AQUACULTURE EXTENSION MANUAL NO. 25 MARCH 1999

THE MODULAR METHOD

Milkfish pond culture

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and NILO M. FRANCO

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SOUTHEAST FISHERIES DEVELOPMENT CENTER
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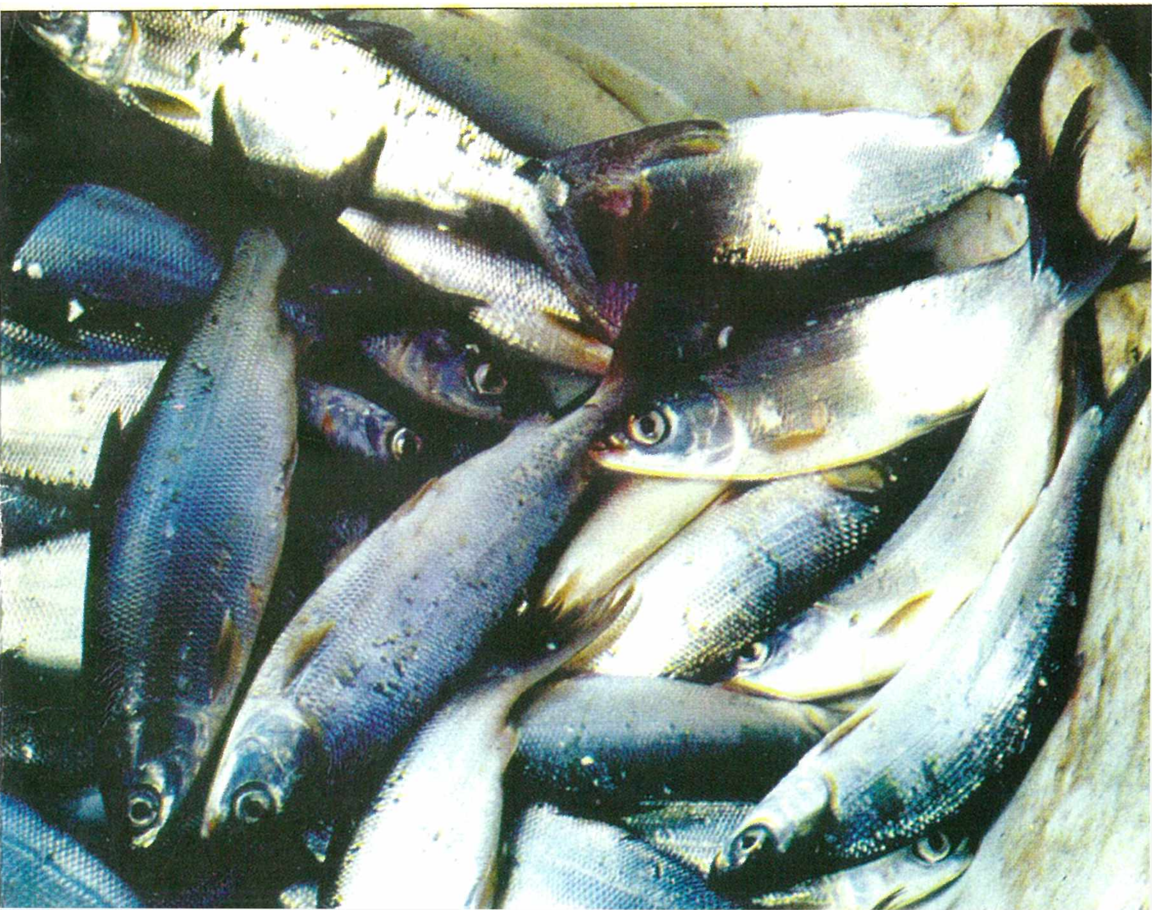

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FOREWORD

Milkfish has the oldest tradition of brackishwater aquaculture in the Philippines. Milkfish production has fluctuated between 150,000 - 250,000 tons over the last decade. On average, however, this production has largely stagnated.

This is beginning to change. Milkfish farmers are taking advantage of technological breakthroughs - development of artificial feeds, engineering of open sea cages, seed production in the hatchery - to move towards higher density systems and to utilize open marine waters. These advances are making milkfish one of the fastest growing sectors in the aquaculture industry.

The modular method of milkfish culture described in this manual is an improvement over the traditional extensive method. It is environment-friendly and can improve yield per unit area. This manual results from AQD's Technology Verification and Extension (TVE) program. TVE facilitates (he change in our recent thrust in AQD which gives more focus on technology transfer and commercialization. TVE bridges the gap between AQD's research output of 25 years and the aquaculture industry's need for sustainable technologies.

We hope this manual will be of use to fishfarmers and aquaculturists, extensionists, and students of aquaculture not only in the Philippines but also in other milkfish-producing countries in Southeast Asia and the world.

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THE MODULAR METHOD: MILKFISH POND CULTURE
MARCH 1999

ISBN 971-8511-35-0

Published and printed by:
Aquaculture Department
Southeast Asian Fisheries
Development Center
Tigbauan, Iloilo, Philippines

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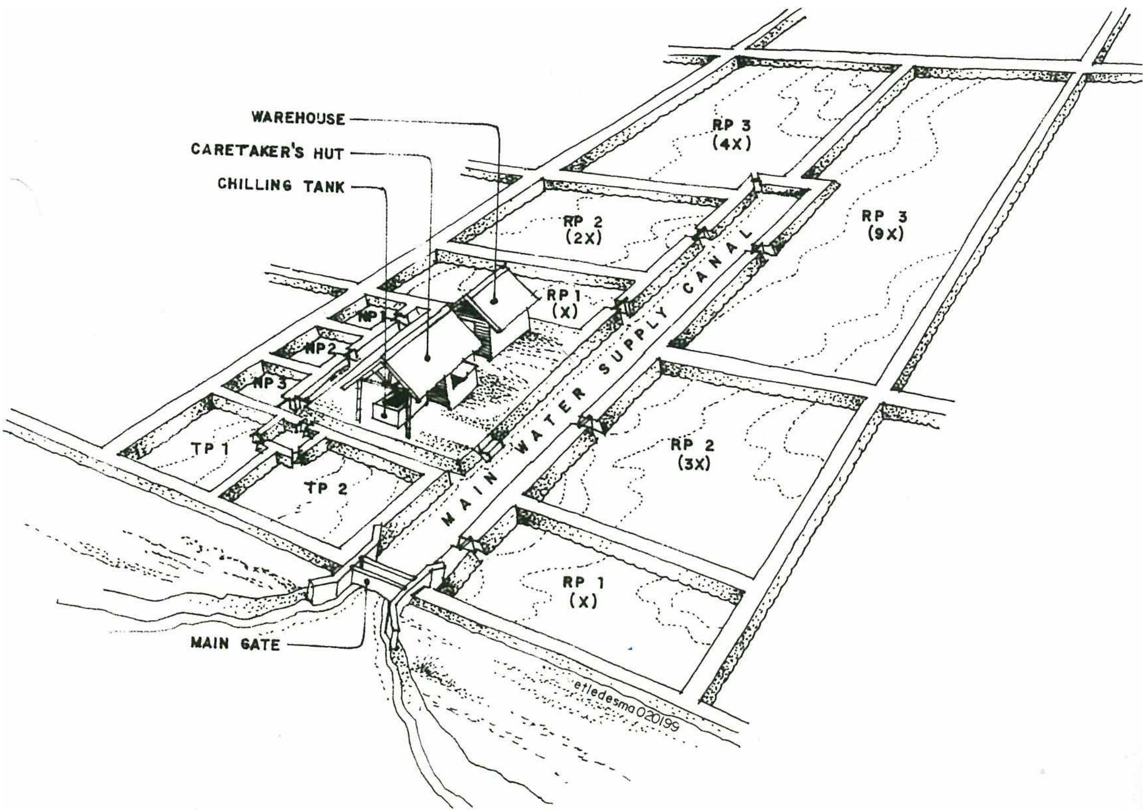


