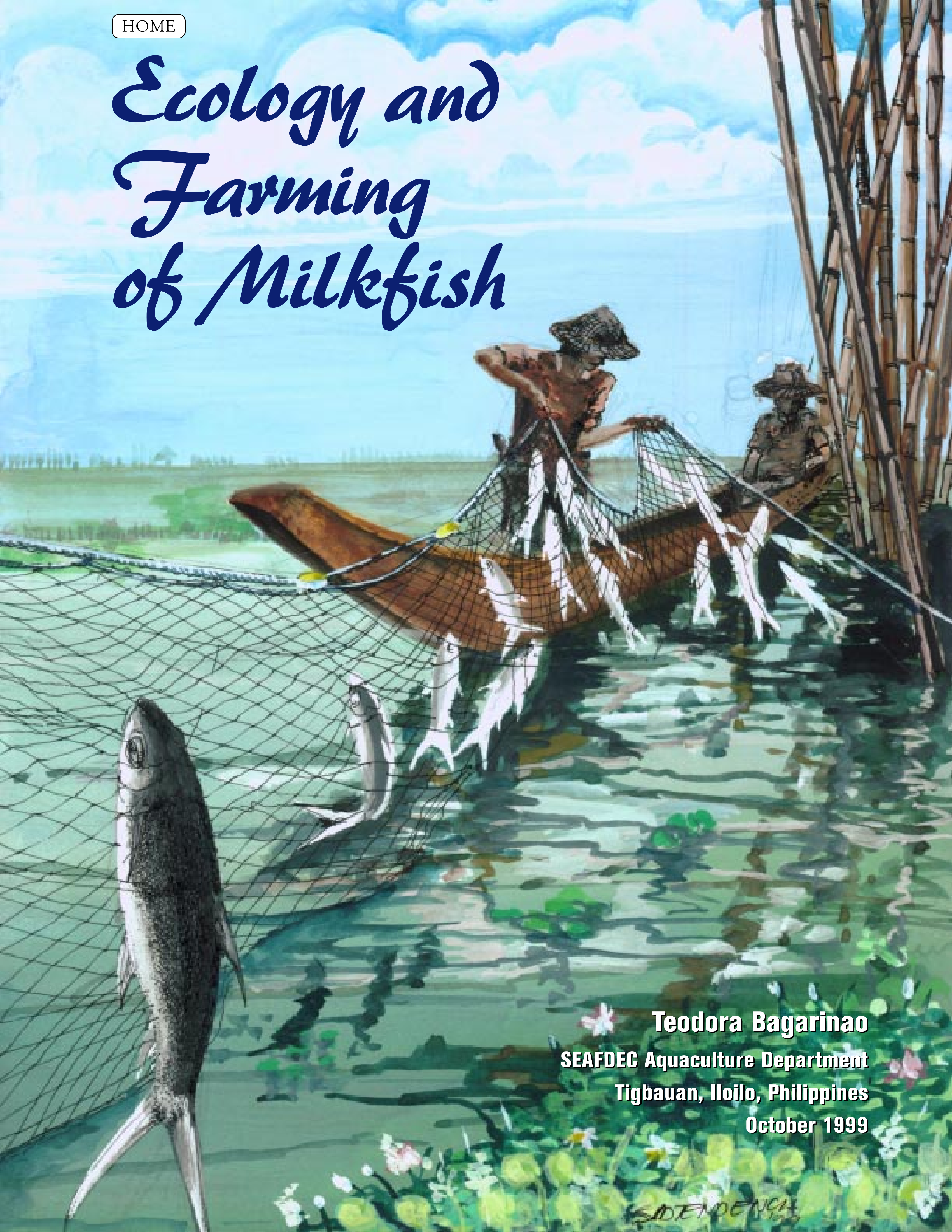
HOME

Ecology and Farming of Milkfish



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October 1999

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Bangus or milkfish *Chanos chanos* (Forsskål), the national fish, is an important part of the diet, economy, ecology, and the science and technology of the Philippines, having been farmed and marketed for about four centuries. This book summarizes the life history and ecology of milkfish and various aspects of the farming industry for the information of all Filipinos. The book celebrates the Centennial of the Philippines on 12 June 1998 and the 25th Anniversary of the SEAFDEC Aquaculture Department and the 5th Anniversary of the AQD Museum on 9 July 1998.

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Cover painting by Isidro Tendencia: Milkfish harvested from pens in Laguna de Bay.

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Preface

High hopes are pinned on aquaculture as the solution to the shortfall in the harvests from capture fisheries relative to the expanding human population. Such expectations can only be fulfilled by herbivorous or omnivorous farmed species not dependent on fishmeal-based feeds. In the Philippines, Indonesia, and Taiwan, milkfish has traditionally been grown on natural food (until about a decade ago), and milkfish farming is widely regarded as the way to domestic food security.

Thus, large investments were made in the Philippines, Taiwan, Indonesia, and Hawaii in infrastructure, credit, research, and training in support of the milkfish industry. The SEAFDEC Aquaculture Department (AQD), in particular, was established in Iloilo, Philippines in 1973 to develop aquaculture in southeast Asia, and milkfish became one major focus of research. Government agencies and fisheries institutions were also fielded in the national effort to intensify milkfish farming starting in the 1970s.

Much has been learned about the biology, ecology and aquaculture of milkfish from those years of research and development. Filipino students, teachers, aquafarmers, researchers, extension workers, and policy-makers must know of these advances and understand how milkfish figures in the ecology and economy of the coastal environment that is the Philippines.

Such awareness is important as we mark a new millenium with a milkfish industry that is changing in practices, players, dynamics, economic outlook and relevance, environmental impact, and prospects for sustainability. Decisions will have to be made at various levels (the farm, the ecosystem, the country, etc.) and it helps when the general public knows the facts and understands the issues. Although this book is a monograph on milkfish, many similar issues apply to other farmed species.

SEAFDEC AQD and Teodora Bagarinao offer this book to the Philippines on the centennial of its nationhood. May there be a thriving milkfish industry during our great grandchildren's generation and beyond.

ROLANDO R. PLATON
Chief, SEAFDEC AQD
Tigbauan, Iloilo
October 1999

Acknowledgements

Books are written only by incurring intellectual debt, and I have plenty. Many friends and critics influenced my life and work in milkfish biology over the past 20 years in more ways than I can thank them for: Jesus Juario, Marietta Duray, Shigeru Kumagai, Yasuhiko Taki, Gunzo Kawamura, Flor Lacanilao, Clarissa Marte, Ronaldo Ferraris, Mila Castaños, Rolando Platon, Renato Agbayani, Jurgenne Primavera, Tetsushi Senta, I-Chiu Liao, Brian Davy, Richard Rosenblatt, and John Hunter. Scientists at SEAFDEC AQD and elsewhere will recognize their work as included in this book; I thank them for their contributions. Clarissa Marte, Marietta Duray, Arnil Emata, and Neila Sumagaysay reviewed parts of the manuscript, but I am responsible for all mistakes that remain. Illustrations are critical to this book: Romeo Buendia provided many recent photographs; Isidro Tendencia, the cover painting; Edgar Ledesma, some drawings; and Shigeru Kumagai, several old photographs. Alberto Purzuelo Jr. of Makinaugalingon Press prepared the lay-out with great technical skill and patience. Friends, family, and my son Carl Emilio made sure that I did not lose my sense of balance through all the computer days and nights.

Maraming salamat po sa inyong lahat.

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HOME

Table of Contents

Introduction

Fish, fishing, and fish farming are very important to the diet, culture, and economy of the people of the Philippines and the rest of Asia. Milkfish farming in Indonesia, the Philippines, and Taiwan started about 4-6 centuries ago, and milkfish has become a national symbol, the official national fish, of the Philippines.

Milkfish figures prominently in the science and technology, and in the economy and ecology of the Philippines. Certainly this is because milkfish is an economic commodity that science and technology is expected to produce more of. Much of the milkfish science and technology and the importance of milkfish to the economy and ecology of the Philippines is described in this book.

Perhaps a thousand scientific papers in all have been written about milkfish over the last hundred years. Sunier (1922) described the natural history of marine fishponds in Batavia, Indonesia. Delsman (1926, 1929) collected the eggs and larvae of milkfish for the first time from the Java Sea. In 1929, American ichthyologist Albert Herre and Filipino co-worker Jose Mendoza of the Bureau of Science, Manila, documented milkfish farming in Rizal, Bulacan, Pampanga, Bataan, Iloilo, and Mactan Island. Herre and Mendoza (1929) also included a speculative account of milkfish biology. Hiatt (1944) wrote about milkfish feeding habits in Hawaiian fish ponds, Chen (1952) about milkfish farming in Taiwan, and Tampi (1957,1958) about milkfish in India. All the early literature went into the FAO Fisheries Biology Synopsis on milkfish (Schuster 1960). Papers on milkfish farming and ecology in Taiwan followed (Lin 1968, Lin 1969).

Since the 1970s, large investments have been made in the Philippines (as well as in Indonesia, Taiwan, and Hawaii) in terms of infrastructure, credit, research, and training in support of the milkfish industry. The SEAFDEC Aquaculture Department (AQD), in particular, was established in Iloilo, Philippines in 1973 to find solutions to aquaculture problems. Government agencies and fisheries institutions were also fielded in the national effort to intensify milkfish farming.

Much has been learned about the biology, ecology, and farming of milkfish during the past 20 years of research and development. Within the past 20 years, SEAFDEC AQD researchers alone have published 166 scientific papers on milkfish and have developed and transferred various technologies in milkfish aquaculture. SEAFDEC AQD itself has published several extension manuals and monographs on milkfish (Kumagai et al. 1980, Smith 1981, Villaluz et al. 1982, Juario and Duray 1982, Juario et al. 1984a, Marte et al. 1984, Bagarinao et al. 1987, Gapasin and Marte 1990, Bagarinao 1991, Emata et al. 1992, FDS 1994, Baliao et al. 1999), some videos, and a poster on the life history. New findings are presented in meetings and taught in training courses at SEAFDEC AQD.

Subject matter of publications about milkfish by SEAFDEC AQD researchers. From Bagarinao and Flores (1995a) in part.

Research topics	Number of papers 1976-1980	1981-1984	1985-1987	1988-1991	1992-1994	1995-1997	Total
Broodstock management		1	1	2	2	1	7
Broodstock management		1	1	2	2	1	7
Endocrinology		1	2	1	3		7
Spawning	5	1	6	2	2		16
Hatchery			3	4	2	7	16
Larval development			3	1	1	1	6
Fry collection, storage	3	1	4			1	9
Nursery	1		4	3			8
Grow-out		1	1	9	1	5	17
Nutrient requirements	1	1	3	4	4	1	14
Digestive physiology		4	11	3	2	1	21
Feed development			1	3	1	1	6
Diseases, parasites	1	2	5	1			9
Tolerance limits		3	2	3	3	1	12
Ecology, biology	6	3	4	1	1		15
Genetics		1		2			3
Total	17	19	50	39	22	19	166

Other investigations on milkfish have also been made by the University of the Philippines, the International Center for Living Aquatic Resources Management in Manila, the Oceanic Institute in Honolulu, the Tungkang Marine Laboratory and Taiwan Fisheries Research Institute in Taiwan, the Gondol Brackishwater Aquaculture Center in Indonesia, and in India and elsewhere. Milkfish farming in Taiwan has recently been described by Chen (1990) and Lee (1995).

