages. Training of the milkfish to feed on artificial diet is necessary for 2 to 3 days and is hand fed while in the nursery cage.

d) When the fingerlings are ready for stocking in grow-out cages, they are graded into uniform size groups before transfer.

e) Stocking in the grow-out cages can be either according to ideal density which will allow fish to grow up to harvestable size or at higher density in which the fish will be distributed to other cages as they grow.

f) Recommended stocking rates depend on the design and location of fish cages:

- Floating and stationary cages in shallow water - 5-30 pcs/m^3

- Floating cages in deep lakes and bays - 30-40 pcs/m^3
- Offshore cages - 40-100 pcs/m^3

g) Commercial formulated pellets are expensive and, therefore, good feeding practice should be followed to obtain fast growth rate of fish, low feed conversion and at the same time prevent pollution of water and deterioration of the cage bottom. Sinking pellets are preferred for sites with stronger winds, waves and current.

h) The following are the feeding methods used in milkfish cage culture:

- Hand Feeding
  - Food ration is broadcasted by hand at fixed areas of the cage.
  - Rations are consumed as these are broadcasted.
  - Allows uniform feeding and observation of appetite and feed response but costly and labor intensive.
- Automatic Feeder – Not only improves feed efficiency but also reduce labor cost.
- Demand Feeder
  - Use for small cages and significantly reduce feed waste.
  - Feed release mechanism triggered by fish on demand.
  - Cost and labor efficient; reflects on appetite and condition of fish.
  - Should be used strictly with a maximum feeder: fish ratio to ensure uniform feeding; cannot be used for smaller than 20 g fish. See table 10 for recommended size range and number of fish per demand feeder.
- Feed Spreader or Feed Blower
  - For bigger cages.
  - Ensure equitable feed distribution with resultant more uniform growth of the fish.

i) Recommended feeding rates at various body weights, feeding frequency and ration distribution for high density culture is provided in Table 7, 8 and 9. The feeding schemes indicated should be used only as a guide and should be regularly evaluated and adjusted as necessary. Actual feed consumption vary depending on prevailing environmental conditions particularly dissolved oxygen, temperature, and availability of natural food. The daily feed ration is computed for a period of 1-2 weeks based on projected daily increase in biomass as determined from the routine sampling of average body weight and observed mortality.

j) Routine management measures to be undertaken:

- Monitoring of growth (every 2 weeks) and mortalities in order to determine accurate fish biomass which form as basis in computing feed ration and projected harvest.
- Regular inspection of cage structure (raft and net cages), cleaning, repairs of nets, and adjustment of anchor ropes.
- The nettings, especially the smaller mesh sizes, could be easily clogged. Net bags should be changed every 1 to 2 months depending on the level of proliferation of fouling organisms (barnacles, oysters, mussels, algae, etc.). The net bags are air or sun-dried before removing the fouling organisms using high-pressure water and brush.
- Plastic drums are rotated regularly to remove the accumulated fouling organisms;
- GI frames should be repainted regularly to avoid corrosion.
- Mooring lines should be also checked regularly for abrasion and accumulation of fouling organisms.

k) Start harvest when the milkfish stock is already of a suitable market size (250-500 g).

- Harvest can either be partial or complete. Partial harvest is sometimes undertaken to let the remaining fish grow at a bigger size and therefore, attain higher yield and income per crop.
- Monitor fluctuations in market price to determine the best time to harvest and realize maximum profit.
- In the event of an impending strong typhoon, however, it becomes necessary to harvest prematurely even at low price.
- The quantity of fish per harvest is also regulated to prevent oversupply in the market. Hence, harvest for one crop may last for several weeks.
- Harvesting is simply done by lifting the net cage. For large cages, the cages are untied and lifted, and the bamboo pole is placed under the netting to gather the stocks on one side and then scooped by net. Harvested fish are then counted and weighed.

24.6 Post-Harvest Handling

Post-harvest handling of milkfish is the same as in Fish Pen Culture Method (Section 19.5).

24.7 Investment Requirements and Costs and Returns of Typical Milkfish Pen and Cage Culture Methods

Bio-technical assumptions, investment requirements, and costs and returns of typical milkfish pen and cage culture systems are shown in Tables 16, 17, and 18.

25. AVAILABILITY OF WILD MILKFISH FRY

No agency in the Philippines monitors and keeps records on the number of milkfish fry caught and traded. Neither has any field estimates on the fry population ever been attempted since. For this reason all milkfish fry quantity figures are either estimates of the number of fry used to attain the level of production figures each year assuming a certain average size at harvest and survival rates or on likely demand based on the computed requirements of fishponds, fish pens and fish cages. The requirement (or usage) figure can range from as high as 3.0 billion per year (PCARRD, 1983) to as low as 1.65 billion.

Based on historical production records before the advent of commercial hatcheries, the Philippine milkfish production reached a high of 234,123 mt in 1991 and dipped to as 148,965 mt in 1993. During this time milkfish hatchery was still largely experimental so the industry was still totally dependent on wild-caught fry. Using the 250 g average size at harvest and 46% survival from fry to market size used by Ahmed et al. (2001), the fry supply from the wild must have reached a high of 2.04 billion in 1991 and a low of 1.30 billion in 1993.

Table 16. Bio-technical assumptions of typical pen and cage culture systems.

Type	Pen_Lagoon	Pen_River	Pen_Freshwater	Cage
Production Area	1,686m^2	1,686m^2	1 ha	10mØ
Stocking Density	10,000	20,000	30,000	55,000
Survival Rate (%)	85%	85%	70%	85%
Culture Period (days)	135	135	250	150
Crops (per year)	2	2	1	2
Ave. Harvest Size (g)	333	333	333	350
Ave. Yield per Crop	2,833	5,667	6,993	32,725
FCR	2	2	0.5	2.4
Farmgate Price (PhP/pc/kg)	75	75	50	75

Table 17. Investment requirements of typical pen and cage culture systems.				
Culture System	**Pen_Lagoon**	**Pen_River**	**Pen_Freshwater**	**Cage**
Capital Outlay				
Construction of Pen/Cage	42,000	42,000	200,000	300,000
Equipment	33,500	33,500	45,000	40,000
Sub-Total	75,500	75,500	245,000	340,000
Working Capital	170,099	315,797	170,406	991,758
TOTAL	245,599	391,297	415,406	1,331,758

Table 18. Costs and returns of typical pen and cage culture systems.				
Item	**Pen_Lagoon**	**Pen_River**	**Pen_Freshwater**	**Cage**
Production	5,667	11,333	6,993	32,725
Sales	424,996	849,992	349,650	2,454,375
Less:				
Variable costs				
Milkfish fingerlings	36,000	72,000	54,000	198,000
Supplemental feed	237,998	475,995	73,427	1,374,450
Direct Labor	-	-	1,500	3,000
Gasoline & oil	7,000	-	5,000	20,000
Caretaker	-	-	6,000	12,000
Repairs & maintenance	2,000	2,000	2,500	2,000
Harvesting cost	3,400	34,000	20,979	98,175
Caretaker's incentive	38,440	85,919	16,615	34,934
Subtotal	324,838	669,914	180,020	1,742,559
Fixed costs				
Depreciation	15,100	15,100	49,000	68,000
Pond rental		-	1,000	500
Subtotal	15,100	15,100	50,000	68,500
Total Costs	339,938	685,014	230,020	1,811,059
Net income before tax	85,058	164,978	119,630	643,316
Undiscounted Economic Indicators				
Unit cost of production	59.99	60.44	32.89	55.34
Return on investment	36%	45%	29%	54%
Payback period	3	2	3.5	2

With the emergence of commercial milkfish hatcheries both in the Philippines and abroad, the issue on wild fry supply has become academic since this has become less important with hatchery-bred fry already gaining wide acceptance among growers and nursery operators. It is estimated that existing local milkfish hatcheries are now capable of producing as much as 1.0 billion fry annually and more hatcheries are still coming on stream. Add to this the ease of importing from Indonesia at very competitive prices and it appears that Philippine milkfish industry can sustain itself using only hatchery-bred fry.

Be that as it may wild-caught fry still has a role to play especially for small-scale fishpond operators with one-time demand running only to tens of thousands in more remote areas of the Philippines where transport cost of fry maybe prohibitive or where the volume demand each time is not high enough to warrant shipment of hatchery fry. With such reduced demand it is likely that even if wild-caught fry supply remains at the estimated historical low of 1.30 billion fry; this should be adequate to serve the small-scale producers although problem of seasonality and distribution may still remain.

Part Five

MILKFISH PROCESSING TECHNOLOGY

26. INTRODUCTION

Milkfish is second only to seaweed among the species produced by the Philippine aquaculture industry in 2004 at 273,592 mt (BFAR 2005). But it ranks first by value at about PHP16.415 Billion (assuming a unit value of PHP60.00). Prawns, a perennial top grosser in the past is down to only PHP12.93 Billion in value (assuming a unit value of PHP350.00 per kg) due to the low production of 35,916 mt. At present milkfish production growth appears to be limited only by the market since seed supply is no longer a constraint with the commercialization of milkfish hatchery technology and the grow-out technology whether in ponds, pens and cages is already well established.

One big problem often cited by milkfish growers is the seasonal fluctuation of market price since it is affected by the supply not only of milkfish itself but also of other fish species whether from capture fisheries or aquaculture. One way to mitigate such price fluctuation is to make milkfish less perishable so that it need not be marketed immediately after harvest. Through appropriate preservation techniques, milkfish can be stored and marketed at a paced schedule rather than all at once. Furthermore processing of milkfish makes it possible to consider the export market and therefore widens the market base. Another compelling reason for marketing milkfish in processed rather than fresh form is the employment it generates and the added value that can be obtained.

The technology to process milkfish into various forms is well established with most of them adaptable to home-scale level of operation with minimal start up cost and equipment needs. It is therefore ideal for dissemination in milkfish producing areas. Milkfish processing will not only widen the market, provide employment and increase household income, but also add to the value to the product so that more money can come into such areas, with all the spin-offs that such additional financial resource could generate.