Perspective of a modular pond system for milkfish

THE MODULAR METHOD

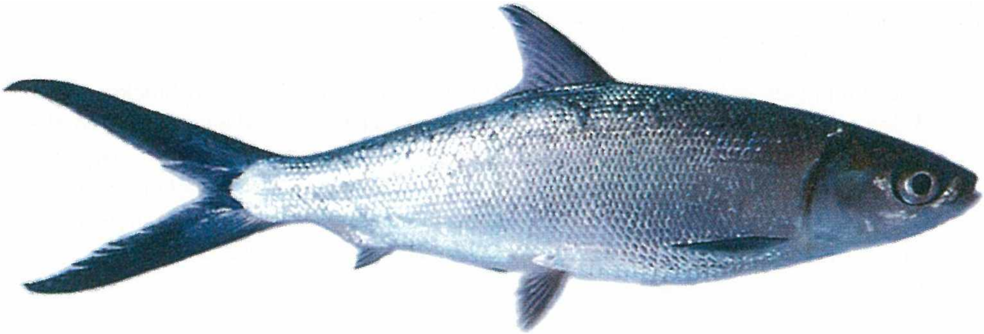
Milkfish pond culture

In the Philippines, culture of milkfish from fingerling to marketable size in brackishwater ponds generally requires the propagation and maintenance of abundant natural food, the *lab-lab*. Compared to *lumut* (filamentous grass green algae or plankton), *lab-lab* is better in supporting milkfish growth though it needs a relatively longer period of propagation, uses more material input and supervision, and is more susceptible to deterioration during prolonged adverse weather conditions. *Lab-lab* can be easily depleted by overgrazing of milkfish.

One attempt to solve the natural food problem is the use of the culture technique called progression or modular pond system. This system incorporates some semblance of stock manipulation. In demonstration experiments at the Leganes Research Station of SEAFDEC Aquaculture Department and in commercial trials in Negros Occidental, Carcar (Cebu), and MERALCO's farm in Buenavista (Guimaras), the modular pond system obtained an annual and consistent production of no less than 2 tons per hectare. This production is an improvement over that of existing industry practice (mono-size extensive / straight culture method) which only yields 700 to 800 kg annually. Though production in straight culture can be increased by using commercially-available feeds, the added cost oftentimes contributes to lower net production or income especially when milkfish market prices are depressed.

Interesting facts about milkfish

Milkfish (*Chanos chanos* Forsskal) or "bangus" as they are called locally comprise the bulk of aquaculture fish production in the Philippines. They are hardy and fast growing, and can be raised in fresh- and brackishwater ponds and pens. Being one of the cheapest sources of protein, milkfish are acceptable to all socioeconomic strata in the country. Over the years, production has improved from what is considered traditional into something more advanced. It is not unusual anymore to hear fishfarmers nowadays talking about pH, salinity, temperature, feed conversion rate, days of culture. Fishfarmers can easily relate these factors to fish production. Better still, fishfarmers have found it a must to learn the biological nature of the cultured commodity.

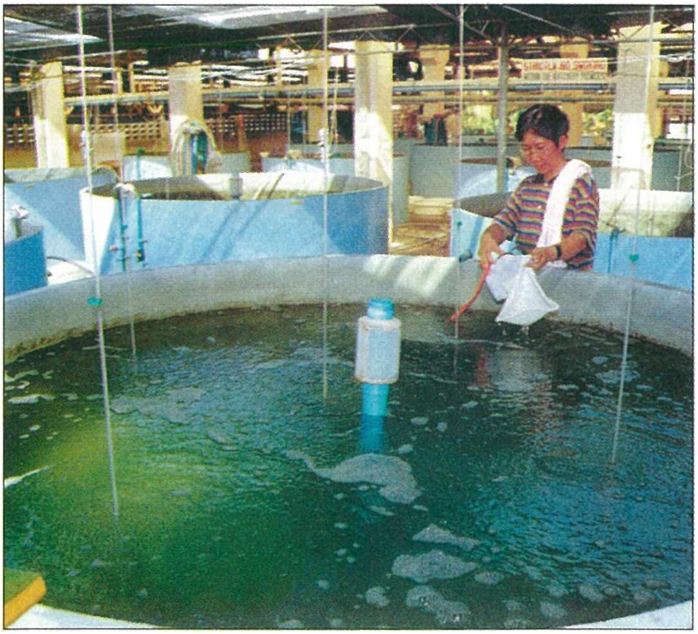


Milkfish are:

- **Filter feeders.** They have no teeth but have fine gill rakers that concentrate microplankton.
- **Benthic feeders.** They nibble or browse on adhering or even floating *lab-lab*, periphyton, or *lumut.*
- **Daytime feeders.** They feed less at night.
- **Euryhaline.** They can withstand extreme but gradual salinity fluctuation (from 0 to 100 ppt) but grow faster in natural waters of 0-40 ppt.
- **Phytophagous.** They eat plant materials, and can easily digest plants owing to their long intestines. But milkfish can also adjust to artificial feeds — rice bran, trash fish, fish pellets — and hence are also considered omnivorous.
- **Resistant to diseases and not cannibalistic.** They do not prey on each other and are not easily affected by infectious diseases, hence, they can be grown in relatively higher densities.
- **Exhibit compensatory growth.** Milkfish growth may be stunted under adverse conditions, but they can grow fast (exponentially) when conditions become favorable again.

ARTIFICIAL BREEDING OF MILKFISH

Reproduction of milkfish broodstock in concrete tanks and floating cages by SEAFDEC/AQD has already been undertaken and documented (see list of AQD publications on page 14). Milkfish broodstock mature from 5 to 10 years old in captivity and spawn spontaneously in concrete tanks and / or floating cages. Survival, growth, and fry quality of hatchery-reared fry is comparable with wild-caught fry.