Filipinos must know of these advances and understand how milkfish figures in the ecology and economy of the coastal environment of the Philippines.

This book is not a how-to manual, but a broad description of the past and present practices and realities in the milkfish industry. The book includes material from several out-of-print AQD publications and two recent reviews (Bagarinao 1994, 1998). Some old data and photographs and existing material from various sources have been included for a historical and cultural context. The book has eight chapters, each free-standing and can be read separately from the others. The text has been simplified for a wide non-specialist readership, but some technical material is presented in tables and figures. For this book to be reader-friendly, literature citations have been omitted in the text but listed at the end of the book.

The last chapter on sustainable milkfish farming is basically an appeal to practitioners and stakeholders in the industry to rethink some principles and realign mindsets to ensure that Filipinos and people everywhere continue to enjoy the dietary and economic benefits that milkfish brings.

Chapter 1

What is this Fish?

The Philippines' national fish

Every Filipino school child learns early in primary school that milkfish is the national fish, narra the national tree, mango the national fruit, sampaguita the national flower, the Philippine eagle the national bird, just as Dr. Jose Rizal is the national hero. Dr. Rizal is probably the most written about Filipino ever, the endangered Philippine eagle is now in everybody's consciousness, and books have recently paid homage to narra, sampaguita, and mango (never mind that the Philippine mango came from India). This book pays homage to milkfish.

Milkfish and milkfish farming are very important to the diet and economy of the people of the Philippines, where milkfish farming started centuries before the Danish taxonomist Petrus Forsskål described milkfish to science in 1775.

So, just how much a part of the Filipino culture and history is the national fish?

A review of books on Philippine culture and history indicates not much at all. Alfredo Roces' ten-volume *Filipino Heritage* hardly mentions milkfish. Nick Joaquin's *Almanac of Manila* likewise gives no hint that milkfish is that important to every day life. Many Filipiniana books have recently come out, including *Philippine Picture Postcards 1900-1920* and *The Philippines, a Journey through the Archipelago.* But nowhere is milkfish mentioned or shown in any of the old postcards or the new photographs of life in these islands. Although *Journey...* has extraordinary photographs of the sea, fish, and fishing, neither *dagat, isda,* nor *bangus* made it to the book's "21 Filipino Things" which includes mango, sampaguita, and the Philippine eagle (wildlife).

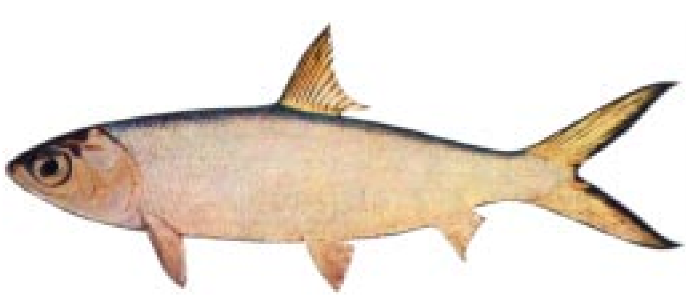
Photographs of milkfish harvest do appear in *Iloilo, the Book,* which inclusion reflects the significance of the milkfish industry to the Ilonggos. Iloilo is one of the top producers of milkfish in the country, and the SEAFDEC Aquaculture Department is, quite fittingly, in Iloilo.

The Philippine Postal Service recently issued a National Symbols series that includes milkfish, and an ASEAN Environment Year commemorative that shows milkfish (?). Note that milkfish is not as well drawn in these stamps as the Philippine eagle and other wildlife. Two other milkfish stamps issued in 1952 and 1985 were better rendered.

The Philippine coins on wildlife featured two national symbols, the narra and the Philippine eagle, but not milkfish. Yet, the small goby Pandaka pygmaea, *a volute shell, the* tamaraw, *a butterfly, the coconut, and the* waling-waling *orchid were in this series of coins.*

Strangely enough, Filipino artists and writers have not commonly depicted milkfish in the country's arts and literature. Have you ever seen a painting or sculpture of milkfish by any artist at all? Whereas carp and goldfish are very common subjects of Chinese paintings, fishing scenes done by Filipinos show the mudfish *dalag* or the catfish *hito*, but hardly ever milkfish.

This nice painting of milkfish is a rare example done by an undetermined Filipino artist (painting printed on a Christmas card).



This painting of milkfish appeared in Alvin Seale's (1908) "Fishes of the Philippine Islands."

Recent drawing of milkfish by Conrado Leysa, an Ilonggo Grade VI pupil, age 12.

Regular artists may find the plain silvery milkfish difficult or boring to draw. In a recent AQD Museum drawing contest, school children asked to draw fresh specimens in front of them drew milkfish less capably than they did the colorful tiger shrimp, grouper, and mudcrab. It takes a skilled illustrator-artist to capture the silvery milkfish on canvas.

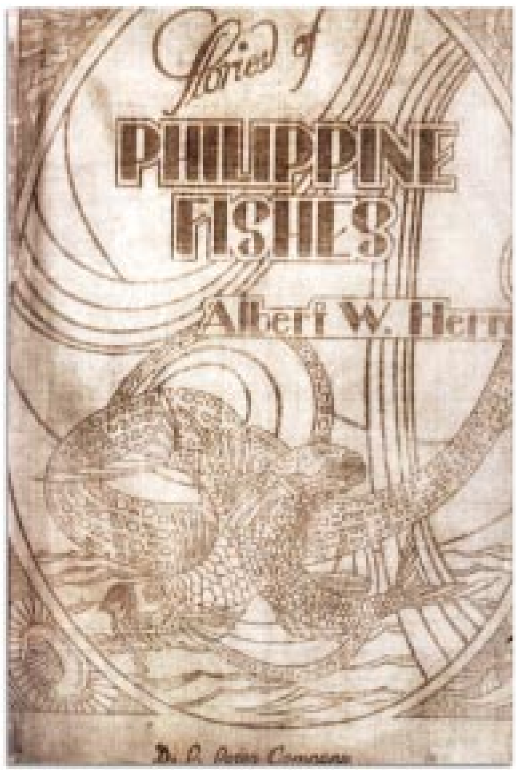
"Fisherman's Family," an oil painting by Tam Austria. Is that milkfish? (A commercial postcard).

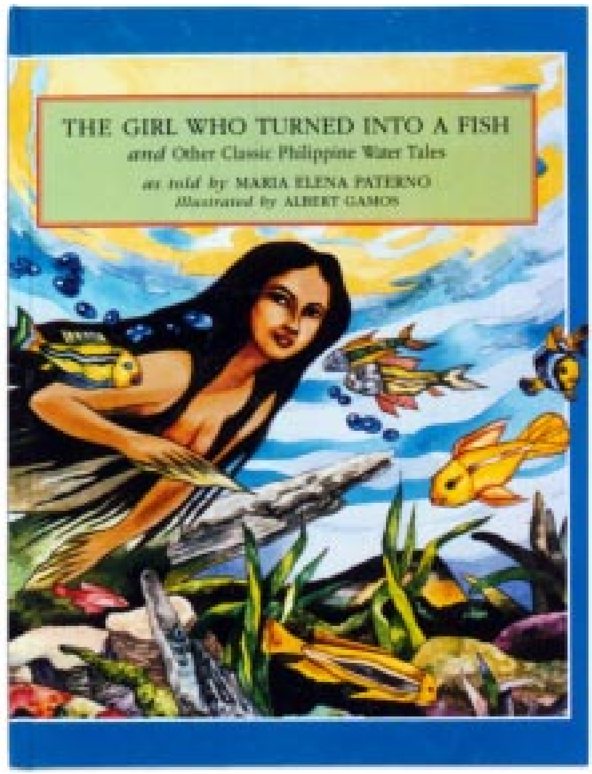
Painting in a B-MEG calendar showing milkfish (?).

Examples of artists' rendition of milkfish

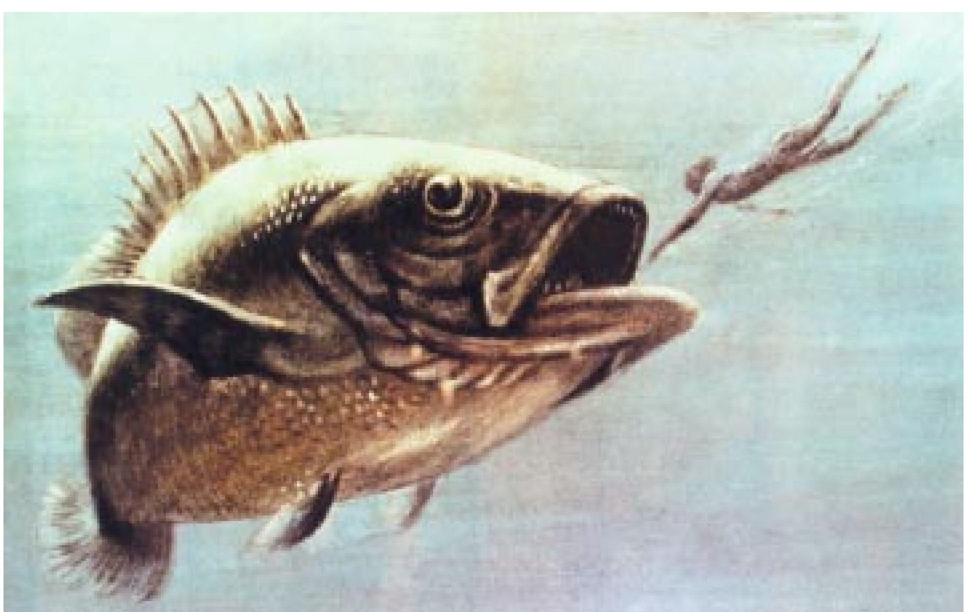
Recent painting by Ilonggo artist showing (inaccurate) milkfish.

Milkfish has not made it into the literary consciousness of Filipinos, either. There is a mermaid story by Ma. Elena Paterno that features milkfish as a minor character. But otherwise, there are no Filipino folk stories about milkfish. The American ichthyologist Albert Herre did write *The Story of the Bañgos* in his 1938 book, *Stories of Philippine Fishes*, written for and dedicated to Filipino children.





The Ilocano epic *Lam-ang* tells of the hero's efforts to catch the dreaded *rarang* fish, and in so doing, falls straight into the open mouth of the man-eating *berkakan* fish. In his earlier exploits, Lam-ang goes to find a bride, and speaks of his fish ponds, the contents of which would not be exhausted in meeting the future in-law's demands. The fish ponds, presumably in Pangasinan, contained *bangus*.