One key element to the successful marketing of processed milkfish products is consistency in quality. Whether intended for local or foreign market quality is of paramount importance in order to capture and maintain a market. Exporting carries with it additional challenges in terms of compliance with the necessary requirements/standards/trade regulations set by importing countries pertaining to consumer safety and quality. High product quality can be achieved only through proper handling and strict implementation of quality control systems. In addition therefore to the “recipes” for the preparation of various products this review also includes elements of Good Manufacturing Practice or GMP and Hazard Analysis and Critical Control Point or HACCP.

27. PROCESSING CONSIDERATIONS

An important factor in fish processing is the freshness of the raw material, which along with proper handling and adequate processing produces a good quality product. As the cliché goes, "trash in, trash out," a poor quality raw material = poor quality product.

27.1 Raw Material Characterization

The character of the product and the freshness of the raw material are the most important factor in determining product quality (Amano, 1988). The characteristics of the raw material include its nutrient content and sensory attributes of the fish. The nutrient content is a given characteristic that could be determined only through laboratory analysis. Its sensory attributes are indicators of freshness which knowledgeable consumers are already aware. However for the purpose of having consistent product quality it is necessary to have a standard measure of freshness.

27.1.1 Nutrient Content

Milkfish is noted for its characteristic flavor, making it among the most savored fish in the country. It is a good source of protein, vitamins and minerals. (See Table 19) Moreover, milkfish livers were found to contain large quantities of omega-3 fatty acids (5.3%), e.g. EPA, believed to have protective effect against cardiovascular disease, and DHA, necessary for proper brain development and function (Suzuki, 1993 in Guirgen, 2000; Guirgen, 2000).

Table 19. Nutritive composition of milkfish

Composition	Content
Moisture	74.6%
Protein	18.4%
Fat	6.0%
Ash	1.0%
Calcium	4.8%
Phosphorus	16.9%
Iron	0.10%
Retinol	120.00 µg/100 g
Beta-carotene	10.00 µg/100 g
Thiamine	0.003%
Riboflavin	0.006%
Niacin (from Tryptophan)	0.770 mg
*Vitamin A	400-673 IU/100g
*Pyridoxine	420.0 µg/100g
*Folic Acid	15.0 µg/100g

Source: DOST, 1990; *Sidwell, 1978 cited in Pineda, 1998 as cited by Guirgen, 2000

27.1.2 Sensory Attributes

Sensory attributes pertain to fish characteristics that can be perceived using the senses. These include characteristics of parts of a fish e.g. the eyes, the gills and the viscera, which can distinguish a fresh

Table 20. Sensory factors in determining the quality of milkfish.

Parameters	Fresh Fish	Stale Fish
Odor	Fishy	Stale, sour or putrid
Eyes	Bright, not wrinkled or sunken, clear pupil	Dull, wrinkled, sunken, graying to reddish pupil
Gills	Bright red, covered with clear slime, odor under gill cover is fresh and fishy	Dull brown or gray, slime cloudy, odor under gill cover sour and offensive
Colors	Bright	Faded
Flesh	Firm, body is stiff, impression made by fingers do not remain, slime is present and clear	Soft and flabby, impressions made by fingers remain, slime absent and sometimes milky
Belly walls	Intact	Often ruptured, viscera protruding
Muscle tissue	White	Becomes pinkish, especially around backbone
Vent	Pink and not protruding	Brown and protruding

Source: Griño, 1980

Box 1. Personal Hygiene

Hygiene is described in a medical dictionary as the science of health, particularly by promoting cleanliness. Hygiene is an important consideration especially in the preparation of food for this would determine or assess the safety and quality of the food. Personal hygiene is very crucial in preventing microbial contamination or any foreign matter contamination of fishery products. This can be achieved by providing adequate washing facilities and other paraphernalia like soap, towel, uniform and others in the fish plant. Hand washing is important in the prevention of contamination in food.

Hand-washing must be done immediately after performing the following activities and before handling of food products:

- Coughing and sneezing
- Visiting the toilet
- Smoking
- Handling equipment and other items
- Handling raw fish
- Handling garbage or soiled materials
- Handling money

Good personal hygiene is maintained through the following:

- Bathing daily
- Using appropriate deodorants
- Washing hair at least weekly
- Keeping nails clean and trimmed
- Wearing clean uniforms and clean underclothing
- Using a hair net or cap and paper masks over nose and mouth when on duty
- Preparing for work in a systematic fashion so that the individual and his clothing are clean at the time he starts to work

Source: Espejo-Hermes, 1998; 2004

from a spoiled fish. Common method used in determining fish freshness is through organoleptic or sensory evaluation as shown in Table 20.

27.2 Safety and Quality Management

In fish trade, be it local or international consumer safety and product quality are highly regarded. Concerns on food safety have become increasingly important resulting to the establishment and implementation of several practices/measures/requirements by fish importing countries and regulatory bodies for monitoring trade. For instance, in 2003, the European Commission temporarily suspended the entry Philippine marine products including milkfish, to the EU market due to "insufficient guarantees" on the monitoring of contaminants and harmful substances in aquaculture products (Anon., 2003). These safety and quality issues are associated with the application of monitoring systems that include the Good Hygienic Practices (GHPs), Good Manufacturing Practices (GMPs), Sanitation Standard Operating Procedures (SSOPs) and the Hazard Analysis Critical Control Point (HACCP). These requirements (GHP, GMP and SSOP) are called pre-requisite programs as they are requirements to other and more specific system e.g. HACCP.

Generally, these prerequisite programs cover the processing plant, its location, building, facilities, utensils and equipment; and operational requirements such as water, cleaning and sanitation including personnel (See Box 1). To define each program, GHP refers to all practices, conditions, and measures necessary to ensure the safety and suitability of food at all stages of the food chain (Espejo-Hermes, 2004). On the other hand, GMP refers to the set of rules implemented in the processing plant which includes adherence to existing rules and regulations in force respecting plant construction, personnel hygiene and sanitation that supports company's policy and standards. And SSOP refers to the set of rules and guidelines on hygiene and sanitation established by a processing plant to achieve the goal of food safety (BFAR, 2001).

Failure in the implementation of these safety and quality systems could spell danger to the consumers. This occurs when fish and fish products consumed are spoiled, contaminated with parasites, pathogenic microorganisms, toxins, heavy metals, pesticides, hazardous materials (e.g. glass, metal). Unwholesome fish and fishery products cause up to 30 percent of food-borne illnesses (Ababouch, 2003).

27.2.1 Hazard Analysis and Critical Control Point

HACCP is a management system in which food safety is addressed through the analysis and control of biological, chemical and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product (Adan, 2000). Biological hazards include bacteria, parasites, viruses and food-borne pathogens; chemical hazards include heavy metals, biotoxin and histamine, other contaminants; and physical hazards e.g. glass, metal. In the country, it had been reported that milkfish causes food poisoning with symptoms similar to histamine intoxication (Fuertes, 2002 in Espejo-Hermes, 2004). This may be attributed to the high level of free histidine in milkfish that accounts for 63% of the total free amino acids (Shiau *et al*., 1996 in Espejo-Hermes, 2004). Another potential hazard would be the effluent from agricultural land carrying with it residues of insecticides, pesticides and other environmental contaminants. A Generic HACCP Plan for frozen deboned milkfish and smoked milkfish are found in Appendix A and B.

28. PROCESSING TECHNOLOGIES

The Philippine fish processing industry started from traditional methods (drying, salting fermentation and smoking) and expanded into modern fish processing (canning, freezing) (Guevara and Camu, 1987; Bassig, 2002). Recent development in the country has been the introduction of value-added products made from minced fish or surimi (Bassig, 2002). Some of these products include fish balls and fish *quekiam* being sold by peddlers; fish patties, fish nuggets and fish sausages that are sold in super markets. Species used in surimi processing are generally fish with white flesh of which milkfish is one.

Milkfish can be processed into various products using traditional, non-traditional, and value-adding e.g. surimi processing. However, though these technologies were already standardized in 1978, they are only being adopted now (Mendoza, 2003). Milkfish products such as smoked bangus, dried, canned, and fermented products are already well established in the country.

28.1 Preservation by Curing

Curing includes drying, salting, fermentation and smoking. In effect all the traditional methods of fish preservation involve curing. Milkfish products that have undergone these processes include *daeng na bangus* (split-salted dried milkfish), *burong bangus* (fermented milkfish with rice), and *tinapa* (smoked milkfish).

28.1.1 Drying

Drying is regarded as the oldest way of preserving fish. It is a simple process not requiring complicated equipment (Guevara et al., 1978). Drying preserves by lowering the water content of a food to a level at which microorganisms cannot grow and reproduce. For dried fish, 20% is considered the safe moisture content (Legaspi et al., 1986b). Although drying can be achieved using other techniques e.g. the use of pressure or absorbent pads and through the addition of salt (Wheaton and Lawson, 1985 in Espejo-Hermes, 1998) natural sun-drying technique is the simplest and for sun-drenched Philippines, the most practical. This process largely depends on the weather, thus the onset of rainy season renders this technique difficult to perform. Another problem is the exposure of the product to the environment making it susceptible to contamination and insect infestation. However screened solar dryers that can protect the product from the elements can be used.

Standardization of milkfish drying was conducted by Guevara et al. (1978) using different sizes of milkfish: small (length: 28.5± 2 cm, weight: 246.0± 4 grams), medium (length: 35.5± 2.5 cm, weight: 347.0± 3 grams) and large (length: 48± 4 cm, weight: 495.0± 5 grams).

Two types of dried fishery products are commonly observed in the country, dried in the round or whole fish that utilizes small-sized fish and the split-salted dried fish, locally known as daeng, for medium-sized fish (Espejo, 1980). The recommended procedure for sun-drying milkfish is detailed in Box 2.