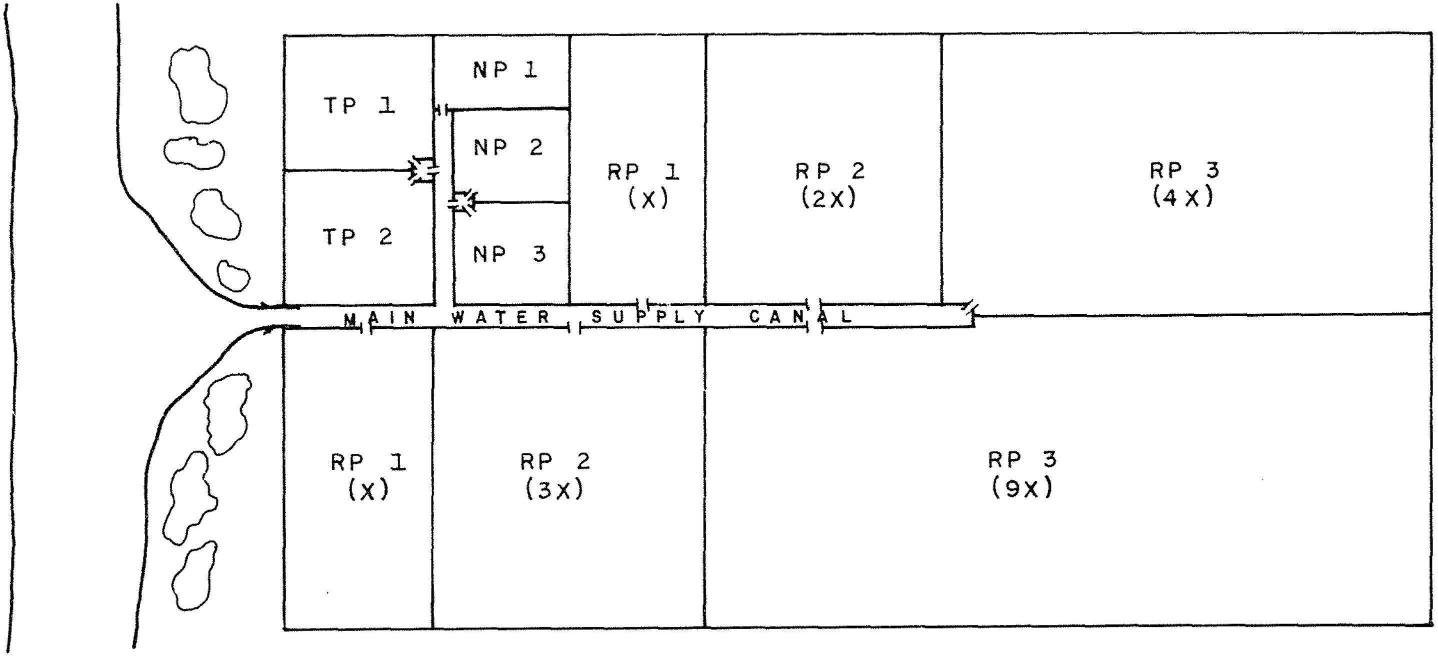
SEAFDEC / AQD's milkfish hatchery in Tigbauan, Iloilo.

Design and operation of modular pond system

Culture of milkfish from fingerling to marketable size is carried out in three stages using ponds with progressively increasing area. The proportion of rearing ponds is 1:2:4.

To design the modular pond system, the topographic map is consulted first followed by actual evaluation of the intended farm site. Different positions of the modules are normally prepared and evaluated, and the most efficient set-up is selected. The major pond components are properly identified, using nomenclatures such as NP for nursery pond, TP for transition pond, FP for formation pond, and RP for rearing pond (Figure 1). Where pond ratios vary considerably, modifications can be made (Figure 2).

From initial stocking, the fish are reared for at least 30 days in each module. The fish are moved periodically from one module to the other by inducing them to swim against the current ("pasulang"). Subsequently, vacated compartments are again prepared for about 15 days for the incoming stock.



NP - nursery pond
TP - transition pond
RP - rearing pond

FIGURE 1 Lay-out of milkfish farm using progression or modular system (Baliao et al. 1997)

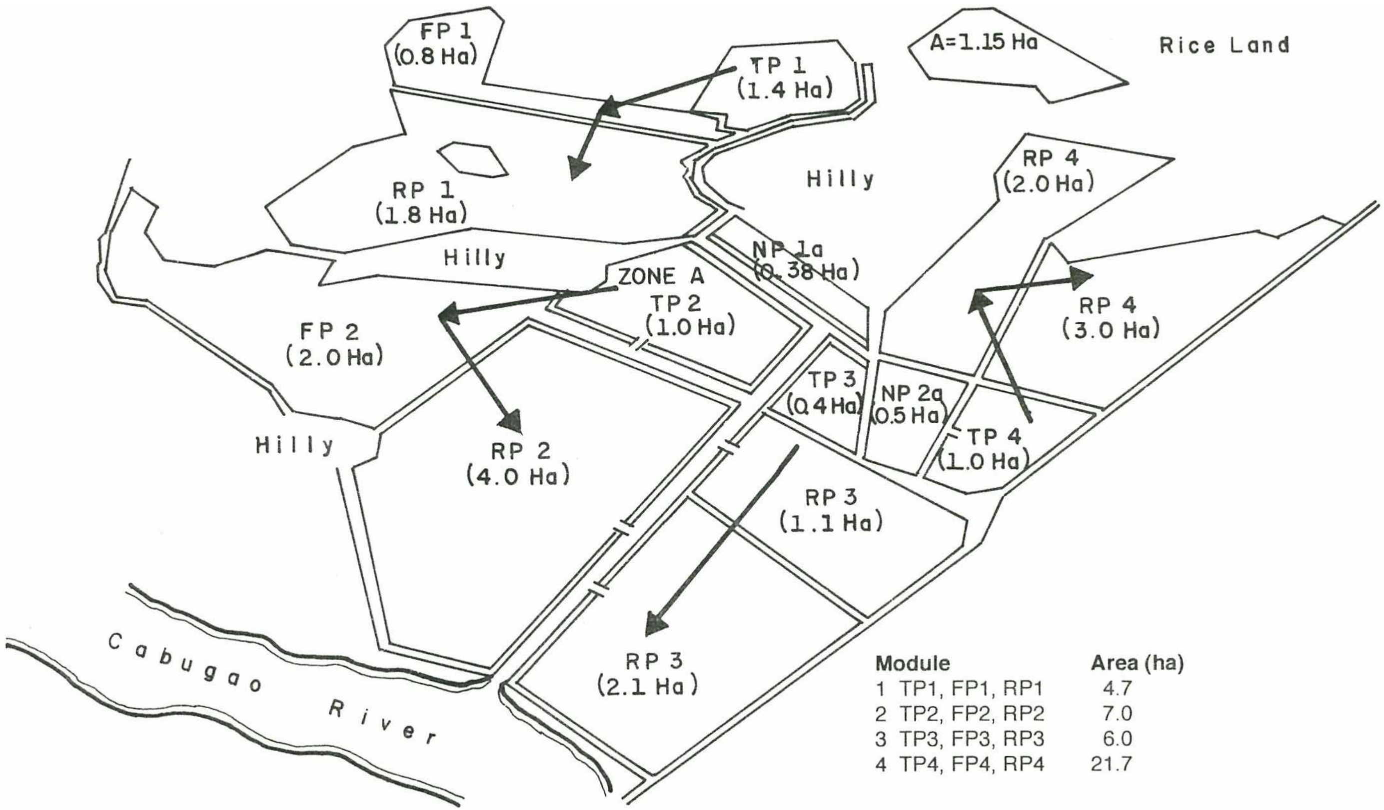


FIGURE 2 Example of a modular farm system with irregular compartments: MERALCO CorFarm, Brgy. Getulio, Buenavista, Guimaras (Baliao et al. 1997)

With this system, extra croppings are obtained (from 6 to 8 per year) without necessarily over-taxing the natural food supply. One important requirement of the modular system therefore is sufficient buffer stock of milkfish fingerlings (at least 25 grams each) in the stunting ponds. If the fishfarmer uses bigger fingerlings for stocking, he can produce marketable fish in three months of culture, and have 6-8 croppings in one year.