Lam-ang, the Ilocano epic hero falls into the mouth of the berkakan. *From Roces (1978).*

Have you ever seen a milkfish dance or any fish dance performed? The *Mangingisda* and *Panulo sa Baybay* dances, which are about fishing, come closest. And yet the Philippines has many animal dances like *itik-itik* and *tinikling* that show the movements of ducks and rails.

"Mangingisda" folk dance of the Bayanihan Philippine Dance Company. (A commercial postcard).

A social leader of the Nauru in costume for the fish dance. From Rhone (1921).

Milkfish figures prominently in the mythology and traditions of the native Pohnpeians, Hawaiians, Tongans and Nauruans in the Pacific. In the December 1921 issue of *National Geographic* is a picture of a Nauruan dancer with milkfish as ceremonial ornament.

Of course, it is a different story in recipe books. Milkfish is enjoyed throughout the country as *relleno, sinigang, pinirito, inihaw, sinugba, tinapa, pinamalhan, paksiw, escabeche, dinaing, pinakas,* etc. It can be cooked all by itself in the simplest ways or mixed with various ingredients in the most elaborate time-consuming ways. But always, milkfish is delicious and satisfying, despite the many bones in the muscles.

Bangus being prepared for sinigang at home.

Rellenong bangus served fancy. From Rosales-Barreto (1997).

The book *Philippine Food and Life* by Gilda Cordero-Fernando shows how fishes like *hito, dalag, kanduli, maliputo, tawilis,* and yes, *bangus,* are an integral part of the kitchen and palate of Filipinos. Doreen Fernandez' *Tikim* includes an essay *"Si Sugpo: Prawns in Philippine Lore and Culture"* that might have been written for *bangus.*

Milkfish is a favorite component of the traditional fish stew-soup or *sinigang* that uses sour fruits such as *batuan*, green *sampalok* or *sambag* (tamarind), or unripe *santol*. *Sinigang* is tasty, lean, healthful, and a much better alternative to the now-popular beef and chicken fare at fastfood outlets.

Sinigang na Bangus sa Santol

(Recipe from Nueva Ecija, from Cordero-Fernando 1992)

INGREDIENTS:

1/2 kg *bangus*, cut crosswise into serving portions
1 banana heart (long and light yellow in color)
1 tbsp vinegar
5 cups rice water (from boiling rice)
3 onions, quartered
1 piece ginger (about 10 g), peeled and sliced
2 medium-size green *santol* cut in halves, with seeds and skin
1 tbsp *patis* (fish sauce)
1 piece finger-long chili
slices of ripe *saba-a* banana
salt to taste

PROCEDURE:

1. Trim banana heart, remove outer cover and banana flowers that are hard and mature, and shred crosswise. Soak immediately in a pan of water with 1 tbsp vinegar to avoid discoloration. Set aside.
2. In a sauce pan, put 5 cups rice water and simmer onion, tomatoes, ginger, and unripe santol. Cook until santol is soft. The peel of the santol gives a nice color to the soup stock.
3. Rinse banana heart and add to the soup stock. Simmer 5 minutes.
4. Add bangus to the soup stock and let boil.
5. Add slices of ripe sab-a, bring to a boil, then let simmer for 5 min. Season with *patis*, salt, and pepper to taste. Serve hot.

Milkfish is considered a first-class fish, less affordable than *galunggong, bolinao, tamban* or *biya* to the low-income consumers, but important to all Filipinos on festive occasions. Catering to Filipinos eating out (that is, with money to spend or an occasion to celebrate), restaurants offer milkfish on the menu. Bangus Restaurant in Greenhills, Metro Manila has long been serving “prime cuts” of bellies or *tiyan ng bangus* in many different ways. *Vientre de bangus* is baked packets of *tiyan ng bangus* with *buro* or fermented rice as sauce. Seafood specialty restaurants (often ethnic *kawayan at sawali* places where customers go *kamayan* or eat with the hands) serve milkfish at rather high prices, even without the service trimmings.

Fried vientre de bangus at Bangus Restaurant, Greenhills.

Bangus sashimi at Bangus Restaurant, Greenhills.

Fried boneless bangus at Chow King's.

Sinugbang bangus at Tatoy's, Iloilo.

An international fish

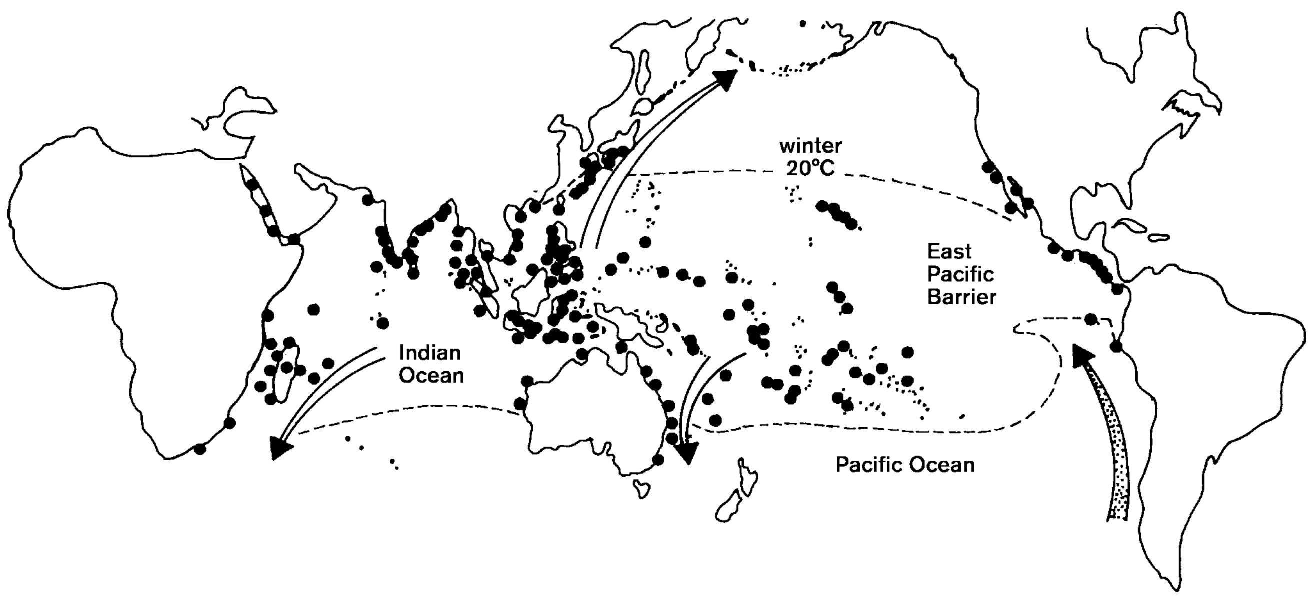
Milkfish is in fact an international fish found throughout most of the Indo-Pacific. It is known by different names in different countries.

Philippines	*bangus, bangrus, banglus, banglot, banglis, sabalo, awa*		
Indonesia	*ikan bandeng, baulo, bolu, balanak sembawa*	Burma	*ga-tin*
Malaysia	*bandang, jangos, pisong-pisong*	Sri Lanka	*plai-meen, vaikka*
Thailand	*pla nua chan*	S India	*pal-meen*
S Vietnam	*ca mang*	Iraq	*binni al-bahr*
Taiwan	*sabahee*	Hawaii	*awa-awa*
Japan	*sabahee*	Mexico	*sabalo*

The Philippines, Indonesia and Taiwan are at the center of the geographic distribution. Milkfish have been recorded as far as 34°N in Japan, in the Pacific islands from Guam to Tuamoto and from Hawaii to Tonga, down to about 34°S along eastern Australia. Milkfish are common in the bays and lagoons of Mexico, and have been reported from 33°N in California to Peru and the Galapagos Islands.

The type specimen of milkfish described in 1775 came from Jeddah in the Red Sea, where schools of milkfish can still be caught by purse seines. Milkfish also occur in the islands in the Indian Ocean and along the eastern African coast down to 34°S.

Milkfish are not found in tropical waters affected by cold ocean currents, but inhabit temperate latitudes affected by warm ocean currents. Milkfish stay relatively close to islands and the continental shelves and have not been caught by open-ocean fishing vessels.

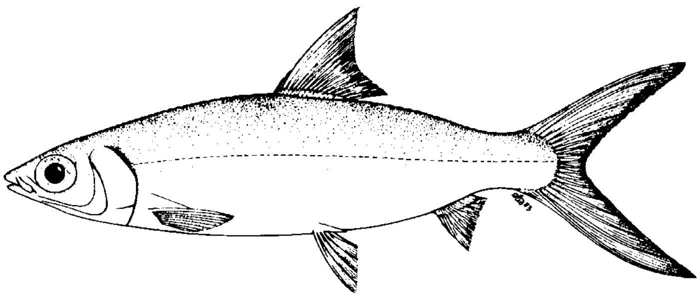


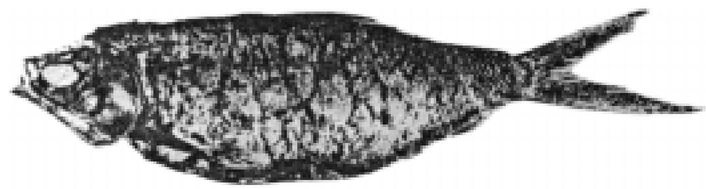
Records of occurrence of milkfish in the Indo-Pacific. The geographic range is limited to water temperatures greater than 20°C in the winter (dashed lines). Such warm water extends to temperate latitudes where there are major warm ocean currents (open arrows), but does not exist in tropical latitudes affected by cold ocean currents (dotted arrows). From Kumagai (1990) and Bagarinao (1994).

Only one milkfish

Chanos chanos (Forsskål, 1775) is the sole species in the Family Chanidae in the Order Gonorhynchiformes. It was first described as *Mugil chanos* by Petrus Forsskål in 1775, based on a juvenile specimen from the Red Sea. Lacepede used the name *Chanos arabicus* in 1803, and Klunzinger used the valid name *Chanos chanos* in 1871, since then followed by other authors.

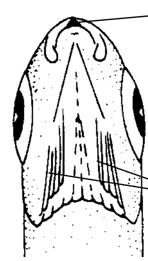
How exactly can we distinguish milkfish from other fishes? Here are the diagnostic characters of *Chanos chanos* according to Forsskål and the Food and Agriculture Organization of the United Nations.