28.1.2 Fermentation

Fermentation is one of the earliest fish preservation methods and is believed to have started long before mankind developed other methods (Guevara *et al*., 1978). Fermentation is the chemical change that takes place in fish that has been properly salted to effect the action of proteolytic enzymes and microorganisms (Legaspi *et al*., 1986b). This preservation method may fall under salting but some products undergo fermentation with little amount of salt added. The difference

Box 2. Sun drying of milkfish
(Guevara et al., 1978)

Ingredients
Fresh fish
Coarse salt

Tools and utensils
Drying trays
Enamel basins
Knife

Procedure
a. Wash the fresh fish, split into butterfly fillet, remove the entrails, gills and viscera. Wash again thoroughly in fresh water.
b. Soak the fish in brine (1:3 salt to water ratio or 64.2° salometer brine) for 30, 45, 60 minutes for small (246.0± 4 g), medium (347.0± 3 g) and large (495.0± 5 g) milkfish, respectively.
c. Arrange fish in drying trays. Lay fish skin-side down, and turn 3 to 4 times on the first day of drying to have the drying even and also to prevent a sun burned and deformed product.
d. Dry for 2 days or 10 to 14 continuous hours, 3 days or 16 to 20 continuous hours, and 4 to 5 days or 28 to 32 continuous hours for small, medium and large milkfish, respectively.
e. Dried milkfish maybe stored at room temp-erature or at refrigerated temperature (5 to 7°C). Refrigeration temperature is recommended for longer storage. When stored at room temperature, it is recommended that the plastic packaging material used be perforated.

between fermented and salted fish is the loss of the original shape of the fish in the fermented fish, which is a partly liquefied product (Espejo-Hermes, 1998). Factors that govern the rate of fermentation reactions include the following:

a) Use of suitable microorganism and the supply of the necessary nutrients;

b) Proper temperature for the growth of microorganisms, 48°C is the optimum temperature for fermentation (Clarke, 1975 in Guevara *et. al*, 1978); and

c) Adequate oxygen.

Maturation is characterized by an acidic smell, very soft flesh and the desired acidic taste. For milkfish, maturation is usually seven days (Guevara *et. al*, 1978).

Product of fermentation ranges from fish paste *(bagoong)* to fish sauce *(patis)* to fermented fish with rice *(buro)*. Milkfish is not used for making bagoong or patis probably because there are much cheaper fish species such as the anchovies which are abundant seasonally. However they continue to be used for making buro. Fermented fish with rice, locally known as burong isda is a rice-fish product in which salted fish and cooked rice are mixed and allowed to ferment (Guevara *et al*., 1978). This maybe categorized as white and red *burong isda*. The main difference between the two is the color; white *burong isda*, which is favored in the Western provinces is the natural product color. Red *burong isda* that is popular in the eastern provinces of the Central Luzon region derives its coloration from the *angkak* (Olympia *et al*., 1990). *Angkak* is essentially a fungus, *Monascus purpureus*, Went (Guevara *et al*., 1978) that grows on rice.

Standardization of milkfish *buro* was conducted by using varying proportions of salt, cooked rice and ground *angkak* (Guevara *et al*., 1978) during three phases in the fermentation process. The microorganisms involved in the fermentation process of *burong bangus* were studied by Olympia *et al*. (1990). Results of the study showed that *Streptococcus* initiated the fermenta-

Box 3. Preparation of Burong Bangus.
(from: Guevarra et al, 1978)

Materials:
1 kg whole milkfish
5 cups cooked rice (752 g)
8 tablespoon salt (75.2 g)
2 tablespoon angkak (17 g)

Tools/Utensils
Knife
Chopping board
Tray, mixing bowl or basin
Glass jars or earthenware

Procedure:
a. Scale and split the fish into butterfly fillet. Remove the gills, viscera, and fins. Cut into smaller sizes. A kilogram of fish should yield about 400 g. Add salt and set aside for 2 hours.
b. Pack in glass jars alternately with a mixture of cooked rice – 750 g (5 cups), salt – 75 g (8 tbsp) and powdered angkak (red rice) – 17 g (2 tbsp). Use 400 g cleaned fish for every 842 to 850 g cooked rice mixture. Cover with plastic film using rubber band to tighten it.
c. Allow to ferment for 7 days at room temperature.
d. Sautee in cooking oil, garlic and onions before serving.

tion process and generally persisted up to the final stage of the process. Then *Pediococcus* appeared although comprising only a small percentage of the microflora. Both *Leuconostoc* and *Lactobacillus* showed up next and were generally present up to the final fermentation day with the *Lactobacillus* predominating the microflora on the concluding stages. Other studies on fermented *burong bangus* were conducted by Mabeza (1983), Tuanquin (1987) and Tuma-ob (1995).

28.1.3 Smoking

Smoking is a very old preservation method and is widely used in many developing countries (Espejo-Hermes, 1998). It is believed that smoking in the Philippines is of Chinese origin (Mendoza, 1986; BFAR-7, 2001). There are three types of smoked milkfish products: whole, gutted, deboned, and soft bone. Commercial milkfish processing techniques is limited to smoking deboned bangus using the traditional Malabon smoking process (PCIERD, undated).

Fish smoking is a preservation method effected by combination of four inter-related processes: salting, cooking, drying and deposition of naturally produced chemicals that result from the thermal breakdown of wood (Cutting, 1965 in Mendoza, 1986), imparting the desired flavor and color to the fish. Smoking may be done hot or cold depending upon the temperature range used. Temperature for cold smoking ranges from 26°C to 32.2°C (Guevara *et al*., 1978) with a process time of about 36 hours (Legaspi et al., 1986b). Hot smoking, which is generally practiced in the country (Espejo-Hermes, 1998) uses a temperature range from 48.8°C to 82.2°C and a shorter process time (Guevara et al., 1978). In smoking, hardwood is preferred to softwood because the resin in softwood imparts objectionable tastes (Mendoza, 1986).

Standardization study on smoking milkfish using different forms of preparing fish i.e. drawn (gutted and eviscerated), split or deboned was conducted by Guevara et al. (1978). Study shows that yield for different forms of fish preparation vary together with the duration of brine soaking. Further, several studies were conducted on smoking milkfish ranging from the effects of various substances e.g. tripolyphosphate on the quality of smoked milkfish (Borlongan, 1976; Batoon, 1979, to storage studies (Baxa, 1977; Peralta, 1999). Other studies on smoked milkfish

Box 4. Preparation of Smoked Bangus
(from: Guevarra et al, 1978)

Materials:
Fresh Milkfish
Coarse salt
Sawdust
Charcoal

Equipment and Tools:
Knife

Drying trays
Enamel basins
Smoke trays
Drum for smoking or smoke house

(For soft boned bangus: pressure cooker, aluminum foil or cheesecloth)

(For 'boneless bangus' a mosquito forcep is required.)

Procedure:
a) Wash fish. Remove gills and viscera.
b) Wash inside and outside of fish thoroughly after eviscerating.
c) Soak fish in brine (1:3 salt to water ratio by volume) for 60, 90 and 120 minutes for small, (250 g); medium, (350 g) and large (500 g) drawn milkfish, respectively.
d) If desired, precook fish by steaming or boiling until the eyes turn opaque. Boiling is usually for 10 minutes to 15 minutes while steaming is around 15 to 20 minutes.
e) Drain until fish are dried to skin feel.
f) Arrange the drained fish on trays. Smoke for 30 minutes to 1 hour or until golden brown color is attained using the drum type smoke house. If a cabinet type smoke house is used, it would take about 2-1/2 hours smoking. It is recommended to turn fish every 30 minutes to obtain a more attractive color.

For smoked soft-boned bangus:
- Drain the fish after brining and wrap with aluminum foil or cheesecloth and cook in pressure cooker at 10 psi for 90. 120 or 150 minutes respectively for small, medium or large fish)
- Proceed with smoking process

For smoked deboned bangus (commonly referred to as "boneless bangus)

were conducted by Baclig (1972), Cabuslay (1976), Mabeza (1976), Pablo (1978) and Peralta (2001).

Smoked fish products are commonly referred to as *tinapa*. Smoked fish may come in different form: drawn, soft-boned or deboned. Smoked drawn milkfish is the conventional smoked *bangus*. It is estimated that in eating the conventional *tinapa*, some 30% of the fish maybe wasted due to the singling-out of the flesh bones (Anon., 1973). On the other hand, smoked soft-boned bangus makes the product 98% edible since even the bones can be eaten having been softened by subjecting it to high pressure (Legaspi *et al*., 1986b). Smoked deboned milkfish is more convenient to consume considering that the bones are already removed. Smoked fish can be kept for three days at room temperature, 15 days at refrigeration temperature and 3 to 6 months in frozen storage (Baltazar and Abella, 1995).

28.2 'Boneless Bangus'

'Boneless bangus" can be considered a uniquely Philippine product and deserves a whole section to itself. The proper technical term is 'deboned bangus'. Deboning would seem to be a simple process. It may be simple for most other species of fish but not for milkfish. One of the unique characteristic of milkfish that serves to narrow down its marketability is its numerous spines. To be precise, a milkfish has 43-44 epaxial intermuscular bones found on each side of the dorsal muscle, 22-24 spines in between the muscle segments on each side, and two large arch-shaped spines, followed by approximately 19 Y-shaped spines and ending in three single delicate spines in the mid portion of the body on each side .

Deboning makes milkfish more acceptable to a wider range of consumers so it is one way of value adding. Deboned milkfish can further be processed into smoked and frozen products to prolong its shelf-life and further widen its market. In addition, smoking of deboned milkfish also improves the product appearance and quality by imparting a desirable flavor and

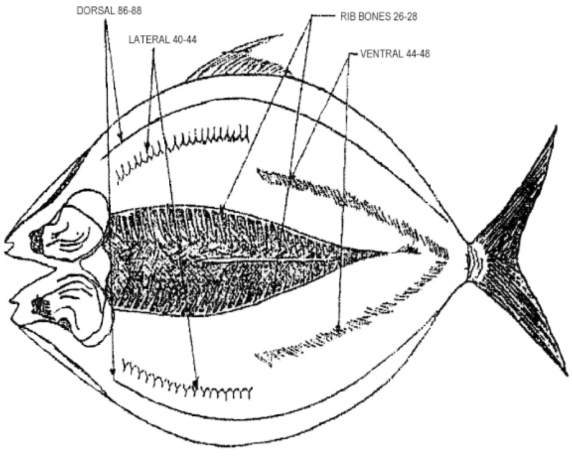
Box 5. Deboning of Milkfish
(Guevara et al., 1973 in Espejo-Hermes, 1998.