Basically, the objectives of the modular system are to:

- optimize yield per unit area
- sustain natural food productivity during the culture period
- control population of unwanted species
- program production, and
- improve cash flow

POND PREPARATION

The amount of *lab-lab* grown in the pond is dependent on the manner of pond preparation. *Lab-lab* is grown chiefly by a combination of organic and inorganic fertilizers.

Preparation of pond for *lab-lab* starts one or two months before stocking the fingerlings. In order to obtain the best growth, eradication of unwanted species and maintenance of good water quality is necessary.

The following are the basic procedure in the production of *lab-lab:*

1 Drain the pond completely and allow to dry for about 1 to 2 weeks until soil cracks. Prolonged drying is not advisable as it makes the soil hard and powdery.

First step in pond preparation: drying the pond bottom until it cracks

2 Eradicate unwanted species by using organic pesticides such as tobacco dust, derris root, and / or a combination of fertilizer and lime. When using tobacco dust, spread over moist bottom 300 to 400 kilograms per hectare, and allow to stand for about a week. The application of a combination of hydrated lime and ammonium sulfate fertilizer (21-0-0) is done by broadcasting lime-ammonium mixture at a ratio of 5:1 on wet areas of the pond bottom during a sunny day. Reaction of lime and fertilizer releases heat and ammonia which effectively kills unwanted species in the pond.

3 Apply chickenmanure at 2 tons per hectare. Flood to a depth barely covering the pond bottom, then apply 15 kg per ha of urea or 45-0-0 two to three days later to speed up the decomposition of chicken manure. Method of application is by broadcasting.

4 Increase depth gradually over a period of one to one-and-a-half months, adding 3 to 5 centimeters to the water level each time until the stocking depth of 30 to 40 cm is reached. An abrupt increase in depth causes *lab-lab* to detach and float. Install fine mesh screens at the gates to prevent re-entry of wild species.

5 Subsequent application of 16-20-0 at 50 kg per ha or 18-46-0 at 20 kg per ha may be made at 1 to 2 weeks interval to bolster growth of *lab-lab.*

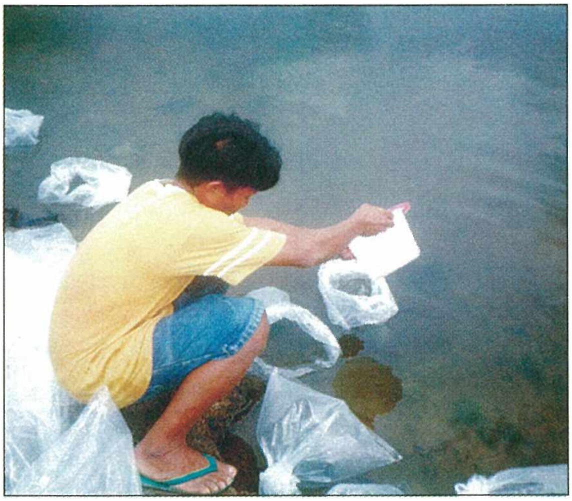
Application of hydrated lime-ammonium sulfate to eradicate unwanted species

Fertilizer application using inorganic fertilizer by broadcasting to bolster growth of lablab.

STOCKING IN NURSERY OR TRANSITION PONDS

Newly-arrived fry are normally contained in double-lined oxygenated plastic bags with salinity ranging from 15 to 25 ppt. The fry are usually emptied into plastic basin to sort out predators. The fry are stocked in the pond in the early morning or late afternoon when the temperature is cool to prevent temperature shock.

If salinity of the water in the transport bag and that of the nursery pond are approximately the same, the fry may be stocked directly into the nursery pond. Stocking rate is from 30 to 50 fry per m^2. However, if the salinity difference is over 5 ppt, acclimation should be done to prevent salinity shock during transfer, especially if the fry is moved from a lower to a higher salinity. To acclimate, gradually add pond water inside transport bags until salinity is equalized.



Milkfish fry

Stocking the nursery or transition ponds

The fry grow to fingerling size (3-5 g) after 30 to 45 days of culture with average survival of 60 to 70%. Newly-grown fingerlings may be stocked right away in the rearing pond. The rest of the fingerlings maybe be held temporarily for 6 months to one year in transition or stunting ponds at the density of 10 to 15 fingerlings per ha. In the transition pond, the fingerlings subsist on natural food like *lab-lab, lumut* or plankton with or without supplemental feeds.

STOCKING IN THE REARING PONDS

As soon as the remaining ponds are ready for stocking, fingerlings are caught from the nursery or stunting ponds and held in a fingerling seine. This seine may be set in a canal where it is carried slowly and closely to the pond where the fish are to be stocked. If this is not possible, place a few hundreds of fingerlings at a time in plastic bags and carry to the pond. For longer distances, oxygenated plastic bags will be necessary to ensure good survival of fingerlings.

It is best to count the fingerlings to prevent under or over stocking. The fingerling seine should be positioned near the mouth of the gate where flowing water can sustain the fish that are crowded in the seine. Stocking in rearing ponds should be done during the cooler part of the day. Release fingerlings at the mouth of the gate where water is normally deep. Do this slowly to prevent environmental shock.

Stocking density in the modular pond system is 3,000 fingerlings per ha based on the area of the last module. Meaning, in a 1:2:4 pond proportion, the last module being 4 hectares will be multiplied by 3,000 to come up with 12,000 fingerlings. The fingerlings will be first stocked in the first module having a 1 ha area. In cases where the set of module is not regular, say, 1:3:5 pond proportion, the rule is to add the pond hectarage (1 + 3 + 5) which is equivalent to 9 hectares in this particular set. A factor of 1,714 is multiplied by 9 ha, giving a total of 15,426 fingerlings to be stocked in the first module.

CARE OF STOCK

The main concern after stocking is the maintenance of optimum water condition for both the fish and the natural food. When using *lab-lab* as the food base, it is necessary to apply fertilizer (16-20-0) at the rate of 1 bag (=50 kg) per ha every 12 to 15 days to maintain good growth of natural food. If the tide allows, replenish about 1/3 of the pond water before every fertilizer application.

In hot months, more frequent flooding is needed to compensate for evaporation. Depth is kept at about 40 cm, at most 50 cm. During rainy months, it is necessary to drain the uppermost freshwater layer in the water column to prevent sudden drop in salinity. Towards the end of the culture period, *lab-lab* may be prematurely depleted because of overgrazing, poor water conditions, or persistent inclement weather. Supplemental feed may be given at a daily rate of about 5% of the estimated total biomass of the fish, using artificial feeds like rice bran or bread crumbs.

Abnormal occurrences such as the fish appearing to be gasping at the surface or swimming in circles may at times be experienced. These are believed to be indications of stress associated especially with insufficient dissolved oxygen. Water should be replenished at the first opportunity. [In extreme cases, mass kills can occur especially in the morning of a very calm and windless day.] If replenishing water is not possible, water from an adjoining pond may be made to flow so that water is agitated. Pumps may also be used in such an emergency. Sudden rain or thunderstorm during a hot day may also present dangers. Sudden change in water temperature may result to fish kills. Adverse weather conditions should be anticipated. Extra precautions should be observed to minimize possibility of dike wash-out, flooding and the like.