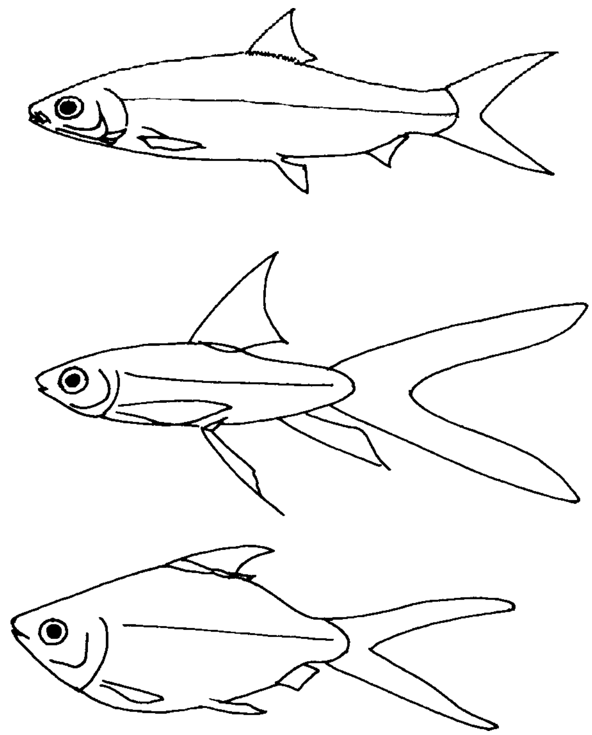


Dried-skin type specimen of milkfish at the Zoological Museum of Copenhagen. From Klausewitz and Nielsen (1965).

- Body elongate, moderately compressed, smooth, and streamlined
- Body color: silvery on belly and sides grading to olive-green or blue on back
- Dorsal, anal, and caudal fins pale or yellowish with dark margins
- Fins without spines
- A single dorsal fin with 13-17 rays, about midpoint of body
- Anal fin short, with 9-11 rays, close to the caudal fin
- Caudal fin large and deeply forked, with large scale flaps at the base in adults
- Pectoral fins low on body with axillary (inner basal) scales
- Pelvic fins abdominal in position, with axillary scales
- Scales small and smooth, 75-91 on lateral line
- No scutes (modified pointed scales) along the belly
- Transparent "adipose" tissue covers the eye
- Mouth small, terminal, without teeth
- Lower jaw with a small tubercle at tip, fitting into a notch in the upper jaw
- No bony gular plate between arms of lower jaw
- Only 4 branchiostegal rays supporting the underside of the gill covers
- Gill rakers fine and numerous
- Pair of pharyngeal sacs or epibranchial organs behind the gills
- Intermuscular bones long and numerous
- Peritoneum black
- Esophagus with spiral folds
- Stomach well developed, with a thick "gizzard" and many pyloric caeca
- Intestine very long and convoluted



Variant forms of milkfish occur but rarely. A goldfish-type specimen with distinctly elongated dorsal, pelvic and anal fins, and a caudal fin as long as the body was found in Iloilo, Philippines. Dwarf or hunchback shad-type specimens have been recorded in Hawaii, Indonesia, and Australia. A milkfish with red head, red fins and brilliant-blue dorsal surface was reported from Darwin Harbor in northern Australia.



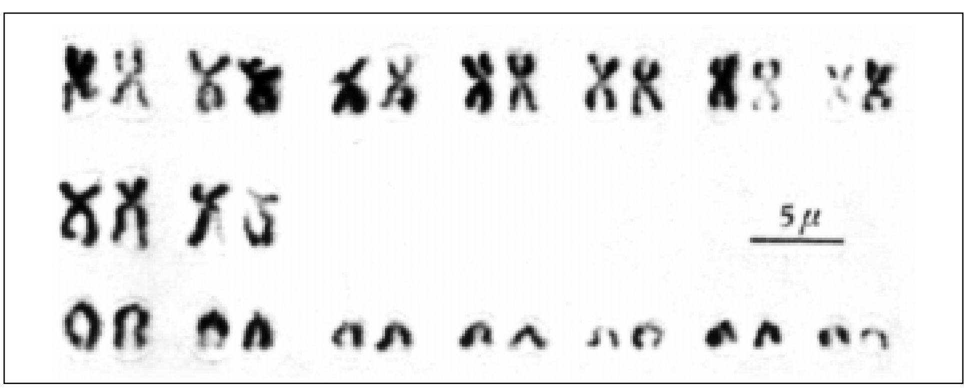
typical juvenile milkfish

goldfish-type juvenile

shad-type juvenile

From Bagarinao (1994).

Milkfish has a diploid chromosome number of 2n=32, consisting of seven pairs of metacentric, two pairs of submetacentric, and seven pairs of acrocentric chromosomes. Milkfish is considered a highly differentiated species despite its early origins or primitive phylogenetic status. A milkfish egg or sperm would have 16 chromosomes each.



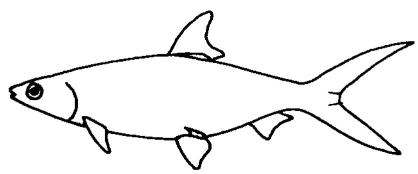
The chromosomes of milkfish at magnification x4870. From Arai et al. (1976).

Milkfish and other fishes of the Order Gonorhynchiformes are most closely related to the freshwater Ostariophysi – the carps, catfishes, loaches, and related forms that dominate freshwater habitats around the world.

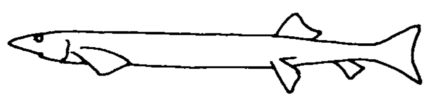
The earliest gonorhynchiform fossils were found in the Cretaceous deposits in Brazil and west Africa. Fossil *Chanos* were found in the freshwater Eocene deposits of Europe and North America. This fact suggests that milkfish originated in fresh waters about 40-50 million years ago, long after the dinosaurs all went extinct 65 million years ago. *Chanos* and *Gonorhynchus* probably invaded the circumtropical Tethys Sea during periods of high sea level and flooding of continents, at least after the Eocene. Global cooling in the middle Eocene caused the extinction of many tropical invertebrates and fishes particularly in the Atlantic. Both *Chanos* and *Gonorhynchus* disappeared from the Atlantic but persisted in the Indo-Pacific; the other gonorhynchiforms are now relict species in Africa.

At present, the Order Gonorhynchiformes includes four families, seven genera and 27 species. They share the following common characters, also present in milkfish: pharyngeal sacs, small mouth, toothless jaws, intermuscular bones, 5-7 hypural plates, and first three cervical vertebrae specialized and associated with one or more cephalic ribs.

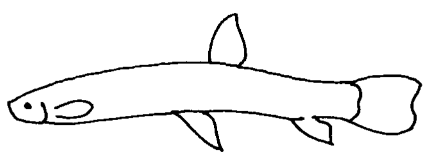
Chanidae
Chanos chanos
marine to freshwater, warm Indo-Pacific



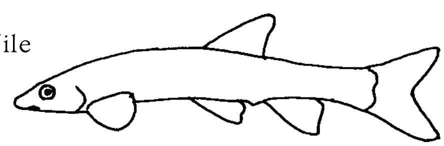
Gonorhynchidae
Gonorhynchus gonorhynchus
marine, cooler Indo-Pacific



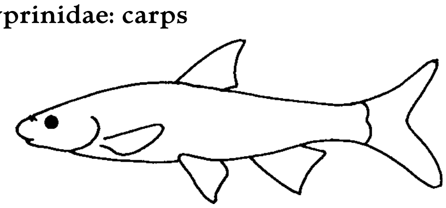
Phractolaemidae
Phractolaemus ansorgei
freshwater, tropical Africa



Kneriidae: 24 species
freshwater, tropical Africa and the Nile



Cyprinidae: carps



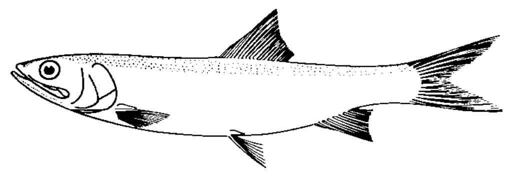
From Nelson (1994).

The early origin 40-50 million years ago and wide Indo-Pacific distribution of milkfish have led to genetic variation among milkfish populations in separate locations. Milkfish populations differ among the following areas: the Hawaiian islands, the central Pacific islands, Tonga, Tahiti, Philippines-Taiwan-Indonesia, Thailand-Malaysia, India, and Africa. Nevertheless, genetic divergence is low and milkfish populations are thought to be all potentially interbreeding, that is, all one species.

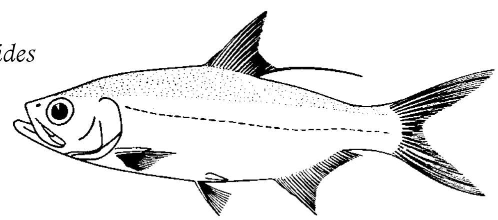
Although genetically one species, populations of milkfish may differ in reproductive and migratory behavior, tolerance to environmental factors, growth and survival, and in other aspects. In having high genetic variability within areas and low genetic differentiation between areas, milkfish is similar to many other commercial fishes.

But back to the practical task of picking out milkfish in the market for dinner or for a science project. How to distinguish milkfish from similar-looking silvery fish species in the Indo-Pacific?

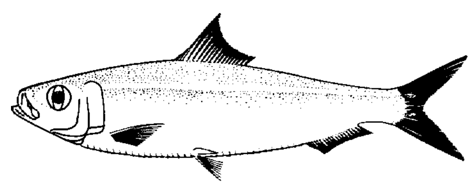
Tenpounder or *bidbid, Elops hawaiiensis*
Mouth much larger, maxilla reaching back behind eye. A bony gular plate present between arms of lower jaw.



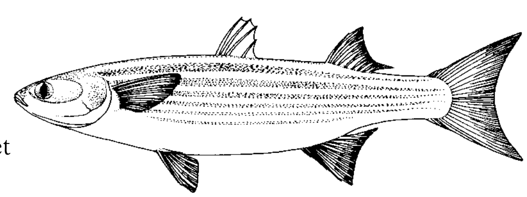
Tarpon or *buan-buan, Megalops cyprinoides*
Has a bony gular plate. Last dorsal fin ray filamentous. Scales large, 30-40 in lateral line.



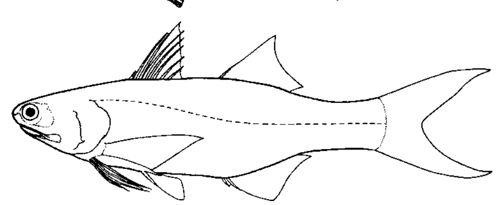
Sardines or *tamban, Sardinella* spp. etc.
Sizes much smaller. Usually 6-7 branchiostegal rays (only 4 in *Chanos*). No lateral line. Scutes usually present along belly.



Mullets or *banak, Lisa* spp., *Valamugil* spp., *Mugil cephalus*
Two short dorsal fins, the first one with 4 spines. Pectoral fins set high on body. No lateral line.



Threadfin, *Eleutheronema tetradactylum*
Snout projects forward of inferior mouth. Two dorsal fins. Pectoral fins with separate rays.