Materials
- Fresh milkfish

Tools and Utensils
- Mosquito forceps
- Knives
- Basins
- Chopping board
- Utility trays

Procedure
Additional steps for washing before and after deboning (in parenthesis) comes from Kok et al, 2002.

a) (Wash fish in chilled 30 to 50 ppm chlorinated water)
b) The fish may or may not be scaled. Trim the fins. Remove the anal fin by making a small cut around the base of the large fins, then pull the fins forward to remove the fin bones and other nuisance bones.
c) Split the fish down the dorsal side. Then turn the knife flat and extend the cut from the tail to the head by running the edge of the knife along the backbone. Let the fish lay open like a butterfly fillet, then remove the gills and internal organs.
d) Lay the fish flat on its skin and hold the knife horizontally to remove the backbone.
e) Put the fish flat on a shallow tray then pull out the rib bones with the aid of forceps. Make a superficial cut slit along the dent of the dorsal muscle from the head to the tail.
f) Remove the spines on the ventral side in the same manner. Take out the filamentous y-shaped spines along the lateral line.
g) (Dip the deboned fish in chilled 1% brine to remove the excess blood)
h) Pack in plastic bag, and freeze. (Deep freezing in a blast freezer at -40°C is recommended for longer shelf life and is necessary to meet export standards).
i) Alternatively it can be sliced into different cuts (bangus belly, etc) before being packed and frozen. It may also be brined and smoked, or marinated prior to packing and freezing.



color to the product. The deboning procedure was developed by BFAR Fish Technologists sometime in the 1960s. The detailed procedure for deboning is presented in Box 5.

28.3 Freezing

Fish are highly perishable with process of decomposition starting almost as soon as it is taken out of the water. Most fish farms kill the fish by putting the fish in ice slurry. This serves two purposes. One, the low temperature immobilizes the fish instantly and prevents it from getting damaged as it trashes about. Two, the low temperature effectively keeps the fish fresh before it can be packed or processed for marketing. After harvest, fish should be iced, chilled or subject to freezing to maintain its freshness and quality. Frozen milkfish products maybe whole (excluding livers and roes) or deboned. It may also be available in prime cuts, bellies, backs, heads and tail.

Freezing hinders the deteriorative activities of microorganisms, either partly or entirely (Espejo-Hermes, 1998). In the country, bulk of frozen milkfish product goes to the export market (USA, Canada) as the local market prefers fresh-chilled fish. Quick freezing is done using blast freezers for frozen, whole bangus that are exported to Guam and the USA. Contact plate freezing is also used for boneless bangus and smoked boneless bangus.

Kok *et al* (2002) recommends freezing temperature of -40°C. Dolendo *et. al* (1978) recommended that, "frozen fish should be stored at -18°C to -20°C to maintain its quality." Further, Hosillos (2003) conducted a study on the effect of carrageenan glaze on the quality of frozen deboned milkfish fillets. Results suggest that glazing helped in minimizing the quality changes during frozen storage and its functionality improved with the addition of carrageenan. It should be noted that most home freezers are capable of going down only to -20°C. At that temperature home freezers are adequate for long term storage but not for the initial deep freezing. The recommended freezing temperature of -40°C can be attained only in industrial freezers.

28.4 Canning

28.4.1 Use of Tin Cans

Fish canning in the Philippines had its start as early as the 1920s, although operations could not be sustained. There were also early attempts to use milkfish as raw

Box 6. Basic Procedure for Canning
(from: Palomares et al. 1978)

Ingredients (per 307 x 201.25 can known as No. 2 flat):

Bangos (dressed)	170 to 180 grams
Desired dressing or sauce	50 to 60 grams

Procedure

1. Scale the fish and remove the head, fins, tail, belly flaps and internal organs.
2. Wash the fish thoroughly to remove the blood and other foreign matters.
3. Cut the fish transversely to fit size of the container, scrape off remaining blood vessels and black pigment and fat of the fish belly.
4. Soak in 90° salometer brine (22.5% salt solution) for 20 minutes. Drain.
5. Place the cut fish inside the cans.
6. Add 50 to 60 g of the desired sauce or dressing but leaving a space of about 42 mm from the top of the can.
7. Exhaust by heating the filled cans over steam or boiling water to an internal temperature of 82.2°C (180°F). For the size of the cans specified, it normally takes 20 minutes heating.
8. Seal cans completely and process according to Table 3

Dressings and Sauces:

a) Packed in brine "salmon style": Add to fish 50 to 60 ml 2 percent brine.
b) Packed in tomato sauce "sardine style": Mix together 12.6 g tomato sauce, 12.6 g tomato paste, 9.0 g corn oil and 0.7 ml hot pepper extract*. Heat to 82.2°C with constant stirring and add sauce to fish.
c) Packed "paksiw style": Add to fish 3 g ginger, 1 g garlic, 5 g green bell pepper, 50 to 60 g 1:1 water-vinegar mixture.
d) Packed in curry: Prepare 50 to 60 g curry sauce by sautéing 2 g garlic, 9.7 g onion and 1 g curry powder in 7 g cooking oil. Add 10.9 g tomato sauce, 1.2 g pepper extract and 66 g coconut milk to which 2.3 g cornstarch has been added. Simmer briefly.

**To prepare hot pepper extract, boil 1 part 'siling labuyo" in 3 parts water until soft. Remove the solids by straining.*

Box 7. Smoked Bangus in Oil
(Palomares et al, 1978)

Ingredients:
Bangus
Salt
Corn Oil

Procedure:
1. Split belly, remove gills, internal organs and blood, wash thoroughly.
2. Make a slight cut along backbone to facilitate intake of salt.
3. Soak fish in 100° salometer brine (25% salt solution) for 30 minutes. Drain.
4. Cook in boiling 80° salometer brine (20% salt solution) until the eyes turn white. Cool.
5. Dry under the sun or any suitable drier until the skin of the fish appears dry.
6. Smoke for 2 hours or until golden brown.
7. Cut the fish transversely to fit the size of the container.
8. Pack in cans (307 x 201.25 size) at 170-180 g/can. Add enough corn oil into each can leaving 0.42 cm (1/6 inch) headspace.
9. Exhaust over steam or boiling water to an internal temperature of 82.2°C (180°F).
10. Seal cans completely and process.

Box 8. Bangos Escabeche
(Palomares et al, 1978)

Ingredients:

Bangos (dressed)	900 grams
Sauce:	
Cooking oil	25 grams
Garlic	10 grams
Ginger	25 grams
Vinegar-water (1:3)	360 ml
Sugar	50 grams
Red bell pepper	30 grams
Ground pepper	1 gram
Onion	50 grams
Salt	1.8 grams

Procedure:
1. Scale and eviscerate fish; wash and clean fish thoroughly. Cut transversely.
2. Soak fish pieces in 90° salometer brine (22.5% salt solution) for 30 minutes.
3. Drain the fish and deep fry in oil until golden brown.
4. Prepare Sauce by sautéing garlic, ginger, onion and red pepper in oil respectively. Add the vinegar-water mixture, sugar, salt and powdered pepper and simmer for 20 minutes.
5. Fill fried fish into cans (170-180 g/can) then add the sauce to 0.42 cm (1/6 inch) headspace.
6. Exhaust over steam or boiling water to an internal temperature of 82.2°C (180°F).
7. Seal cans completely and process.

material even prior to and during the 2nd World War. It is only fairly recent that canned or bottled milkfish products are always available in grocery shelves.

Canning involves the application of sufficient amount of heat to the food material contained in hermetically sealed containers with the aim of destroying spoilage agents that would otherwise spoil the fish at normal storage conditions (Palomares *et al*., 1978). Canning remains as one of the best methods of preventing spoilage that result from microbial action. The process must be adequate to eliminate heat resistant spores of *Clostridium botulinum* or other heat resistant spores (PCARRD, 1996). Strict monitoring should be implemented to be assured that adequate processing is given to the product to ensure that health risk organism (pathogenic) are destroyed.

Standardization of canning procedures for milkfish was conducted by Palomares et al. (1978) for various recipes or products namely bangus, sardine style; bangus, salmon style; bangus relleno; paksiw na bangus; smoked bangus in oil; bangus escabeche; and curried bangus. The basic procedure for canning is as shown in Box 6 while boxes 7 to 9 details the recipe

Box 9. Canned Rellenong Bangus
(Palomares et al, 1978)

Ingredients

Bangus	700 grams
Tomatoes	90 grams
Garlic	15 grams
Onions	80 grams
Red bell pepper	75 grams
Cooked green peas	75 grams
Raisins	28 grams
Corn oil for sautéing	70 ml
Salt	7 grams
Sweet pickles	75 grams
Monosodium Glutamate (MSG)	3 grams
Kalamansi juice and soy sauce mixture (1:2)	(enough to cover fish skin)

Procedure:

1. Scale and eviscerate the fresh fish and then wash thoroughly to remove the blood and other foreign matter. Drain.
2. Separate the flesh from the skin and debone the meat. Marinate skin into a mixture of kalamansi juice and soy sauce (1:2).
3. Sauté garlic, onion and tomatoes in oil. Add the minced meat, peas, red pepper, pickles, raisin, salt and MSG.
4. Stuff the sautéed mixture into the skin. Freeze.
5. Cut the frozen stuffed fish transversely into can sizes.
6. Pack in can (307 x 201.25 size) at 170-180 g/can. Add enough corn oil: water mixture (1:1) leaving 0.42 (1/6 inch) headspace.
7. Exhaust into an internal temperature of 82.2°C (180°F). Seal cans completely and process.

Table 21. Recommended minimum processing time for canned milkfish products packed in different can sizes.