POND UTILIZATION AND PRODUCTION SCHEDULE

In the modular pond system, six crops a year is possible. As a rule, maintain a year-round inventory of the following:

- stunted milkfish fingerlings (10 to 20 g)
- organic fertilizer (chicken manure)
- chemical fertilizers (45-0-0 and 16-20-0)
- pesticide (21-0-0 or hydrated lime)

Below is a production schedule tried by AQD in one of its cooperating fishfarms:

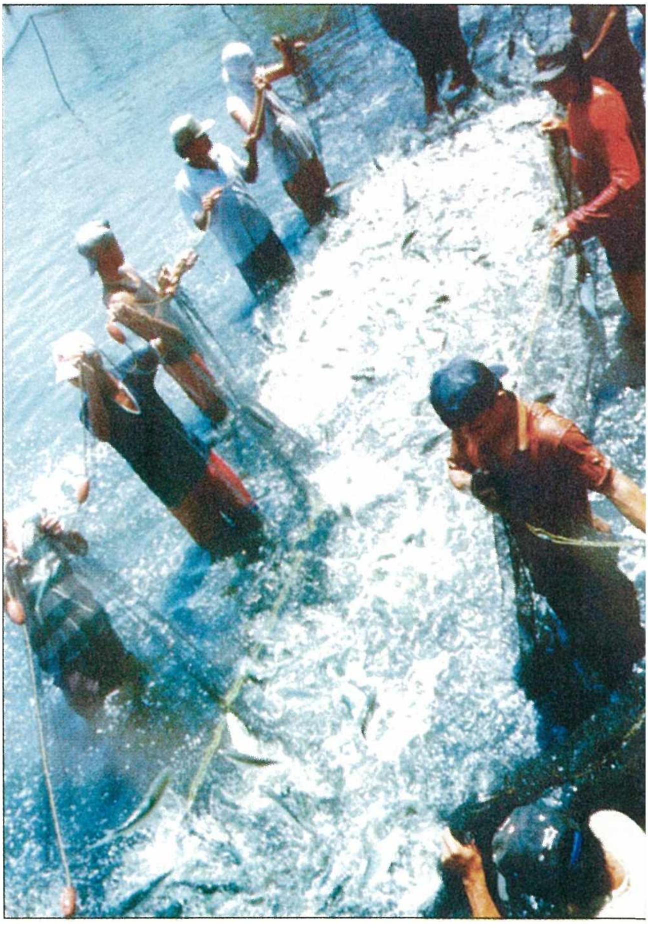
	TRANSITION POND	FORMATION POND	REARING POND
First crop	PP Feb 13-March 14 S March 15 CP March 15-April 15 T April 16	PP March 14-April 15 S April 16 CP April 16-May 16 T May 17	PP April 15-May 16 S May 17 CP May 17-June 17 H June 18
Second crop	PP April 17-May 2 S May 3 CP May 3-June 3 T June 4	PP May 18-June 3 S June 4 CP June 4-July 5 T July 6	PP June 19-July 6 S July 6 CP July 6-Aug 6 H Aug 7
Third crop	PP June 5-July 5 S July 6 CP July 6-Aug 7 T Aug 8	PP July 7- Aug 8 S Aug 8 CP Aug 8-Sept 8 T Sept 9	S Sept 9 S Sept 9 CP Sept 9-Oct 9 H Oct 10
Fourth crop	PP Aug 9-Sept 9 S Sept 10 CP Sept 10-Oct. 10 T Oct 11	PP Sept 10-Oct 10 S Oct 11 S Oct 11-Nov 11 T Nov 12	PP Oct 11-Nov 11 S Nov 12 CP Nov 12-Dec 13 H Dec 14
Fifth crop	PP Dec 15-Jan 15 S Nov 13 CP Nov 14-Dec. 13 T Dec 14	PP Jan 17-Feb 16 S Dec 14 CP Dec 14-Jan 15 T Jan 16	PP Feb 18-Mar 18 S Jan 16 CP Jan 16-Feb 16 H Feb 17
Sixth crop	PP Dec 15-Jan 15 S Jan 16 CP Jan 16-Feb 16 T Feb 17	PP Jan 17-Feb 16 S Feb 17 CP Feb 17-Mar 18 T Mar 19	PP Feb 18-Mar 18 S Mar 19 CP Mar 19-Apr 13 H Apr 14

LEGEND: PP - pond preparation; S - stocking; CP - culture period; T - transfer; H - harvest

HARVEST AND POST-HARVEST

So far, the most common and the best technique of harvesting milkfish is still the "pasulang" method or inducing the fish to swim against the water current. The fish are gathered in the catching pond or canal system during spring tide, and drag seines are used to collect them. They are scooped into chilling tanks or boxes where the temperature is low enough to kill them. In the chilling tank or box, a 1:1 ratio of ice to a kilogram of fish is enough to lower the temperature of the fish to about 4°C in two hours. The remaining fish on the now totally drained pond are collected by hand.

Milkfish are sorted according to quality (size, freshness, among others) and then packed into wooden boxes ("kahon"), metal tubs ("banera"), or bamboo baskets ("kaing") ready for retailers and fish brokers. Harvested "bangus" may be sold fresh, dried, smoked, deboned, pickled or sent to cannery for processing or packed in cans like sardines.



Economics and costing

MODULAR POND SYSTEM

Item	Unit	Field trial data
Farm area	ha	7
Stocking rate per crop	pcs per ha	2,957
Number of pieces per run per 7 ha	pcs	11,828
Initial weight	g	11.12
Survival rate	%	93.30
Number at harvest	pcs	11,036
Final weight	g	252.76
Total weight per crop	kg	2,789
Harvest of 6 crops	kg	16,734
Days of culture	days	92
Growth gain per day	g	2.63
COST-AND-RETURNS		
Farm area	ha	7
Annual yield	kg	16,734
Selling price	₱/kg	50.00
Gross revenue	₱	836,700.00
Total cost of production	₱	276,111.00
Net profit before tax	₱	560,589.00
Less: Income tax	₱	196,206.15
Net profit after tax	₱	364,382.85
Return of investment	%	131
Payback period	year	0.76

References

Agbayani RF, Baliao DD, Franco NM, Ticar RB and Guanzon NG. 1989. An economic analysis of the modular pond system of milkfish production in the Philippines. Aquaculture 83:249-259

Baliao DD. 1982. Management of brackishwater ponds for milkfish fingerling production in Sri Lanka. J. Inland Fish. Sri Lanka 1:17-29

Baliao DD. 1983. Milkfish nursery pond and pen culture in the Indo-Pacific region. In: Proceedings of the Second International Milkfish Conference, Juario JV, RP Ferraris and LV Benitez (Eds). Iloilo City, Philippines. p 97-106

Baliao DD, Franco NM and Agbayani RF. 1987. The economics for fingerling production in brackishwater ponds. Aquaculture 62:195-205

Dureza VA. 1977. Production responses of milkfish *Chanos chanos* (Forsskal) in brackishwater ponds to additional substrates for fishfood organisms. PCARR Fisheries Research Forum, Manila