From Fischer and Whitehead (1974)

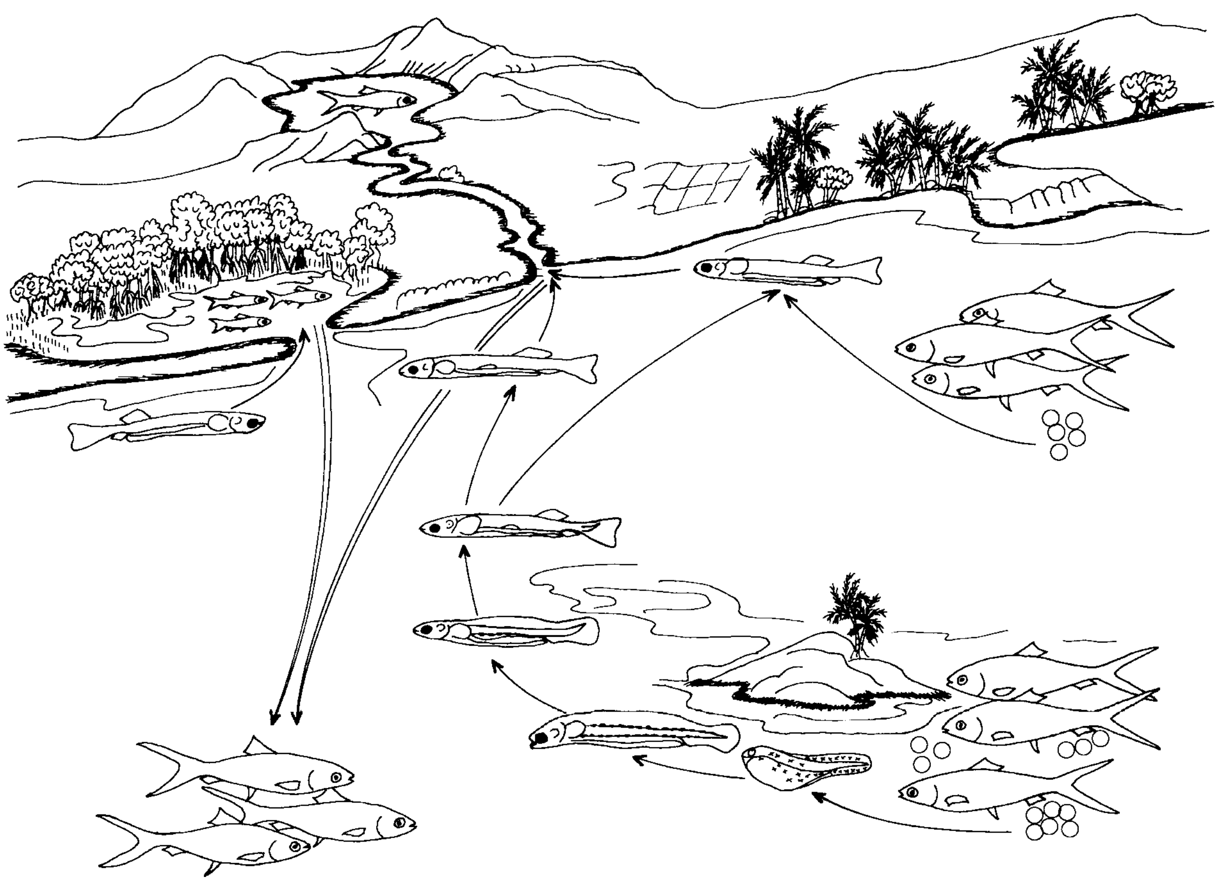
Chapter 2

Milkfish in Nature

The fish life cycle generally consists of four stages: egg, larva, juvenile, and adult, with a sub-adult stage in species with long life spans. Milkfish, like most fishes, go through indirect development and complete metamorphosis, in which eggs hatch into larvae that look very different from the adults.

Milkfish is a large, long-lived species, and its habitat, behavior, and food habits change with size and stage in the life cycle. Milkfish in the wild migrate from one habitat to another. Adults spawn at sea, the larvae migrate inshore, juveniles settle in shallow-water habitats, and large juveniles and sub-adults return to sea. Little is known about the actual movements, particularly during the period after the juveniles leave the nursery grounds, and the period after the spawning of adults at sea.

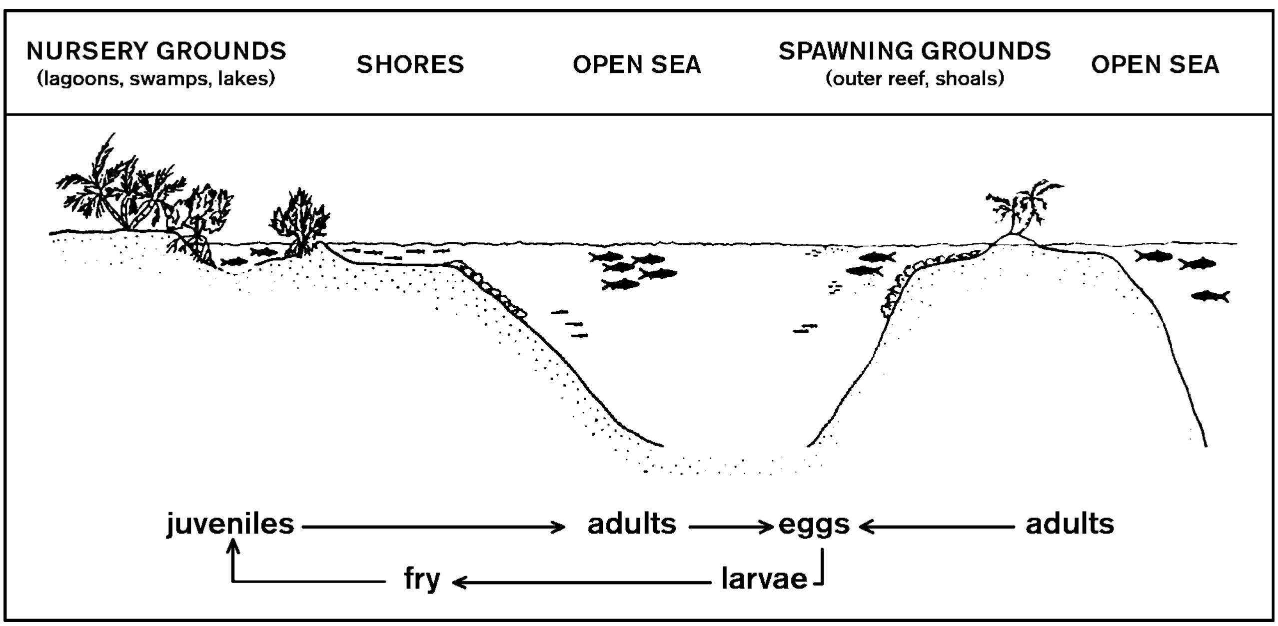
To ensure the survival of milkfish populations in the wild, coral reefs, beaches, mangrove swamps, estuaries, rivers, and lakes must be protected.



From Bagarinao (1994).

Summary of life history data

	Adults ->	**Eggs ->**	**Larvae ->**	**Fry/Transform ->**	**Juveniles ->**	**Sub-adults**
Size	50-150 cm Tl	dia 1.1-1.3mm	3.5 mm at hatch to 16 mm TL	10-16 mm TL 15-20 mm TL	2-50 cm TL	50-70 cm TL
Duration, age	5-20 years	1 day	1-21 days	2-4 weeks	1-12 months	1-5 years
Habit	pelagic, schooling	pelagic	pelagic	pelagic to demersal, schooling	demersal, schooling	pelagic schooling
Habitat	open sea, coasts, near reefs	open sea, near reefs	open sea, near reefs	shore waters, surf zone, coastal wetlands	shallow food-rich coastal wetlands, ponds	large lagoons, freshwater lakes, open sea
Feeding Habits, food	fish larvae zooplankton algae, diatoms small benthos pellets	yolk	zooplankton diatoms fine feeds	zooplankton diatoms small benthos fine feeds	microbial mat diatoms, algae detritus zooplankton small benthos pellets	microbial mat diatoms, algae zooplankton benthos detritus pellets



From Buri et al. (1981)

Sub-adults (sabalo, lumulukso)

Sub-adult milkfish or *sabalo* used to inhabit Laguna de Bay, Naujan Lake, Taal Lake, and other freshwater lakes in the Philippines. During their downriver migration, they used to get caught in the tight maze of fish corrals set across the lake outlet or river. Migrating milkfish were called *lumulukso* because of the astonishing jumps they made when trying to escape. But the major rivers and lakes in the country are no longer clean nor freely navigable and upstream migration is no longer possible. As early as the 1920s, Laguna de Bay was already polluted and the Pasig River had so many boats that milkfish no longer came in.

Taal Lake in Batangas used to be populated by large numbers of sub-adult milkfish that were caught with several other migratory fishes in fish corrals or *baklad* (made of bamboo poles and sidings) set across Pansipit River. Catches of migratory fishes have declined and *baklad* Pansipit has been prohibited. Taal Lake is now full of tilapia and catches of the endemic *Sardinella tawilis* have also declined.

Monthly average number of migratory fishes caught by *baklad* Pansipit during the months that they occurred. Numbers in parentheses are totals for the species for the year. From Villadolid (1936).

Year	Mullets (*banak*)		*Caranx marginatus* (muslo)	*Caranx ignobilis* (maliputo)	*Caranx* sp. (manipis)	*Anguilla mauritiana* (igat)	*Chanos chanos* (lumulukso)	
1888	1,888	(3,788)	16,283	928	8,844	-	786	(7,079)
1889	4,200	(8,370)	12,369	1,474	10,630	-	1,520	(10,750)
1890	1,057	(3,641)	14,405	611	4,225	-	1,601	(14,406)
1926	200	(476)	9,082	342	428	7	353	(962)
1927	311	(920)	7,244	372	2,886	7	334	(2,105)
			(86,927)	(2,605)				
1933	527	(3,356)	5,969	207	1,107	199	420	(2,946)
1934	117	(734)	6,688	416	999	268	530	(5,841)
			(80,256)	(3,333)				

Taal Lake seen from the north shore. Tilapia cage farming is an established business in the lake. Milkfish have begun to be grown in cages in Taal as well.

Similarly, annual catches in Butas River leaving Naujan Lake in Mindoro have declined since 1958. Milkfish left the lake throughout the year, but the peak migration was in August-December. Milkfish in the lake measured about 3-4 kg, 60-70 cm long, and were sexually immature. The fish apparently reach sexual maturity after a relatively short period at sea; milkfish 4-9 kg, 80-100 cm, caught just offshore of Naujan are sexually mature.

Volume of migratory fishes caught by fish corrals from Lumangbayan-Butas River, the outlet of Naujan Lake in Mindoro. Data from Delmendo & Angeles (1971), Reyes (1978), and Mercene & Alzona (1984).

Year	Mullets (kg)	*Caranx marginatus* (kg)	*Lutjanus malabaricus* (kg)	*Lutjanus argentima-culatus* (kg)	*Chanos chanos* (kg, no.)		*Anguilla, Scatophagus* etc. (kg)
1958	121,538	1,977	6,908	4	23,898	(6,216)	3,436
1959	48,215	10,203	5,228	1,029	22,708	(8,145)	3,427
1960	112,324	12,286	1,912	2,246	62,826	(19,440)	1,788
1961	28,447	10,333	3,178	4,534	32,143	(22,257)	1,472
1962	8,544	15,690	3,448	3,061	49,718	(21,785)	1,481
1966	31,680	17,581	4,845	41,918	2,720		
1967	4,244	6,692	5,080	29,025	755		
1977	39,550	12,835	2,772	4,674	2,571	(537)	104
1978	36,070	3,146	5,955	13,525	1,625	(335)	849
1982-83	2,268	546	721	649	12,160	482	

Recent fisheries statistics record no more *sabalo* but only juvenile milkfish in lakes, mostly escapees from fish pens and cages destroyed by storms. Some 1,000-5,000 mt of *bangus* and as much as 18,000-24,000 mt of tilapias were taken by the inland municipal fisheries in Laguna de Bay, Naujan Lake, Taal Lake, and other lakes in the country in 1985-1995.