Products	**Can Size** (307 x 201.25)				**Can Size** (307 x 409)			
	115.6°C (240°F)		121.1°C (250°F)		115.6°C (240°F)		121.1°C (250°F)	
	time (min)	F_o	time (min)	F_o	time (min)	F_o	time (min)	F_o
Salmon style bangus	49.0	4.844	32.0	4.069	70.0	4.965	49.0	4.525
Sardine style bangus	75.0	3.270	56.0	3.699	114.0	3.539	92.0	4.677
Paksiw na bangus	55.0	4.332	38.0	3.920	83.0	4.587	59.0	4.591
Bangus escabeche	70.0	4.885	49.0	5.009	111.0	5.210	84.0	5.101
Curried bangus	78.0	5.075	56.0	4.982	118.0	5.343	90.0	5.167
Smoked bangus in oil	72.0	5.490	48.0	4.416	98.0	4.647	72.0	4.391
Bangus relleno	70.0	4.135	52.0	3.874	104.0	4.272	77.0	4.046

The F_o value is the number of minutes at a specific temperature required to destroy a specific number of organisms having a specific Z value (the temperature change required for a specific thermal death time curve to pass through one log cycle. the z-value is equal to 10 degree C in the commercial sterilization of *Clostridium botulinum*).

and procedures for various specialty products. Table 21 shows the recommended minimum processing time for canned milkfish products packed in different can sizes. Other studies on milkfish canning were conducted by Bersamin et. al (1955), Navarro and Sulit (1955), Gonzales (1972) and Alfaro (1979).

28.4.2 Use of Glass Jars

The use of tin cans requires specialized equipment for sealing such as a sealer or preferably a vacuum sealer. Furthermore the tin plates needed to make the cans are imported and its landed price in the Philippines is affected by the strength of the local currency. However the same preserving effect can be obtained by using glass jars. This process is sometimes also referred to as "bottling" Glass jars are locally manufactured and are recyclable. They can be hand-sealed after cooking. It is such factors that have given rise to several cottage industry scale fish bottling operations many of which has milkfish in

Table 22. Implements and consumables required in preserving fish using bottles.

Implements:	Consumable materials:
Pressure cooker with gauge Stove Frying pan or wok (kawali) Stock Pot Balance (1 kg capacity) Chopping Board Knives Strainer Hot air blower (hand held hair-dryer) Tongs Mittens	8 oz glass jars metal caps PVC seals Labels

Box 10. Bottled Bangus in Corn Oil
(Adapted from Gamboa, 2000 and BFAR-7, 2001)

Ingredients (per 8 oz bottle)

Bangus			
Corn oil	(To fill)	Chili pepper (siling labuyo)	1 pc
Carrots	2 slices	Iodized salt	½ tsp
Pickles	2 slices	MSG	(pinch)
Pepper corn	3 pcs.	Bay leaf	1 pc

Procedure:

1. Remove the head, fins, tail, belly flaps and internal organs.
2. Cut the fish transversely to fit the size of the bottle.
3. Wash the fish thoroughly to remove all traces of blood
4. Partially dehydrate and pre-process fish by either of two ways:
   a. Dry for 2 hours under the sun or until firm and deep fry in oil for 2 minutes (Gamboa, 2000)
   b. Soak in 10% brine solution (1 part salt to 9 parts of water) for 15-25 minutes depending on the size of the fish (BFAR-7, 2001)
5. Place the fish inside the bottles and add the rest of ingredients.
6. Fill with corn oil, leaving ¼ inch space from top of bottle.
7. Lightly cap bottles and exhaust by putting in a hot water bath or by steaming for 15 to 20 minutes.
8. Cap bottles tightly while still hot and check for leakage by inverting each bottle.
9. Arrange in pressure cooker and process for 100 minutes at 10 psi.
10. Allow pressure to drop. Remove the jars, allow to cool and wash with soap and water.
11. Dry bottles, apply label and plastic cap sealer.
12. Store for at least one month to attain desired flavor before distributing

NOTE: One variant is to use smoked bangus in which case the pickles, sliced carrots and bay leaf are not required. See Box 4 for smoking procedure.

various forms as part of the product line. The implements and materials needed for canning fish in glass jars are simple as listed in Table 22.

The procedures involved in the use of glass jars do not differ significantly from the procedures involved when using tin cans. It still requires a pressure cooker to attain the required temperature. However based on available printed materials it appears that unlike for canning the basic process in using glass jars has not been standardized even within BFAR especially as regards when the bottles are tightly sealed. Gamboa (2000) in a brochure released by the BFAR-NIFTDC recommends sealing the bottles tightly before processing. However BFAR-7 (2001) in its own brochure recommends closing the jars lightly before processing with the tight sealing done only after processing. Gonzales (personal communication) clarified that the proper procedure, consistent with that for canning, is to exhaust the filled jars by subjecting them to steam or hot water bath until the temperature inside the jars have reached 82.2°C. Only then are these tightly sealed and processed at the recommended time and pressure.

28.4.3 Value Added Processing

Value addition refers to the transformation of seafood into new, varied, high qual-

Box 11. Bottled Bangus in Tomato Sauce
(Adapted from BFAR-7, 2001)

Ingredients

Bangus		Chili pepper (siling labuyo)	1 pc
Corn oil	1- 2 tbsp	10% brine (1 part coarse salt to 9 parts water))	(to cover fish)
Tomato paste (diluted at 1 part to 4 parts water)	(to fill)	Iodized salt	½ tsp
Pepper corn	3 pcs	MSG	(pinch)

Procedure:

1. Remove the head, fins, tail, belly flaps and internal organs.
2. Cut the fish transversely to fit the size of the bottle.
3. Wash the fish thoroughly to remove all traces of blood
4. Soak in 10% brine for 15-25 minutes depending on the size of the fish.
5. Place the fish into bottles.
6. Add the following ingredients: ½ tsp. iodized salt, 1 pc. hot pepper, 3 pcs. pepper corn, a pinch of MSG (vetsin), 1-2 tbsp. corn oil, and fill up the bottle with hot tomato paste diluted with water at a ratio of 1:4 (1 part tomato paste to 4 parts water).
7. Cover the bottles loosely
8. Exhaust bottles by steaming for 15-25 minutes depending on the size of the fish.
9. Tighten the bottle caps. Invert the bottles to check for leakage. Arrange inside the pressure cooker and process at 10 psi for 110 minutes.
10. After processing time, wait for the pressure cooker to reach zero before opening. Immediately take out the bottles one at a time. Let cool at room temperature.
11. Wash the bottles with soap and water to remove grease. Let dry.
12. Install the plastic cap seal. Store in a dry and cool place for at least one month. Label when ready for distribution.

ity delicacies, or simply into appetizing fish specialties, involving development of new products to meet the exacting specifications and requirements of the consumers both in local and international markets (Santos-Yap, 1996). Value-added products may also be modified versions of some traditional products, e.g. smoked hamonadong bangus (Mendoza, 1980). Value-added products are gaining popularity especially in the urban areas due to their "ready-to-cook" or even "ready-to-serve" nature which does away with time-consuming and messy preparation. Technically the "boneless" or deboned bangus" qualifies as a value-added product. There are however different ways to further enhance the value of deboned bangus.

28.4.4 Pickled or Marinated Bangus

Pickled or marinated fish and fishery products depend on the preservative action of the combination of vinegar and

Box 12. Marinated Bangus
(Guevarra et al, 1978)

Ingredients (Good for one fish)

Milkfish (butterfly fillet)	200 to 220 g	**Pickling Solution**	:
Saturated brine (25% salt solution),	to cover fish totally	Water	33 ml
Vinegar,	to cover fish totally	Vinegar	66 ml
Sliced onions	15 g	Sugar	25 g
Sliced red pepper	6 g	Cloves	1.5 g
		Ground pepper	1.1 g

Procedure:

1. Soak the butterfly fillet milkfish in the saturated brine for 12 hours.
2. Drain-off the fish and wash quickly.
3. Soak in vinegar for another 12 hours.
4. Drain and place in suitable container (e.g. plastic bag.) Add sliced onions and red pepper.
5. Simmer pickling sauce mixture for 15 minutes. Cool. Add to fish in glass jars or any suitable container.

(NOTE: Marinated bangus are now available in most wet markets in urban areas although these are made using garlic and crushed pepper corn instead of the pickling solution described above. Those marketed through supermarkets are packed in plastic, frozen and properly labelled. They are serve fried.)

Box 13. Kippered Bangus
(Guevara *et al*., 1978)

Ingredients (per fish)

Milkfish	350 g size
Salt	150 g
Vinegar	600 ml
Soy sauce	16 ml
Ground black pepper	4.8 g

Procedure
1. Scale and split the fish into butterfly fillet. Remove gill, viscera and fins.
2. Debone, wash thoroughly and drain.
3. Soak for 60 minutes in marinating solution enough to cover the fish.
4. Drain and dry the marinated fish under the sun or in a cabinet drier for 30 minutes.
5. Smoke for 45 minutes or until golden brown at 82°C.
6. Cool and pack in cellophane bags. If not consumed immediately, store in refrigerator.

Box 14. Rollmops
(Guevara *et al*., 1978)

Ingredients:

Milkfish sticks (cut from fillet)	800 g	Pepper corn	10 g
Mixture of 20% brine and vinegar (1:1)	(to cover fish)	Cloves	7 g
Carrots		Bay leaf	4 g
Dill pickle	250 g	Pickling Sauce:	
Red pepper	150 g	Vinegar	1 Liter
Ginger	70 g	Sugar	200 g
	50 g	Sliced onions	100 g

Procedure
1. Scale fish and cut off the head, fins and tail. Split into butterfly fillet and remove the backbone and viscera. Cut into sticks and wash thoroughly.
2. Cover sticks with enough of the saturated salt solution-vinegar mixture.
3. Drain and roll the cured sticks over a piece of pickled cucumber and fasten with a plastic tooth pick.
4. Arrange in bottles with the vegetables and spices separated from the pickling sauce. The pickling sauce is prepared as follows: dissolve the sugar in vinegar, add the onions, simmer mixture until onions appear done, and allow to cool. Add the vegetables and spices.
5. Pour cooled pickling liquid into the bottles enough to immerse and cover the rollmops.
6. Store at refrigerated temperature (4 to 7°C).

salt (Meyer 1965 in Espejo, 1980). The acetic acid content of the pickle must be 15%, to control bacterial growth (aver, 1950). Spoilage can be retarded by using vinegar with 5% or more acetic acid in addition to keeping fish in cool rooms (Tressler and Lemon, 1950 in PCARRD, 1986). Further, sugar also acts as preservative by increasing the thickness of the pickling solution that lowers water activity (Lagua *et al*., 1977in PCARRD, 1986). Spices (whole cloves, black pepper, onions, etc.) also have some preservative actions (PCARRD, 1986). Pickling/ marinating is commonly used for fatty fish (Espejo-Hermes, 1998).