Gapasin RSJ, Marte CL. 1990. Milkfish hatchery operations. Aquaculture Extension Manual No. 17. SEAFDEC Aquaculture Dept, Tigbauan, Iloilo. 25 pp

Lijauco M, Juario JV, Baliao DD, Grino E and Quinitio G. 1983. Milkfish culture in brackishwater ponds. Aquaculture Extension Manual No. 4. SEAFDEC Aquaculture Dept, Tigbauan, Iloilo

Philippine Council for Agriculture and Resource Research. 1976. The Philippines recommends for bangus. Los Banos, Laguna, Philippines

Philippine Council for Agriculture and Resource Research. 1982. Milkfish research: State of the art. Los Banos, Laguna, Philippines

Rabanal HR, Montalban, HR and Villaluz D. 1951. The preparation and management of *bangus* fishpond nursery in the Philippines. Phil. J. Fish. 1:3-35

Rabanal HR. 1984. Technological innovation in characteristics, design and management of ponds used in brackishwater aquaculture. Workshop on artisanal fisheries development in Indonesia with special emphasis in brackishwater pond culture. Jakarta, Indonesia

Acknowledgment

With special thanks to Romulo Ticar, Ronnie Ticar, Uldarico Derotas, and Jesus Amihan whose help contributed to the success of this Technology Verification Project. We also thank the cooperators Rodolfo Alvarez of Ilog, Negros Occidental; Ramon Montinola of Silay, Negros Occidental; Carlos Co of Carcar, Cebu and Engr. Carlito J. Rabang of the Meralco Corporate Farm Inc., Getulio, Buenavista, Guimaras for allowing us to field-test this modular method for milkfish production.

To Renato Agbayani and Neila Sumagaysay for reviewing the draft of the manual, and the Development Communication staff who edited, designed and produced it. We appreciate their efforts.

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SEAFDEC/AQD research publications on milkfish

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(63-33) 335 1008, 336 2891

Agbayani RF, Baliao DD, Franco NM, Ticar RB, Guanzon NG Jr. 1989. An economic analysis of the modular pond system of milkfish production in the Philippines. AQUACULTURE 83 (3-4): 249-259

Alava VR. 1998. Effect of salinity, dietary lipid source and level of growth of milkfish (*Chanos chanos*) fry. AQUACULTURE 167: 229-236

Alava VR, Kanazawa A. 1996. Effect of dietary fatty acids on growth of milkfish *Chanos ch no.* fry in brackish water. AQUACULTURE 144(4): 363-369

Almendras JME. 1987. Acute nitrite toxicity and methemoglobinemia in juvenile milkfish (*Chanos chanos* Forsskal). AQUACULTURE 61(1): 33-40

Bagarinao TU. 1998. Historical and current trends in milkfish farming in the Philippines. de Silva SS (ed). Tropical Mariculture. Academic Press: 381-422

Bagarinao T. 1994. Systematics, distribution, genetics and life history of milkfish, *Chanos chanos*. ENVIRON. BIOL. FISHES 39 (1): 23-41

Bagarinao TU. 1991. Biology of milkfish (*Chanos chanos* Forsskal). Tigbauan, Iloilo, Philippines: SEAFDEC Aquaculture Department. 94 pp

Bagarinao T. 1986. Yolk resorption, onset of feeding and survival potential of larvae of three tropical marine fish species reared in the hatchery. MAR. BIOL. 91 (4): 449-459

Bagarinao T. 1986. The milkfish seed resources survey in Sri Lanka: Status, problems and recommendations. J. INLAND FISH. 3: 96-107

Bagarinao TU, Kumagai S. 1981. Studies on the habitat and food of juvenile milkfish in the wild. FISH. RES. J. PHILIPP. 6(1): 1-10

Bagarinao T, Thayaparan K. 1986. The length-weight relationship, food habits and condition factor of wild juvenile milkfish in Sri Lanka. AQUACULTURE 55 (3): 241-246

Baliao DD. 1982. Management of brackishwater pond for milkfish fingerling production in Sri Lanka. J. INLAND FISH. 1: 17-29

Baliao DD, Franco NM, Agbayani RF. 1987. The economics of retarding milkfish growth for fingerling production in brackishwater ponds. AQUACULTURE 62 (3-4): 195-205

Bautista MN, dela Cruz MC. 1988. Linoleic (omega 6) and linolenic (omega 3) acids in the diet of fingerling milkfish (*Chanos chanos* Forsskal). AQUACULTURE 71 (4): 347-358

Bautista MN, del Valle MJ, Orejana FM. 1991. Lipid and fatty acid composition of brackishwater- and freshwater-reared milkfish (*Chanos chanos* Forskal). AQUACULTURE. 96 (3-4): 241-248

Benitez LV, Tiro LB. 1982. Studies on the digestive proteases of the milkfish *Chanos chanos,* MAR. BIOL. 71 (3): 309-315

Brackishwater Information System Project (BRAIS). 1988. Milkfish abstracts. 1988. Tigbauan, Iloilo, Philippines: SEAFDEC Aquaculture Department. 104 pp

Bombeo-Tuburan I. 1989. Comparison of various water replenishment and fertilization schemes in brackishwater milkfish ponds. J. APPL. ICHTHYOL. 5 (2): 61-66

Bombeo-Tuburan I. 1988. The effect of stunting on growth, survival, and net production of milkfish (*Chanos chanos* Forskal). AQUACULTURE 75 (1-2): 97-103

Bombeo-Tuburan I, Agbayani RF, Subosa PF. 1989. Evaluation of organic and inorganic fertilizers in brackishwater milkfish ponds. AQUACULTURE 76 (3-4): 227-235

Borlongan IG. 1992. The essential fatty acid requirement of milkfish (*Chanos chanos* Forsskal). FISH PHYSIOL. BIOCHEM. 9 (5-6): 401-407

Borlongan IG. 1992. Dietary requirement of milkfish (*Chanos chanos* Forsskal) juveniles for total aromatic amino acids. AQUACULTURE 102 (4): 309-317

Borlongan IG. 1991. Arginine and threonine requirements of milkfish (*Chanos chanos* Forsskal) juveniles. AQUACULTURE 93 (4): 313-322

Borlongan IG. 1990. Studies on the digestive lipases of milkfish, *Chanos chanos.* AQUACULTURE 89 (3-4) 315-325.