Butas River

Naujan Lake from the south shore

Adults (sabalo)

Adult milkfish are called *sabalo* in Tagalog or *awa* in Cebuano. *Sabalo* have a silvery, muscular, streamlined body and a large forked tail, typical of a pelagic migratory fish. Wild *sabalo* measure 50-150 cm total length and 5-18 kg body weight, and may be 5-20 years old.

Sabalo are swift and powerful swimmers in the open sea. They may be seen in small to large groups or 'schools' along the coast and around islands where coral reefs are well developed. They often swim with dorsal fins or caudal fins sticking out of the water like sharks, and with much jumping around. *Sabalo* are extremely wary and very capable of defending themselves. When a *sabalo* is hooked, it makes repeated runs at tremendous speed; when it is speared, it can tow a fisherman for some minutes. Adult milkfish is considered "the most powerful fish in Palau."

Fishing for *sabalo* larger than 60 cm has been prohibited in the Philippines since 1975 in a government effort to protect the spawning stocks that produce the seed postlarvae. *Sabalo* are incidentally caught in fishing gear used for other coastal fishes. Before the ban, 3,418 *sabalo* were caught by fish corrals in Morong, Bataan in 1952. Fish corrals and the Japanese all-nylon equivalent *otoshi-ami* both have long barrier fences that block fish that are swimming and perhaps migrating along the coast. Trapped in fish corrals, the *sabalo* struggle violently when the net closes in. They often jump out of the bag, sometimes with enough power to hurl the 5-8 kg fish to a height of 8 meters and a horizontal distance of 10 meters.

Sabalo *caught in fish corrals struggle violently.*

Fisheries statistics in 1985-1995 recorded 6-64 mt of milkfish (*sabalo*) from the commercial marine fishery, i.e., boats greater than 3 gross tons operating more than 7 km offshore. Fishermen who incidentally catch *sabalo* do not set them free, thinking (perhaps correctly) that the fish are stressed and will die anyway. The ban against catching *sabalo* is reinforced under the Philippine Fisheries Code of 1998. Violations are punishable by imprisonment for 6 months to 8 yr, and/or a fine of P80,000, forfeiture of the catch and fishing equipment used, and revocation of the fishing license.

As a result of the ban, the fishermen refuse to provide information, and not much is known about *sabalo* populations and movements at sea. As a result of the illegal fishing, the *sabalo* stocks and the *semilya* fishery may be depleted without researchers and government doing something effective about the problem.

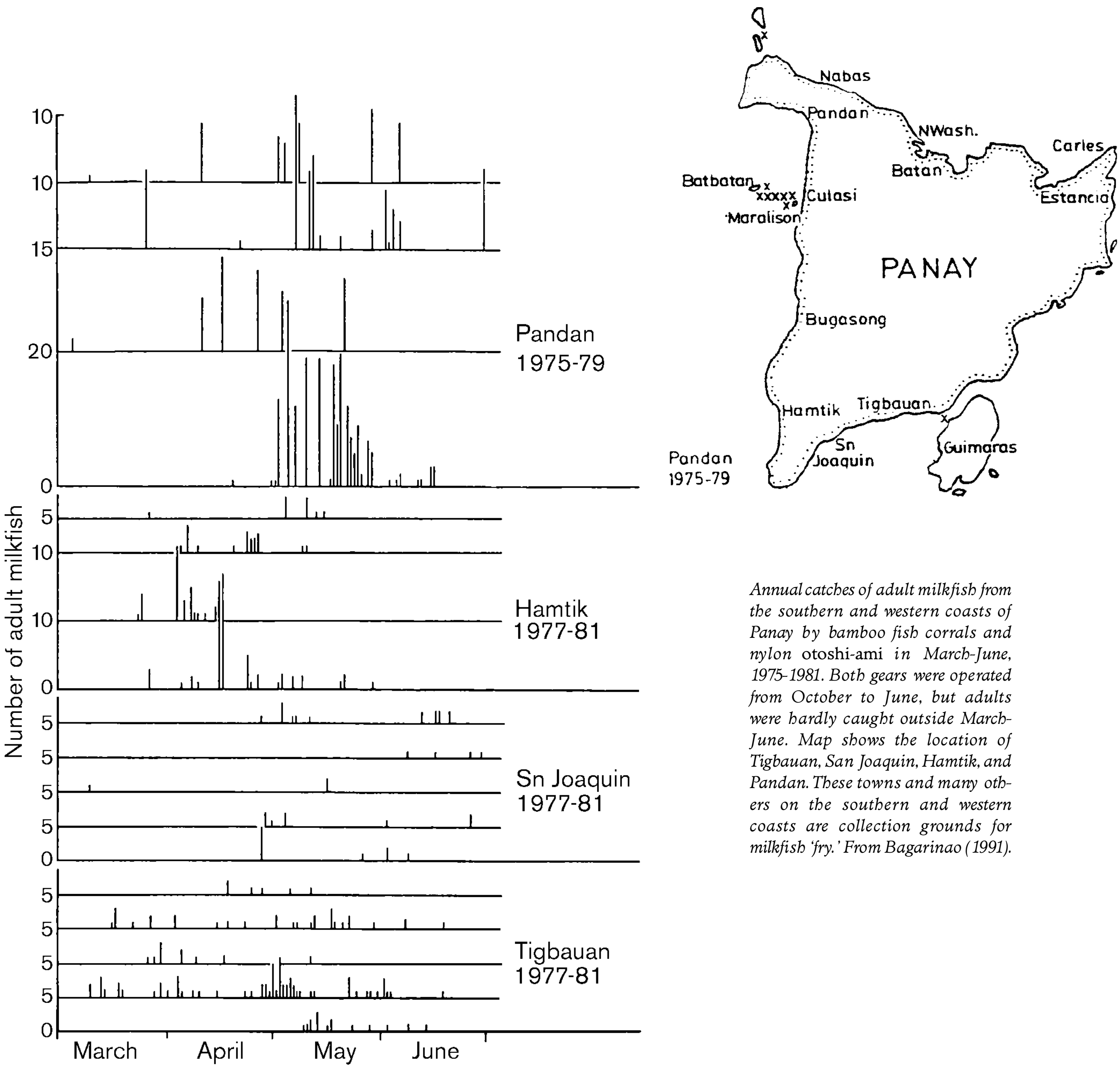
Small fisheries targeting adult and juvenile milkfish have been reported in India, the Red Sea, Madagascar, Indonesia, Mexico, and the Pacific islands.

Fish corral, Tigbauan, 1998.

Otoshi-ami in Naujan Bay, Mindoro, 1983.

Sabalo were caught by the SEAFDEC Aquaculture Department for research purposes in 1975-1979 from around the southern and western coasts of Panay Island. These catches provided the little information available about *sabalo* in Philippine seas. These wild *sabalo* were also used in the induced spawning experiments that started off the development of milkfish hatcheries.

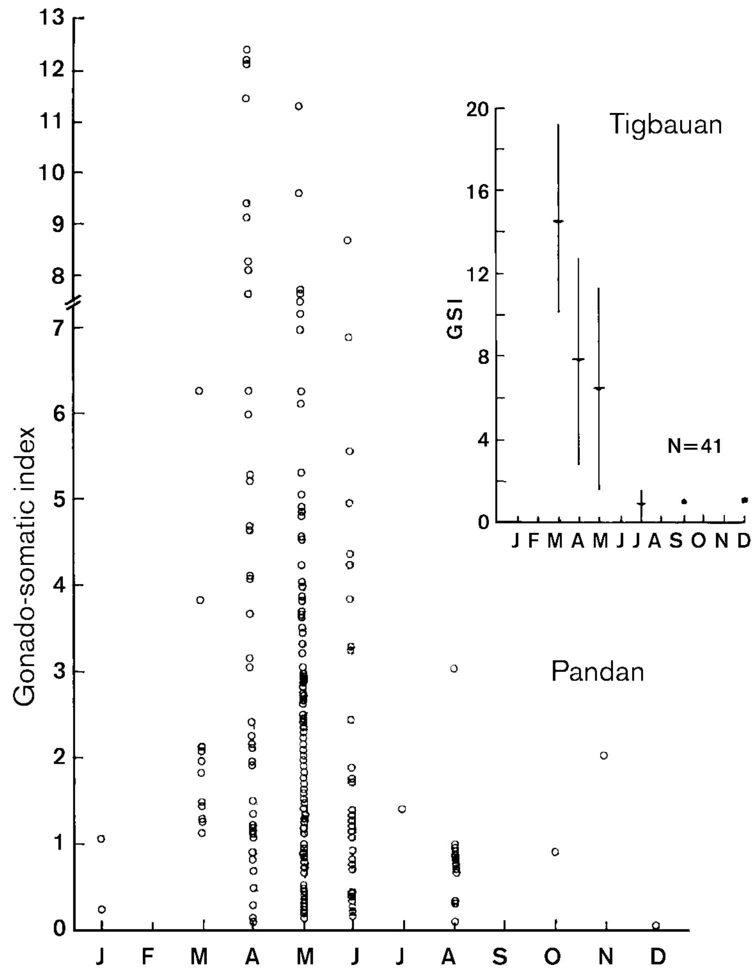
The *sabalo* were caught in fish corrals in Tigbauan, San Joaquin and Hamtik and in the *otoshi-ami* in Pandan Bay, presumably during their coastal spawning migration. The *sabalo* appeared in Tigbauan in March and were caught in small numbers through June. In Hamtik, *sabalo* showed up mostly in April. *Sabalo* catches were highest in Pandan and especially in May.