Procedures for preparation of marinated milkfish were developed by Guevara *et al*., (1978). Formulated procedures include marinated milkfish, kippered milkfish and roll mop. Such products are referred to as "semi-preserves" for it can be kept only for a certain period of time (Espejo-Hermes, 1998).

28.4.5 Surimi (minced fish) processing

Mincing makes the fish flesh comminuted into small particles, which is eventually transformed into a paste. The resulting paste can be modified and/or altered to attain the desired characteristics of the finished product. Surimi is a Japanese term for a semi-processed frozen minced fish protein, where the minced meat has undergone leaching or washing with cold water, and permissible additives such as sugars and polyphosphates have been

Box 15. Fishball
(BFAR)

Ingredients

Minced fish meat	500 grams
Cornstarch	1½ cups
White sugar	4 tbsp.
Monosodium glutanate	¼ tsp.
Salt	2 tbsp.
Cold water	

Procedure:

1. Remove scales, gills and internal organs of fish. Wash thoroughly in clean water. Separate meat from skin and bones.
2. Chop or grind fish meat. Wash 2x in cold water. Drain and press to remove excess water. Add salt, white sugar, vetsin and cornstarch. Mix thoroughly. Add water gradually. Continue mixing to obtain a homogenized mixture. Form into balls and set at 40°C water for 20 minutes.
3. Drop balls into simmering water. When balls float, they are already done. Drain and let cool before packing. Store in freezer until ready for use.
4. To cook: Deep fry for 2-3 minutes. Drain. Serve with sweet and sour sauce.

BOX 16. Milkfish Patties
(Peralta, 1995)

Ingredients/Materials

Milkfish	White pepper
Salt	Bread crumbs (fine)
Iced water	Flour
Sugar	
Vegetable oil	3% sorbitol
Chopped onion/powder	0.2% tripolyphosphate
Chopped garlic	

Procedure:

1. Gut, gill and remove heads. Wash with ice water without scaling. Keep in ice until ready for filleting.
2. The iced fish is filleted and skinned. The bones and fillets are separated and both are washed thoroughly to remove blood and scales.
3. The fillets are passed through the meat bone separator first, followed by the backbone. The meat from these two is collected separately.
4. The minced meat are washed twice with iced water with 0.2% salt (meat to water ratio is 1:4). The third washing contains 0.3% salt. Water is discarded after 20 minutes stirring. Due to the low temperature of the water fat floats to the surface. Blood and extractives are leached out to the water.
5. The leached meat is placed in two layers of cheesecloth and dehydrated using a hydraulic press. Approximately 15% moisture is pressed out.
6. The meat is further minced in a silent cutter for 30 minutes, before adding 3% sorbitol and 0.2% tripolyphosphate consecutively. The silent cutter must be cooled to prevent premature "gelling" or "settling."
7. Prepared meat is molded into blocks, frozen and then wrapped in white polyethylene bags. They are stored in a freezer at -30°C, until needed for different surimi based product.
8. Shave thawed surimi.
9. Pass through a silent cutter for mincing and add salt while mincing
10. Add the water to improve the texture of the meat.
11. Add all other ingredients, adding breadcrumbs and flour last.
12. Mold into patties.
13. Steam for 5 min.
14. Cool and dip in batter.
15. Dredge in breadcrumbs.
16. Arrange in containers and freeze.

added (Santos-Yap, 1996, Espejo-Hermes, 1998.) The introduction of meat-bone separators or deboners in the 1970s influenced the promotion of minced fish products (Espejo-Hermes, 1998). Surimi has been proven to be a versatile product with many uses e.g. used as an ingredient or additive to the development of new products from seafood, meat or poultry; used as a base material for the production of seafood analogues (imitation of the real seafood products) and used as meat extender to various meat products. Recently, milkfish was considered as potential raw material for surimi as it has white flesh and it is meaty (Peralta, 1998).

Several studies were conducted on surimi processing using bangus as raw material, and the surimi further developed into products such as fish patties (Peralta, 1995), fish burger (Peralta, 1998), fish sausage, fish balls, fish nuggets (Mendoza et al., 2002). Other studies dealt on the effects of washing on the sensory qualities of surimi fish fingers (Alcazar, 1998; Pineda, 1998). Generally low value fish species are used for surimi processing so they can be converted into higher value products such as for instance imitation crab legs. Milkfish cannot be considered a low value fish and its use for surimi developed in order to make use of bits of flesh adhering to the bones during the deboning process or of trimmings when making other milkfish products. Other products that can be developed using milkfish surimi include milkfish nuggets, lumpiang shanghai, siomai, embutido and longganisa.

28.5 Milkfish by-products

By-products refer to parts of the raw material called offal which do not become part of the major product (Santos et al., 1978) e.g. viscera, head, fins, tail. For instance, in some milkfish processing establishments, the viscera, head, fins, tail and the bones are considered waste and are thrown away. These fish parts can be utilized in making another product to maximize its use. As described by Santos *et al*. (1978), "the efficient utilization of any kind of raw materials makes it imperative that all parts be transformed into something useful."

Several studies were conducted to assess the utilization of these so-called "processing waste." The study conducted by Santos et al. (1978) was on preparation of meal, silage and hydrolyzate (bagoong) from milkfish offal. Study conducted by Panggat et al. (undated) was the development of value-added products from milkfish processing wastes. Other studies are on the utilization of bangus spines or bones as ingredient for burgers (Sajonas, undated; Calmorin, 2000), utilization of milkfish bones into polvoron (Calmorin, 1999), utilization of bangus scales and offal as animal feeds (Mendoza and Taruc, 2003) and textural properties of restructured fish fillets from milkfish deboning wastes (Lat, 2002). Thus the byproducts maybe classified into two categories, those that are fit for human consumption and those which are suitable only as ingredients for formulated feed either for aquaculture or livestock.

28.5.1 Food products

Two food products have been developed using what are otherwise considered waste materials: Early on Sulit *et al.* (1957) suggested milkfish offal as ingredient for making fish kropek, a form of rice cracker. It involved converting the offal into fish meal and using the fish meal to flavor the kropek which is made principally of rice flour. A novel approach is to use milkfish bone as ingredient for making a type of confection, suitable for desert. Calmorin (1999) successfully incorporated powdered milkfish bones in making polvoron, a sweet and powdery desert that is conventionally made of flour, milk powder, sugar and butter (Box 17).

Box 17. Milkfish Bone Polvoron
(Calmorin, 1999 in Surtida, 2000)

Ingredients:

All purpose flour	Sugar	Vanilla extract
Powdered milk	Butter	Milkfish bones

Procedure

1. Soak milkfish bone in a marinating solution overnight.
2. Pressure cook for 1 hour at 10 psi.
3. Grind until powdery. Sun dry.
4. Toast flour until golden brown.
5. Sift flour. Press the lumps, and sift flour again.
6. Blend all ingredients except for butter and vanilla extract.
7. Heat butter and vanilla extract.
8. Thoroughly blend all ingredients with butter-vanilla mixture. Cool, mold and wrap, and pack.

Box 18. Conversion of Milkfish Offal Into Fish Meal
(Santos et al 1978)

1. The raw materials (heads, fins, tails and viscera) are washed in tap water and drained thoroughly.
2. These are steamed for 30 minutes and cooled.
3. The steamed and cooled samples are pressed to separate the press liquor from the press cake. The former may be used for the recovery of oil and the manufacture of the condensed fish solubles.
4. The press cake* is dried, either by sun-drying or cabinet drying, although the latter is preferred. The cake is then ground into suitable particle size and packaged in polyethylene bags or jute bags.

* Where antioxidants are to be incorporated, the press cake prior to drying is soaked in a solution of the antioxidant for the required period of time e.g. 200 ppm TBHQ (tertiary butylhydroxyquinone) for 10 minutes and drained.

Box 19. Fish Silage from Milkfish Offal
(Santos et al 1978)

1. The raw materials consisting of heads, tails, fins and viscera are washed and drained thoroughly. These may be ground or chopped, depending upon the size of the fish from which they are obtained.
2. A 30 percent solution of sulfuric acid is added in an amount equal to 15 percent of the weight of the raw materials.
3. The set up is kept in bottles or wooden barrels and stirred daily for one month to affect better distribution of the acid and the disintegration of the raw materials. The local clay pots ("banga") could be very good containers for the product.

28.5.2 Animal Feed Material

The other alternative to using offal is to use these directly as animal or fish feed or process them into a form that is more easily handled and stored. Santos *et al*. (1970) wrote that such waste materials may be converted into fish meal or into fish silage.

Fish meal is the better known form because of its nature as a dry powder which lends to easier packing, storage and transport. It should be noted that fish meal is a global commodity and is standard ingredient in livestock, poultry and fish feed principally as a source of animal protein. Its processing however requires specialized equipment such as steamers, press and grinders. Fish silage is a less known form of preserving the waste material. Because of its liquid form it is not as convenient to pack and transport. However because it does not require any special equipment to make it maybe an ideal way to convert and store fish processing wastes in rural areas where they can conceivably be used as in-gredient (in lieu of fish meal) for farm-made feeds. The procedures for preparing fishmeal and fish silage are detailed in Boxes18 and 19.

29. CONCLUSION

It is obvious that milkfish can be processed into a wide range of products. The types of product that can be produced is limited only by the imagination and creativity of any budding or practicing processor. In practice however, the type of product that can be produced under a given setting will be limited by two factors: skills and capital. While skills can be imparted through training and demonstration some process undoubtedly requires more training than others. Capital, at the level required for milkfish processing, is available in local financial institutions. It is however the access to such capital that is often a problem especially for the rural sector.