Borlongan IG, Benitez LV. 1992. Lipid and fatty acid composition of milkfish (*Chanos chanos* Forsskal) grown in freshwater and seawater. AQUACULTURE 104 (1-2): 79-89

Borlongan IG, Benitez LV. 1990. Quantitative lysine requirement of milkfish (*Chanos chanos*) juveniles. AQUACULTURE 87 (3-4): 341-347

Borlongan IG, Coloso RM, Mosura EF, Sagisi FD, Mosura AT. 1998. Molluscicidal activity of tobacco dust against brackishwater pond snails (*Cerithidea cingulata* Gmelin). Crop Protect. 17: 401-404

Buri P. 1981. Pigmentation pattern in the early developmental stages of milkfish (*Chanos chanos*): A key for larval identification. FISH. RES. J. PHILIPP. 6 (1): 51-55

Buri P, Banada V, Trino A. 1981. Developmental and ecological stages in the life history of milkfish *Chanos chanos* (F.). FISH. RES. J. PHILIPP. 6 (2): 33-58

Chaudhuri H, Juario JV. 1977. Use of hormones in breeding cultivated warm-water fishes with special reference to milkfish, *Chanos chanos* (Forskal). FISH. RES. J. PHILIPP. 2(2): 1-6

Chaudhuri H, Juario J, Samson R, Tiro L. 1976. Notes on the external sex characters of *Chanos chanos* (Forskal) spawners. FISH. RES. J. PHILIPP. 1(2): 76-85

Chaudhuri H, Juario JV, Primavera JH, Samson R, Mateo R. 1978. Observations on artificial fertilization of eggs and the embryonic and larval development of milkfish, *Chanos chanos* (Forskal). AQUACULTURE 13 (2): 95-113

Chiu YN, Benitez LV. 1981. Studies on the carbohydrases in the digestive tract of the milkfish *Chanos chanos.* MAR. BIOL. 61 (2-3): 247-254

Coloso RM, Tiro LB, Benitez LV. 1992. Requirement for tryptophan by milkfish (*Chanos chanos* Forsskal) juveniles. FISH PHYSIOL. BIOCHEM. 10(1): 35-41

Cruz ER. 1981. Acute toxicity of un-ionized ammonia to milkfish (Chanos chanos) fingerlings. FISH. RES. J. PHILIPP. 6 (1): 33-38

Cruz ER, Tamse CT. 1989. Acute toxicity of potassium permanganate to milkfish fingerlings, *Chanos chanos.* BULL. ENVIRON. CONTAM. TOXICOL. 43 (5): 785-788

Cruz ER, Pitogo CL. 1989. Tolerance level and histopathological response of milkfish (*Chanos chanos*) fingerlings to formalin. AQUACULTURE 78 (2): 135-145

dela Peña LD, Chiu YN, Ganchero F. 1987. Evaluation of various leguminous seeds as protein sources for milkfish, *Chanos chanos* Forsskal, juveniles. ASIAN FISH. SCI. 1(1): 19-25

Duray MN. 198_. The effect of tank color and rotifer density on rotifer ingestion, growth and survival of milkfish (*Chanos chanos*) larvae. PHILIPP. SCI. 32: 18-26

Duray M, Bagarinao T. 1984. Weaning of hatchery-bred milkfish larvae from live food to artificial diets. AQUACULTURE 41 (4): 325-332

Emata AC, Marte CL, 1994. Natural spawning, egg and fry production of milkfish, *Chanos chanos* (Forsskal), broodstock reared in concrete tanks. J. APPL. ICHTHYOL. 10(1): 10-16

Emata AC, Marte CL. 1993. Broodstock management and egg production of milkfish, *Chanos chanos* Forsskal. AQUACULT. FISH. MANAGE. 24 (3) 381-388

Emata AC, Marte CL. 1992. The use of a visual implant tag to monitor the reproductive performance of individual milkfish *Chanos chanos* Forsskal. J. APPL. ICHTHYOL. 8(1-4): 314-317

Emata AC, Marte CL, Garcia LMB. 1992. Management of milkfish broodstock. Tigbauan, Iloilo, Philippines: SEAFDEC Aquaculture Department. 22 pp

Estudillo CB, MN Duray, Marasigan ET. 1998. Growth and survival of milkfish (*Chanos chanos*), sea bass (*Lates calcarifer*), and rabbitfish (*Siganus guttatus*) larvae reared at the same density in different sized tanks. ISR. J. AQUACULT. - BAMIDGEH 50: 20-24

Gapasin RSJ, Bombeo R, Lavens P, Sorgeloos P, Nelis H. 1998. Enrichment of live food with essential fatty acids and vitamin C: effects on milkfish (*Chanos chanos*) larval performance. AQUACULTURE 162 (3-4): 271-288

Garcia LMB, Gapasin RSJ. 1988. An inexpensive tag for short-term studies in milkfish (*Chanos chanos* Forsskal) and in seabass (*Lates calcarifer* Bloch). J. APPL. ICHTHYOL. 4 (3): 101-104

Garcia LMB, Toledo JD. 1988. Critical factors influencing survival and hatching of milkfish (*Chanos chanos* Forsskal) eggs during simulated transport. AQUACULTURE 72 (1-2) 85-93

Hara S, Canto JT Jr, Almendras JME. 1982. A comparative study of various extenders for milkfish, *Chanos chanos* (Forsskal), sperm preservation. AQUACULTURE 28 (3-4): 39-346

Hilomen-Garcia G.V. 1998. Sensitivity of fertilized milkfish (*Chanos chanos* Forsskal) eggs to mechanical shock and simulated transport. AQUACULTURE 159 (3-4): 239-247

Hilomen-Garcia GV. 1997. Morphological abnormalities in hatchery-bred milkfish (*Chanos chanos* Forsskal) fry and juveniles. AQUACULTURE 152 (1-4): 155-166

Juario JV, Storch V. 1984. Biological evaluation of phytoplankton (*Chlorella* sp., *Tetraselmis* sp. and *Isochrysis galbana*) as food for milkfish (Chanos chanos) fry. AQUACULTURE 40 (3): 193-198

Juario JV, Quinitio GF, Banno JE, Natividad M. 1980. Effects of exogenous hormone injections on milt consistency in newly caught, wild milkfish. KALIKASAN 9 (2-3): 321-326

Ferraris RP, Almendras JM, Jazul AP. 1988. Changes in plasma osmolality and chloride concentration during abrupt transfer of milkfish (*Chanos chanos*) from seawater to different test salinities. AQUACULTURE 70 (1-2): 145-157

Ferraris RP, Catacutan MR, Mabelin RL, Jazul AP. 1986. Digestibility in milkfish, *Chanos chanos* (Forsskal): Effects of protein source, fish size and salinity. AQUACULTURE 59 (2): 93-105

Fernandez RD, Tendencia EA, Leano E.M, Duray MN. 1996. Bacterial flora of milkfish, *Chanos chanos,* eggs and larvae FISH-PATHOL. 31 (3):123-128

Gerochi DD, Lijauco MM, Baliao DD. 1988. Comparison of the silo and broadcast methods of applying organic fertilizer in milkfish, *Chanos chanos* (Forsskal), ponds. AQUACULTURE 71 (4): 313-318

Kumagai S, Castillo NM. 1980. Changes in the length and weight of milkfish, *Chanos chanos*, larvae preserved in formalin. FISH. RES. J. PHILIPP. 5(1): 17-23

Kumagai S, Bagarinao TU. 1979. Results of drift card experiments and considerations on the movement of milkfish eggs and larvae in the Northern Sulu Sea. FISH. RES. J. PHILIPP. 4 (2): 64-81

Lavina EM. 1978. A study on certain aspects on the biology and control of *Caligus* sp., an ectoparasite of the adult milkfish *Chanos chanos* (Forskal). FISH. RES. J. PHILIPP. 3(2): 11-24

Lim C, Sukhawongs S, Pascual FP. 1979. A preliminary study on the protein requirements of *Chanos chanos* (Forskal) fry in a controlled environment. AQUACULTURE 17(3): 195-201

Marte CL. 1988. An improved method for collecting naturally spawned milkfish eggs from floating cages. AQUACULTURE 71 (4): 387-392