Annual catches of adult milkfish from the southern and western coasts of Panay by bamboo fish corrals and nylon otoshi-ami *in March-June, 1975-1981. Both gears were operated from October to June, but adults were hardly caught outside March-June. Map shows the location of Tigbauan, San Joaquin, Hamtik, and Pandan. These towns and many others on the southern and western coasts are collection grounds for milkfish 'fry.' From Bagarinao (1991).*

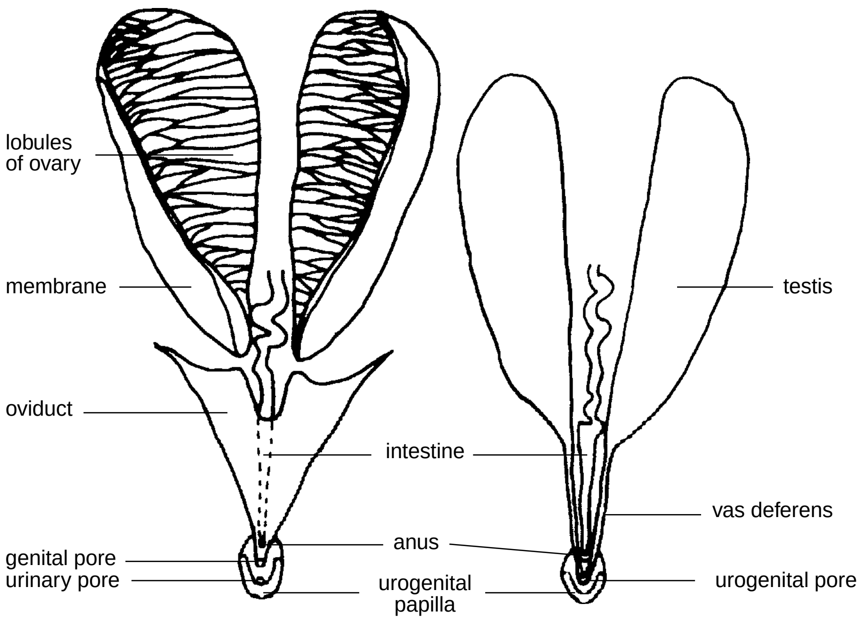
The *sabalo* caught off Tigbauan and Pandan in 1976-1977 were 80-120 cm long, 5-9 kg in total weight, and had gonads (ovaries and testes) ranging from undeveloped to very large, up to 20% of body weight. Off Pandan, *sabalo* had the largest (mature) gonads in April-May, and more 'spent' fish in May-June ('spent' fish had just spawned and had gonads less than 5% of body weight). Off Tigbauan, *sabalo* had the largest gonads in March and spent fish become more frequent in April-May.

Seasonal pattern in the gonadosomatic index (ovary weight as percent of total body weight) of female milkfish in Pandan and Tigbauan in 1976-77. From Bagarinao (1991).



Wild sabalo *from Pandan, 1976.*

Male and female milkfish are separate but look nearly identical. Females have three pores in the urogenital area, and males have two. The left and right gonads are similarly developed. The ovaries are half-exposed to the abdominal cavity, and the testes are covered by a smooth tunica.



Pair of milkfish ovaries, with the rest of the reproductive system, and the three pores in the urogenital area of females.

Pair of milkfish testes, and the rest of the reproductive system, and the two pores in the urogenital area of males.

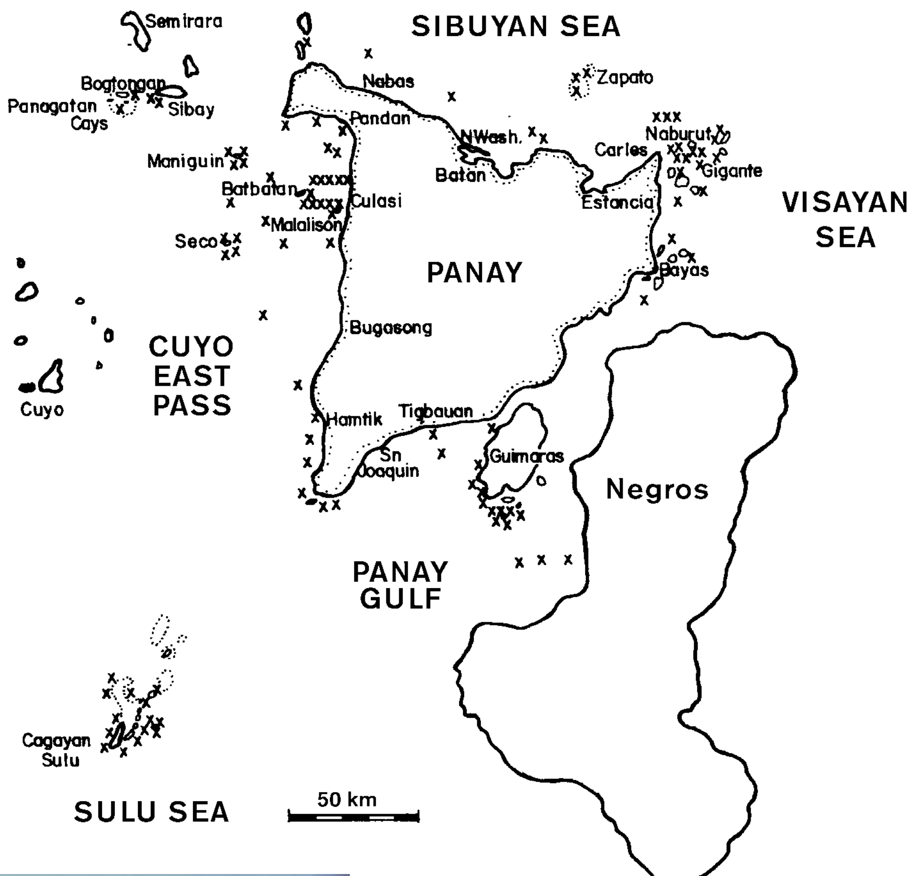
Adult milkfish from Pandan Bay, 1975. Note size of ovaries (immature and maturing).

Mature ovaries can be 10-25% of the body weight of females.

Spawning grounds of milkfish were located by towing plankton nets at many locations around Panay Island. Some 1,898 tows made in 1976-1980 yielded 1,694 milkfish eggs in March-June, the most eggs in April.

These eggs were collected from around Maniguin Island, Seco Island, Batbatan Island, and Maralison Island off Antique, around the Cagayan Sulu Islands in the Sulu Sea, and Zapato Island off Capiz. In April-May 1980, intensive plankton sampling in the waters of Maralison, Batbatan, and Culasi on the west coast of Panay indicated that milkfish spawned on the coral reefs west of Maralison Island and some of the eggs drifted north with the current along the coast.

Plankton samples were taken from stations marked x. Milkfish eggs were found around Maralison, Batbatan, Seco, and Maniguin islands off Antique, around Zapato Island in the Sibuyan Sea, and around the Cagayan Sulu islands in the Sulu Sea. From Bagarinao (1991).



Maralison Island from the air, with the fringing reef shown.

The coral reefs of Maralison are milkfish spawning grounds.

Thus, milkfish spawn offshore in clean, clear, fully saline, warm (25-30°C), shallow (<200 m) waters over sand or coral reefs, within a few kilometers of shore or around small islands. Eggs are spawned over water deep enough to minimize predation by plankton-eaters like coral polyps, and near enough to the coast to assure the return of larvae inshore.

Spawning of milkfish is seasonal. The spawning season at sea is longest near the equator (8-12 months, for example in Java) and becomes shorter with latitude up to 20° north or south (5 months, for example in Taiwan and Hawaii). In places with long seasons, there may be a marked spring peak and a minor fall peak. Seasons are more or less the same in the wild and in captivity.

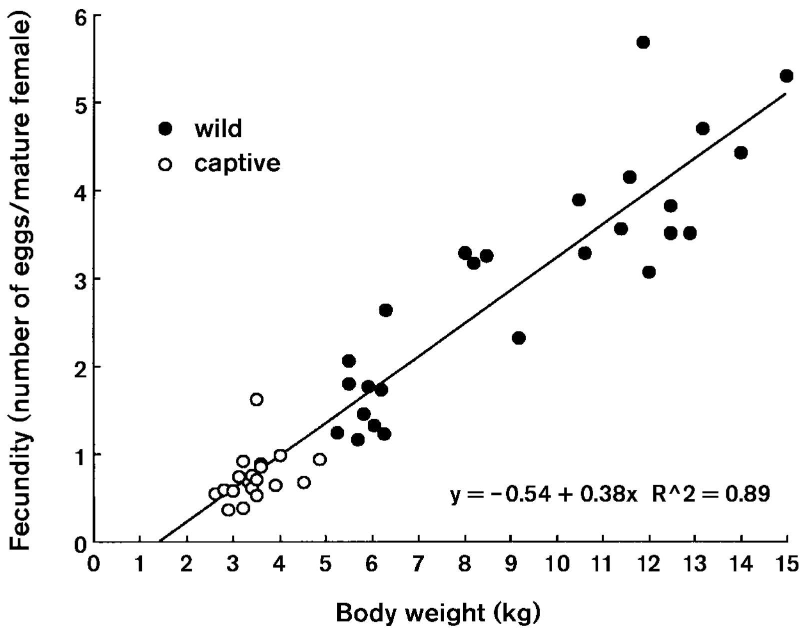
Spawning seasons of milkfish in different localities (various authors). From Bagarinao (1991).

Locality	Basis of estimate	Season	Peaks
Taiwan			
Tungkang, 22°N	High GSI, yolky oocytes	May-Aug	July
Ponds	Spawning of broodstock	Apr-Sep	May
Hawaii			
Oahu, 20°N	High GSI, yolky oocytes	Jun-Aug	July
Tanks	Spawning of broodstock	Mar-Sep	
Philippines			
Panay, 11-12°N	Egg collection, high GSI, and fry occurrence pattern	Mar-Nov	Apr, Sep
Igang, cages	Spawning of broodstock	Apr-Oct	May-Jul, Sep-Oct
Tigbauan, tanks	Spawning of broodstock	Apr-Oct	
Indonesia			
Java, 7-8°S	Egg collection, high adult GSI	Jan-Dec	Sep, Apr
Gondol, Bali, tanks	Spawning of broodstock	Jan-Oct	
India			
Mandapam, 9°N	Fry and fingerling occurrence	Mar-Nov	Apr, Sep
Pichavaram, 12°N	Juvenile recruitment	Jan-Sep	

Milkfish spawning has never been directly observed at sea, although fishermen in the Philippines and in Palau report schools of milkfish massing together at certain areas in the reefs or lagoon at particular times. Off Antique, spawning occurs around midnight, based on the developmental stages of eggs collected in plankton net tows. More milkfish spawn during the first and last quarter moon than during the full and new moon.

Females produce large numbers of eggs; mature ones have ovaries that weigh 10-25% of body weight. Fecundity increases with body weight; females 3-14 kg in weight produce 0.5-6 million eggs per fish or about 380,000 eggs/kg body weight. Captive females may produce more eggs than wild females of similar size; for example, broodstock of average weight 6.6 kg spawned 3.5 million eggs each or 535,000 eggs/kg. One female may spawn up to 3-4 times a year.

Fecundity of both wild and captive milkfish increases with body weight. From Bagarinao (1991).