In order for the processing technologies to be applicable to the rural communities where milkfish is an important product, selection of the technology should be based on simplicity and capital intensity. Preferably the process should be capable of being capitalized at the micro finance level. As it turns out the more complex the process the more capital intensive it also becomes. Thus ranking the different processes in terms of simplicity and skills required in effect also mirrors its ranking in terms of capital requirement In the order of complexity the various processes can be ranked as follows:

1. Drying.
2. Marinating

3. Fermenting, or pickling
4. Smoking.
5. Deboning.
6. Value added processing.
7. Bottling.
8. Canning.

Having ranked the various processes, the most basic consideration in selecting a technology appropriate for dissemination is the marketability and market competitiveness of the product.

Undoubtedly drying is the simplest process and would require the lowest start-up capital. However the final product form, dried split milkfish, will have to compete with existing dried fish product coming from capture fisheries. Price wise it may not be able to compete considering the generally higher price of milkfish compared to various fish species from capture fisheries. However, drying cannot be completely ruled out. In instances of simultaneous early or unscheduled harvest due to an impending fish kill episodes or other disaster, drying maybe the only way to cut the losses.

Marinating is another simple process to prolong the shelf life of milkfish. However the marketability and price of the product is enhanced if the fish is first deboned. There is a market for partially deboned milkfish with only the vertebra and the bones which are attached to it removed, but this is limited to small size milkfish (150 to 200 g). This is considered a single serve size.

Fermenting the milkfish into "burong bangus" is also simple and is only slightly more complicated than marinating due to the risk of contamination by other undesirable micro organisms during the fermentation process. However "burong bangus" is a regional delicacy that is well like only in Central Luzon and Southern Tagalog. Elsewhere in the Philippines it can be considered an acquired taste so that its market is severely limited even in Metro Manila.

Smoked fish in general and smoked bangus in particular has a wide acceptance in the country. Like the marinated bangus its price and marketability is also enhanced by deboning. Smoked soft boned bangus although developed and introduced earlier than smoked "boneless" bangus never really caught on as evidenced by the fact that it is not readily available if at all in the local market.

"Boneless" bangus in all its various forms, plain frozen, smoked, marinated, prime cuts, etc, is the most popular form of processed milkfish. The reason is obvious. While the taste of milkfish is highly desirable its numerous intermuscular bones makes many people have second thoughts about having it. Remove the bones and its desirability is greatly enhanced. While deboning is a meticulous process it is relatively simple once the technique is learned and the proper tool – nothing more than the mosquito forceps, is made available. It is a labor intensive process. It is highly doubtful if the process can ever be mechanized as with the filleting of tilapia and other fish species. In a labor-rich society deboning milkfish would seem to be an ideal activity to generate employment. Furthermore "boneless" bangus has now found a market outside Philippine shores. While limited primarily to what is known as the ethnic Filipino market, with a stepped up market promotion and provided local growers can come up with a consistent volume and quality deboned milkfish has potentials in the mainstream market abroad.

Value added processing can make good use of trimmings and residual flesh produced in the deboning process. Products that have been produced from such residual material include fishball, fish lumpia, fish quekiam, and fish sausages. The recipes although not all presented in this report mimic those for meat. Knowing the resourcefulness of the Filipinos there is no doubt that individual processors will be able to develop their own recipes and techniques with very little guidance. These product lines are additional income sources that cannot be dismissed outright.

Canning or "preservation in hermetically sealed containers" whether with the use of glass jars or tin cans requires proper temperature to kill microbes, proper pressure to attain the desired temperature and sufficient time to ensure that the sterilization process is complete. Thorough sealing after a proper exhaustion process is also crucial to make sure no outside air can get inside the containers after the process. As such it requires not only specialized equipment in the form of a pressure cooker with a pressure gauge but also greater understanding of the process and more training. Many family-run operations especially in Northern Mindanao are doing well and have expanded from cottage industry level to a semi-industrial scale of operation judging from the variety and volume of various bottled fish products now available in supermarket shelves. However the fact remains that it is a more complex process, requires higher initial capital and is definitely "not for everyone" at the village level of operation.

Another consideration to be made in canning of bangus is the fact that while Filipinos are fond of canned fish, these often consist of canned sardines. Milkfish in the other hand is mostly purchased in fresh form for home cooking. Since sardines can be very cheap seasonally, the raw material for canning is very much cheaper than milkfish. Just how acceptable and how competitive canned milk-fish is when compared to the usual canned fish products has not really been studied.

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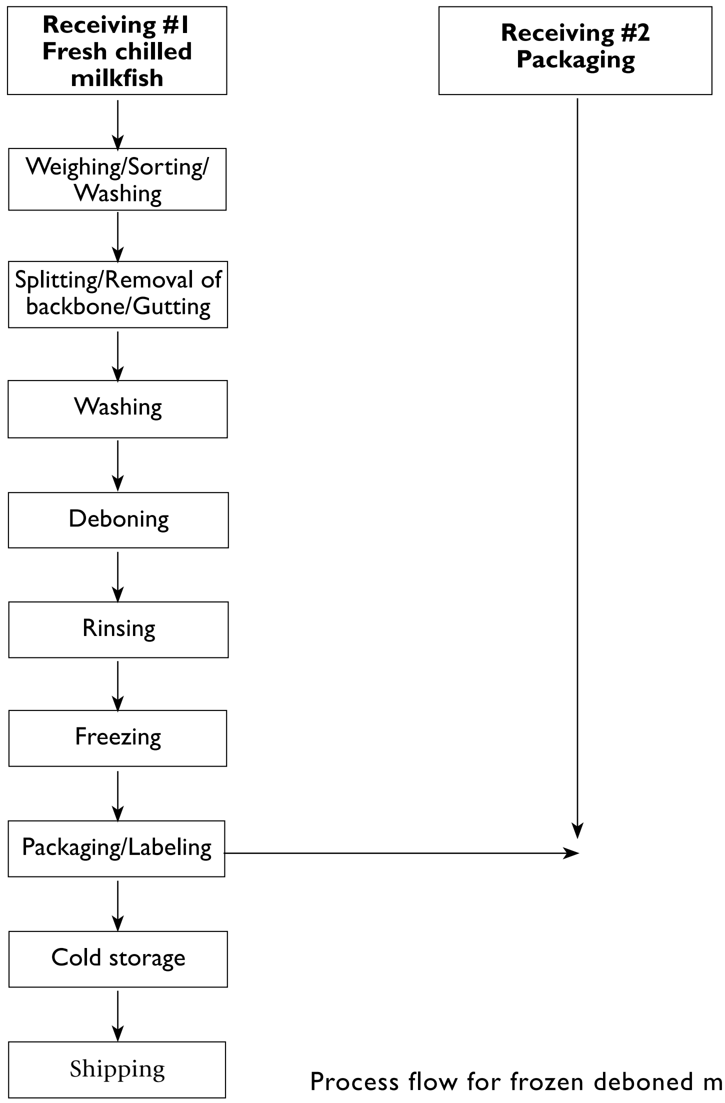
Appendix A

Generic HACCP Plan for Frozen Deboned Milkfish (Espejo-Hermes, 2004)



Process flow for frozen deboned milkfish

Appendix Table 1. Hazard analysis worksheet for frozen deboned milkfish

PROCESSING STEP	POTENTIAL HAZARDS INTRODUCED, CONTROLLED OR ENHANCED AT THIS STEP	POTENTIAL FOOD SAFETY HAZARDS SIGNIFICANT (YES/NO)	JUSTIFICATION	APPLICABLE PREVENTIVE MEASURES TO SIGNIFICANT HAZARDS	CRITICAL CONTROL POINT (YES/NO)
RECEIVING (MILKFISH)	Biological (Pathogens)	No	Likely not to occur due to competition from dominant microflora and SSOP in place; end user will cook the product		
	Biological (Histamine)	Yes	Time-temperature abuse	Maintenance of temperature at 4.4°C or below	YES
	Biological (Parasites)	No	End user will cook the product		
	Chemical (Industrial and Environmental contaminants)	Yes	Aquaculture raised	Reliable supplier Periodic analytical testing	YES
	Chemical (Veterinary Drugs)	Yes	Aquaculture therapeutants above regulatory levels may potentially be carcinogenic, allergenic, and/or cause antibiotic resistance in man.	Incoming lots accompanied by certificate attesting to proper drug use. On site verification of farm. Periodic analytical testing.	YES
	Physical (none)				
WEIGHING, SORTING, WASHING	Biological (Pathogens)	No	Water quality meets specification; SSOP		
	Biological (Histamine)	No	Time at this location is short		
	Physical (none)				
SPLITTING/ REMOVAL OF BACKBONE, GUTTING	Biological (Histamine)	No	Insufficient time		
	Chemical (none)				
	Physical (metal inclusion)	No	Metal inclusion is not likely to occur		
WASHING	Biological (Histamine)	No	Time at this location is short		
	Chemical (none)				
	Physical (none)				
DEBONING	Biological (Histamine)	No	Time at this location is short		
	Chemical (none)				
	Physical (none)				
RINSING	Biological (Histamine)	No	Insufficient time		
	Biological (Pathogens)	No	Time at this location is short		
	Chemical (none)				
	Physical (none)				
FREEZING	Biological (Histamine)	No	Low temperature		
	Chemical (none)				
	Physical (none)				
PACKAGING/ LABELING	Biological (Histamine)	Yes	Time and temperature abuse by shippers, distributors or consumers	Proper labeling	YES
	Chemical (none)				
	Physical (none)				

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Appendix Table 1 continued….