Marte CL, Lacanilao F. 1986. Spontaneous maturation and spawning of milkfish in floating net cages. AQUACULTURE 53 (2): 115-132

Marte CL, Lam TJ. 1992. Hormonal changes accompanying sexual maturation in captive milkfish (*Chanos chanos* Forsskal). FISH PHYSIOL. BIOCHEM. 10(4): 267-275

Marte CL, Sherwood NM, Crim LW, Harvey B. 1987. Induced spawning of maturing milkfish (*Chanos chanos* Forsskal) with gonadotropin-releasing hormone (GnRH) analogues administered in various ways. AQUACULTURE 60 (3-4): 303-310

Marte CL, Quinitio GF, Garcia LMB, Lacanilao F. 1984. A guide to the establishment and maintenance of milkfish broodstock. Tigbauan, Iloilo, Philippines: SEAFDEC Aquaculture Department. 36 pp

Pantastico JB, Baldia JP, Reyes DM Jr. 1986. Feed preference of milkfish (*Chanos chanos* Forsskal) fry given different algal species as natural feed. AQUACULTURE 56 (3-4): 169-178

Primavera JH, Eldani A. 1981. Effect of different stocking combinations on growth, production and survival of milkfish (*Chanos chanos* Forskal) and prawn (*Penaeus monodon* Fabricius) in polyculture in brackishwater ponds. AQUACULTURE 23 (1-4): 59-72

Primavera JH, Apud F, Usigan. 1976. Effect of different stocking densities on survival and growth of sugpo (*Penaeus monodon* Fabricius) in a milkfish-rearing pond. PHILIPP. J. SCI. 105(3): 193-203

Pudadera BJ Jr, Lim C. 1982. Evaluation of milkfish (*Chanos chanos* Forskal) and prawn (*Penaeus monodon* Fabricus) in polyculture system. FISH. RES. J. PHILIPP. 7 (1): pp. 51-59

Santiago CB, Banes-Aldaba M, Songalia ET. 1983. Effect of artificial diets on growth and survival of milkfish fry in fresh water. AQUACULTURE 34 (3-4): 247-252

Santiago CB, Pantastico JB, Baldia SF, Reyes OS. 1989. Milkfish (*Chanos chanos*) fingerling production in freshwater ponds with the use of natural and artificial feeds. AQUACULTURE 77 (4): 307-318

Sumagaysay NS. 1998. Milkfish (*Chanos chanos*) production and water quality in brackishwater ponds at different feeding levels and frequencies. J. APPL. ICHTHYOL. 14: 81-85.

Sumagaysay NS. 1994. Utilization of feed and rice straw compost for milkfish, *Chanos chanos*, production in brackishwater ponds. J. APPL. ICHTHYOL. 7 (4): 230-237

Sumagaysay NS. 1993. Growth, daily ration, and gastric evacuation rates of milkfish (*Chanos chanos*) fed supplemental diet and natural food. J. APPL. ICHTHYOL. 9 (2): 65-73

Sumagaysay NS, Borlongan IG. 1995. Growth and production of milkfish (*Chanos chanos*) in brackishwater ponds: Effects of dietary protein and feeding levels. AQUACULTURE 132 (3-4): 273-283

Sumagaysay NS, Chiu-Chern YN. 1991. Effects of fiber in supplemental feeds on milkfish (*Chanos chanos* Forsskal) production in brackishwater ponds. ASIAN FISH. SCI. 4 (2): 189-199

Sumagaysay NS, Marquez FE, Chiu-Chern YN. 1991. Evaluation of different supplemental feeds for milkfish (*Chanos chanos*) reared in brackishwater ponds. AQUACULTURE 93 (2): 177-189

Sumagaysay NS, Chiu-Chern YN, Estilo VJ, Sastrillo MAS. 1990. Increasing milkfish (*Chanos chanos*) yields in brackishwater ponds through increased stocking rates and supplementary feeding. ASIAN FISH. SCI. 3 (2): 251-256

Tamse CT, Piedad-Pascual F, de la Cruz M. 1983. Some histological observations on the opaque eyes of milkfish *Chanos chanos* Forskal. FISH. RES. J. PHILIPP. 8 (2): 69-72

Toledo JD, Gaitan AG. 1992. Egg cannibalism by milkfish (*Chanos chanos* Forsskal) spawners in circular floating net cages. J. APPL. ICHTHYOL. 8 (1-4): 257-262

Villaluz AC, Unggui A. 1983. Effects of temperatures on behavior, growth, development and survival in young milkfish, *Chanos chanos* (Forskal). AQUACULTURE 35 (4): 321 - 330

Villaluz AC, Amandakoon HP, de Alwis A. 1982. Milkfish fry and fingerling resources of Sri Lanka. J. INLAND FISH, 1:7-16

Villegas CT. 1990. The effects on growth and survival of feeding water fleas (*Moina macrocopa* Strauss) and rotifers (*Brachionus plicatilis*) to milkfish (*Chanos chanos* Forsskal) fry. ISR. J. AQUACULT.- BAMIDGEH 42 (1): 10-17

Villegas CT, Lumasag GL.1991. Biological evaluation of frozen zooplankton as food for milkfish (*Chanos chanos*) fry. J. APPL. ICHTHYOL. 7 (2): 65-71

Villegas CT, Bombeo T. 1982. Effects of increased stocking density and supplemental feeding on the production of milkfish fingerlings. FISH. RES. J. PHILIPP. 7 (2): 21-27

Villegas CT, Millamena O, Escritor F. 1990. Food value of *Brachionus plicatilis* fed three selected algal species as live food for milkfish, *Chanos chanos* Forsskal, fry production. AQUACULT. FISH. MANAGE. 21 (2): 213-219

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The modular method: milkfish pond culture

SEAFDEC Aquaculture Department
Tigbauan, Iloilo, Philippines
MARCH 1999

The Southeast Asian Fisheries Development Center (SEAFDEC) is a regional treaty organization established in December 1967 for the purpose of promoting fisheries development in the region. Its Member Countries are Japan, Malaysia, the Philippines, Singapore, Thailand, Brunei Darussalam, and the Socialist Republic of Viet Nam.

Representing the Member Countries is the Council of Directors, the policy-making body of SEAFDEC. The chief administrator of SEAFDEC is the Secretary-General whose office, the Secretariat, is based in Bangkok, Thailand.

Created to develop fishery potentials in the region in response to the global food crises, SEAFDEC undertakes research on appropriate fishery technologies, trains fisheries and aquaculture technicians, and disseminates fisheries and aquaculture information. Four departments were established to pursue the objectives of SEAFDEC.

- The **Training Department** (TD) in Samut Prakan, Thailand, established in 1967 for marine capture fisheries training
- The **Marine Fisheries Research Department** (MFRD) at Changi Fisheries Complex, Singapore, established in 1967 for fishery post-harvest technology
- The **Aquaculture Department** (AQD) in Tigbauan, Iloilo, Philippines, established in July 1973 for aquaculture research and development
- The **Marine Fishery Resources Development and Management Department** (MFRDMD) in Kuala Terengganu, Malaysia, established in 1992 for the development and management of the marine fishery resources in the exclusive economic zones (EEZs) of SEAFDEC Member-Countries.