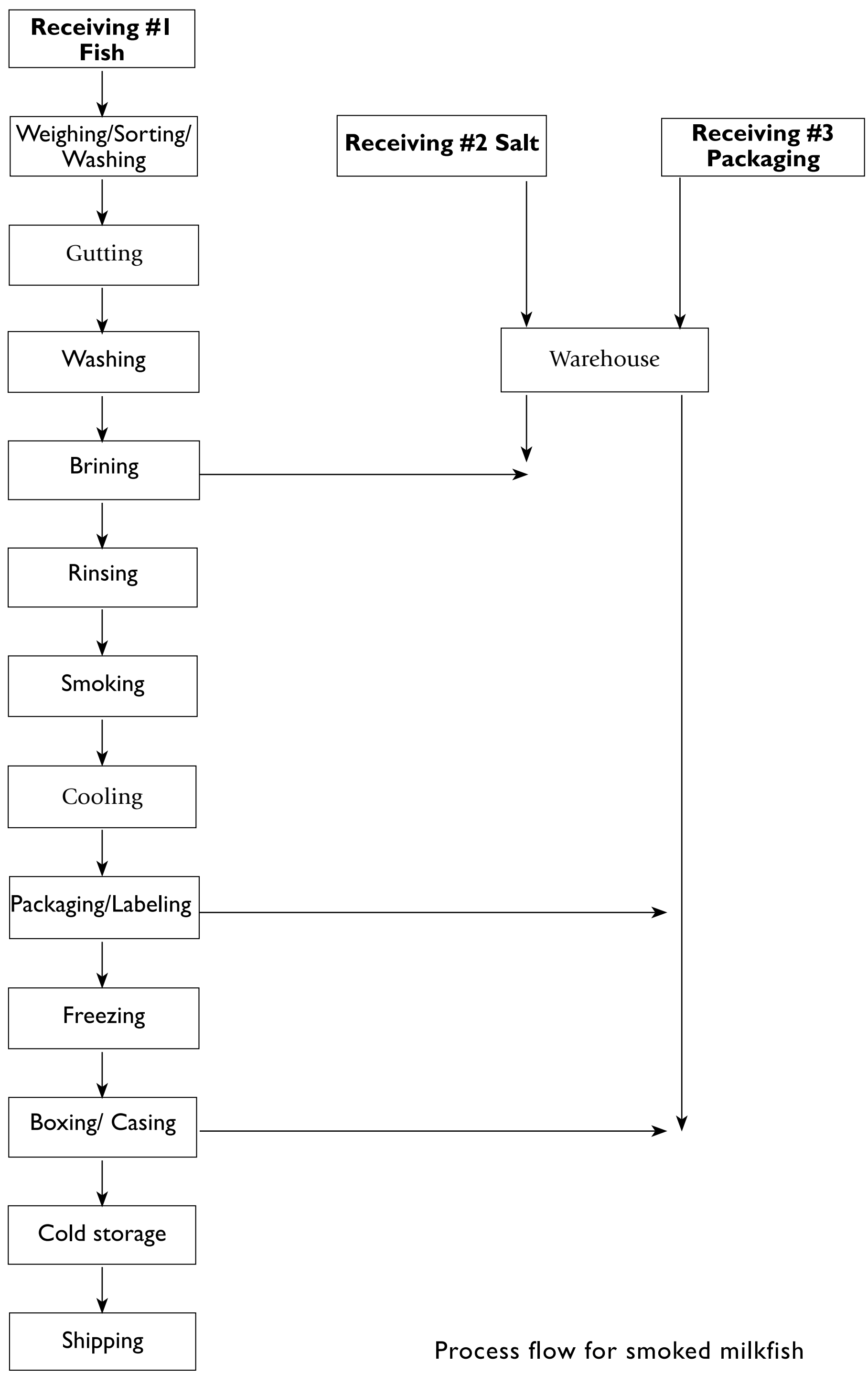
PROCESSING STEP	POTENTIAL HAZARDS INTRODUCED, CONTROLLED OR ENHANCED AT THIS STEP	POTENTIAL FOOD SAFETY HAZARDS SIGNIFICANT (YES/NO)	JUSTIFICATION	APPLICABLE PREVENTIVE MEASURES TO SIGNIFICANT HAZARDS	CRITICAL CONTROL POINT (YES/NO)
COLD STORAGE	Biological (Histamine)	Yes	Fluctuation in temperature may occur inside the cold store	Maintenance of temperature at -20°C or below	YES
	Chemical (none)				
	Physical (none)				
SHIPPING	Biological (Histamine)	Yes	Time-temperature abuse	Adequate warning labels on packages will control this hazard	NO
	Chemical (none)				
	Physical (none)				

Appendix Table 2. HACCP plan for frozen deboned milkfish.

CRITICAL CONTROL POINT (CCP)	SIGNIFICANT HAZARDS	CRITICAL LIMITS for each PREVENTIVE MEASURE	MONITORING				CORRECTIVE ACTION	RECORDS	VERIFICATION
			What	How	Frequency	Who			
Receiving of Raw Material CCP #1	Histamine formation (Biological)	Less than 4.4°C 50 ppm histamine content	Internal temperature of incoming raw material Fish flesh	Probe thermo-meter Histamine content	Every lot received	Quality Assurance Personnel	If internal temperature is above 4.4°C, hold for evaluation If histamine content is 50ppm or greater, reject lot	Temperature logbook of raw material Histamine analysis results records	Check accuracy of thermometer; weekly review of histamine analysis of incoming raw materials; Weekly review of monitoring and corrective action records
	Veterinary drugs (Chemical)	Certificate indicating proper drug usage	Presence of a certificate indicating proper drug usage	Visual	Every lot received	Quality Assurance Personnel	Reject lot	Grower's drug usage certificate receiving records	Visit farm of fish supplier within the year and at a pre-determined frequency to review the grower's drug usage procedures; Weekly review of monitoring, corrective action and verification records
	Industrial and environmental contaminants (Chemical)	Certificate indicating that the fish were not harvested from waters that were contaminated by chemicals	Presence of a certificate	Visual	Every lot received	Quality Assurance Personnel	Reject lot	Copy certificate receiving record	Visit fish supplier each year and collect soil and/or water samples and review the agricultural and industrial practices in the area; Weekly review of monitoring, corrective action and verification records
Packaging/ Labeling CCP #2	Histamine formation (Biological)	All products labeled 'keep frozen'	Packaging material	Visual	Each lot	Production staff	Re-label products	Production logbook	Daily record review Weekly review of monitoring, corrective action and verification records
Cold Storage CCP #3	Histamine formation (Biological)	4.4°C	Temperature of cold storage	Chart recorder	Continuous	Maintenance/ Quality Control Personnel	Hold for evaluation; Maintain temperature of cold storage	Cold storage temperature logbook/ recorder charts	Check the accuracy of the temperature recording device; Weekly review of monitoring, corrective action and verification records

Appendix B

Generic HACCP Plan for Smoked Milkfish (Espejo-Hermes, 2004)



Process flow for smoked milkfish

Appendix Table 3. Hazard analysis worksheet for smoked milkfish.

INGREDIENT/ PROCESSING STEP	POTENTIAL HAZARDS INTRODUCED, CONTROLLED, OR ENHANCED AT THIS STEP	POTENTIAL FOOD SAFETY HAZARDS SIGNIFICANT (YES/NO)	JUSTIFICATION	APPLICABLE PREVENTIVE MEASURES TO SIGNIFICANT HAZARDS	CRITICAL CONTROL POINT (YES/NO)
RECEIVING (MILKFISH)	Biological (Pathogens)	No	Likely not to occur due to competition from dominant microflora and SSOP in place; end user will cook the product		
	Biological (Histamine)	Yes	Time-temperature abuse	Maintenance of temperature at 4.4°C or below	YES
	Biological (Parasites)	No	Smoking step will control this hazard		
	Chemical (Industrial and Environmental contaminants)	Yes	Aquaculture raised	Reliable supplier Periodic analytical testing	YES
	Chemical (Veterinary Drugs)	Yes	Aquaculture therapeutants above regulatory levels may potentially be carcinogenic, allergenic, and/or cause antibiotic resistance in man.	Incoming lots accompanied by certificate attesting to proper drug use. On site verification of farm. Periodic analytical testing.	YES
	Physical (none)				
RECEIVING (SALT)	Biological (Pathogens)	No	Salt quality meets specification		
	Chemical (Contaminants)	No	Salt quality meets specification		
	Physical (Foreign Matter)	No	Salt quality meets specification		
WEIGHING, SORTING, WASHING	Biological (Pathogens)	No	Water quality meets specification; SSOP in place		
	Biological (Histamine)	No	Insufficient time		
	Chemical (none)				
	Physical (none)				
GUTTING	Biological (Histamine)	No	Insufficient time		
	Chemical (none)				
	Physical (none)				
WASHING	Biological (Histamine)	No	Insufficient time		
	Chemical (none)				
	Physical (none)				
BRINING	Biological (Histamine)	Yes	Time-temperature abuse	Brining time and brine concentration control	YES
	Biological (pathogen growth)	Yes	Brine concentration not sufficient to prevent the growth of C. botulinum type E and non-proteolytic types B and F	Control of brining time and brine concentration	YES
	Chemical (none)				
	Physical (none)				
RINSING	Biological (Histamine)	No	Insufficient time		
	Chemical (none)				
	Physical (none)				
SMOKING	Biological (Histamine)	Yes	Time-temperature abuse	Control of smoking time and temperature	YES
	Biological (pathogen growth)	Yes	Heating process not sufficient to destroy pathogens	Control of smoking time and temperature	YES
	Chemical (none)				
	Physical (none)				

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Appendix Table 3 continued....

INGREDIENT/ PROCESSING STEP	POTENTIAL HAZARDS INTRODUCED, CONTROLLED, OR ENHANCED AT THIS STEP	POTENTIAL FOOD SAFETY HAZARDS SIGNIFICANT (YES/NO)	JUSTIFICATION	APPLICABLE PREVENTIVE MEASURES TO SIGNIFICANT HAZARDS	CRITICAL CONTROL POINT (YES/NO)
COOLING	Biological (Pathogens)	Yes	Cross contamination likely to occur during cooling	Cooling time and temperature control	YES
	Chemical (none)				
	Physical (none)				
PACKAGING/ LABELING	Biological (Pathogens)	Yes	Likely growth of pathogens if water phase salt is low when temperature is abused by shippers, distributors and consumers	Proper labeling	YES
	Chemical (none)				
	Physical (none)				
FREEZING	Biological (none)				
	Chemical (none)				
	Physical (none)				
BOXING/ CASING	Biological (none)				
	Chemical (none)				
	Physical (none)				
COLD STORAGE	Biological (none)				
	Chemical (none)				
SHIPPING	Biological (Pathogens)	Yes	Likely growth of pathogens if water phase salt is low when temperature is abused	Adequate warning labels on packages	NO
	Chemical (none)				
	Physical (none)				