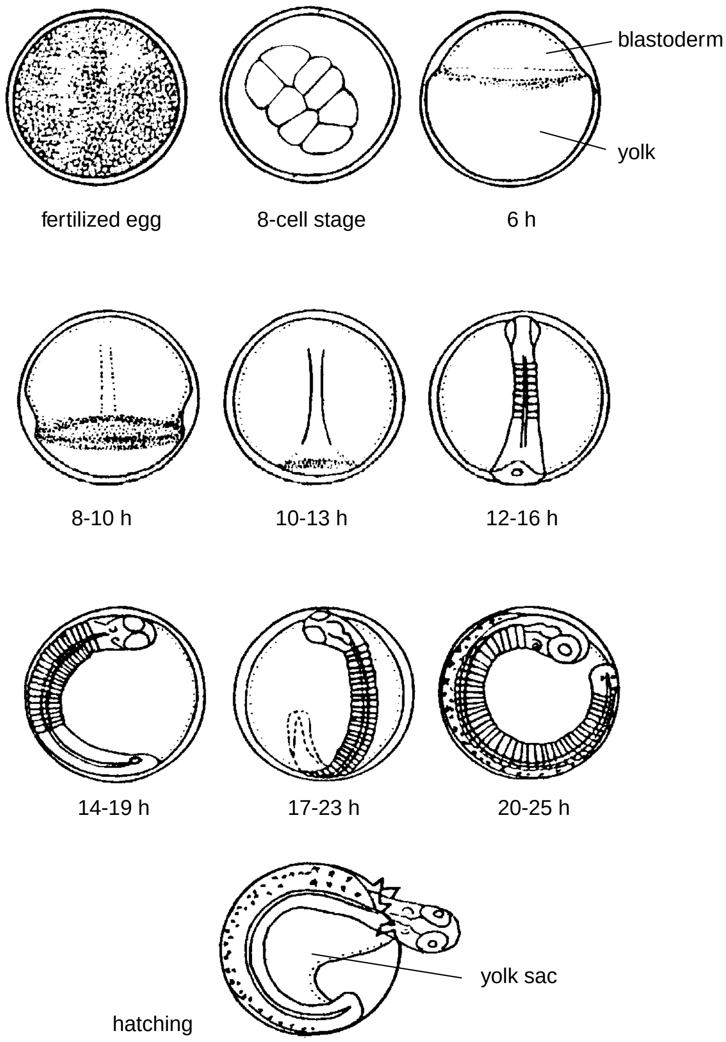
Sabalo graze on epiphytic algae and bottom-living cyanobacteria and small animals. They also swim through plankton masses, eating juvenile sardines and anchovies, copepods, small shrimps, and a variety of other zooplankton. On the other hand, *sabalo* at sea probably fall prey to sharks, but not very many other predators, given their large size, swimming ability, and schooling habit.

Gut of adult milkfish full of larval and juvenile sardines.

Eggs and embryos

Milkfish eggs at sea float mostly in the top one meter of the water column (pelagic) and are carried by the currents and waves (planktonic). Fertilized milkfish eggs are discrete, spherical, 1.1-1.3 mm in diameter, with finely granulated yolk, no oil globule, narrow perivitelline space, and no structures on the egg envelope.

Embryonic development takes about 24 hours in seawater of 26-28°C, but hatching can be hastened in warmer water and delayed in colder water.



Fertilized eggs of milkfish, showing embryonic development and hatching. Embryos are curled in the C-position at 14-19 hours after fertilization, when the head, eye vesicles, and ear vesicles have differentiated, and 19-20 somites are visible. From Bagarinao (1991).

Blastoderm covers 2/3 of the yolk. 8-10 hours.

Embryo with 9-10 somites; optic vesicles appear. 11-16 hours.

Embryo curled in C-position. 14-19 hours.

Tail of embryo starts to separate from the yolk. 17-25 hours.

Plankton net tows around Panay Island in 1976-1979 and particularly off Culasi, Antique in 1976-1980 yielded 1,694 eggs in 188 positive tows (those with milkfish eggs) out of a total 1,898 tows. These tows also caught milkfish larvae, as well as the eggs and larvae of many other marine fishes.

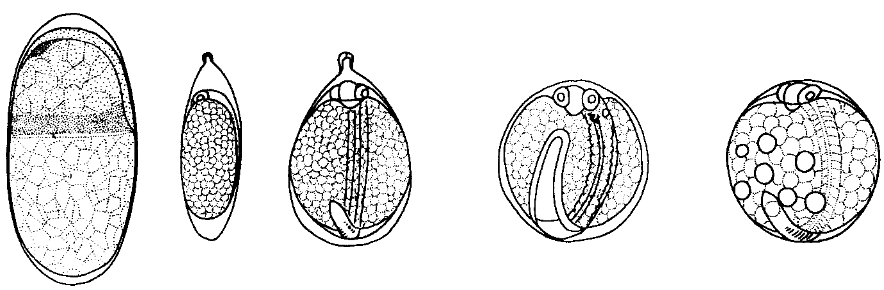
Collection of milkfish eggs from waters around Panay, and especially off Antique in 1976-1980. Data from Senta et al. (1980) and Kumagai (1990).

Month	Around Panay 1976-1979			Maralison-Culasi Apr-May 1980		
	Tows	Eggs	Eggs/tow	Tows	Eggs	Eggs/tow
Feb	25	0	0			
Mar	160	72	0.5			
Apr	443	323	0.7	315	631	2.0
May	416	123	0.3	279	518	1.9
Jun	196	26	0.1			
Jul	4	0	0			
Aug	22	0	0			
Sep	10	0	0			
Oct	23	1	0			
Nov	5	0	0			
Total	1304	545	0.4	594	1149	1.9
	positive 91		**6.0**	**positive 97**		**11.8**

SEAFDEC research vessels for plankton surveys, 1976-80.

It takes some time and skill to identify milkfish eggs in plankton samples from the open sea. The characteristics useful for identification of marine fish eggs are shown below; asterisks* indicate those true of milkfish. Milkfish eggs share many characters with many other pelagic marine fish eggs, but are among the few that are larger than 1 mm in diameter and have no oil globule.

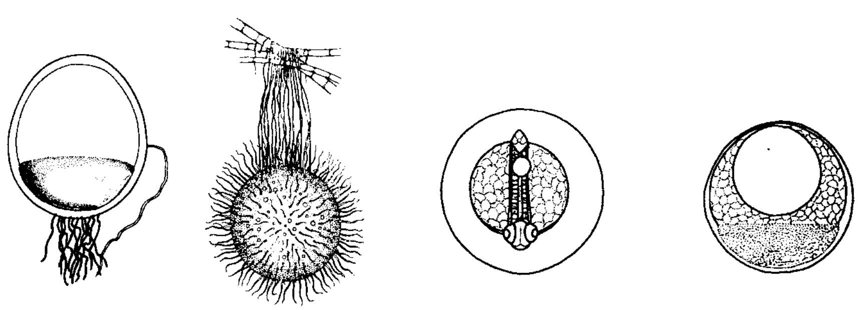
- Diameter of egg and yolk
  - Pelagic* (suspended in water column) or demersal (sinks)
    - Discrete* or massed (sticky)
      - Spherical* or ellipsoid
        - Oil globule absent* or present
          - Perivitelline space narrow* or wide
            - Egg envelope smooth* or ornamented
              - Yolk finely granulated* or non-granulated
                - Larva with <45 myotomes* or >50 myotomes at hatching
                  - Pigments on finfold, body, gut



Pelagic, discrete, ellipsoid eggs without oil globules

Spherical egg with narrow perivitelline space without oil globules

Spherical egg with many oil globules



Adhesive demersal eggs with tendrils on egg envelope

Egg with wide perivitelline space

Egg with one large oil globule

Variety in marine fish eggs. From Moser et al. (1984).

Larvae

Newly hatched milkfish larvae measure 3.5 mm in total length, have a large yolk sac, unpigmented eyes, and no mouth. Egg size, larval size at hatching, amount of yolk, and initial mouth size are greater in milkfish than in many other tropical marine fishes, a size advantage that determines in part the relatively high survival and the abundance of milkfish larvae in the wild.

The morphological and behavioral development of milkfish larvae proceeds in stages, defined and illustrated here.

Stage I. Yolk sac larvae: TL 3.5-5.4 mm

Yolk present. Finfold pigmented except at the tail. Larvae sink slowly in the water column, head down, and intermittently jerk around and swim up. 3 days.

Stage II. Pre-flexion larvae: TL 5.0-6.2 mm

Yolk absent. Eyes fully pigmented. Mouth open and larvae begin to feed. Notochord tip straight. No pigments on finfold. Two lines of pigments dorsal and ventral to the trunk from behind the head to the caudal peduncle. Pectoral fins present. Larvae keep horizontal position in the water column and react to light and currents. 5 days.

Stage III. Flexion larvae: TL 5.4-10 mm

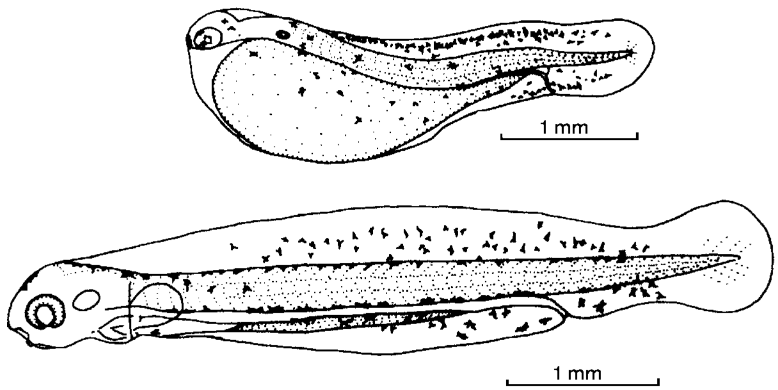
Notochord tip flexed. Finfold differentiated into dorsal, anal, and caudal fins. The line of pigments dorsal to the trunk becomes indistinct. Another line of pigments develops ventral to the abdomen starting at the throat. Pigments develop on the caudal fin rays. Larvae are transparent except for the eyes. Larvae begin to school; phototaxis and rheotaxis become stronger. 6 days.

Stage IV. Post-flexion larvae or 'fry': TL 10-17 mm

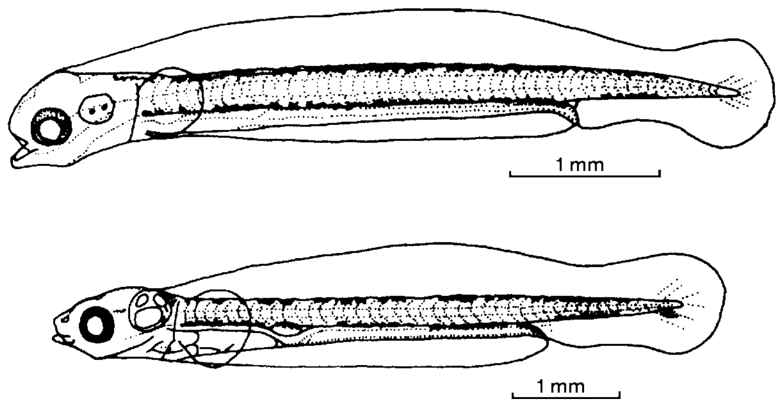
Vertebral column completely ossified. Caudal fin forked. Dorsal finfold disappears. Adult complement of fin rays present. Pigments widely spaced along the dorsal contour except the fin. Line of pigments on the abdomen more than half-way along intestine length. Larvae very transparent and react instantly to external stimulation. Highly resistant to sunlight exposure, salinity changes, crowding, and even injury. 7 days.

Stage V. Metamorphosis or transition stage: TL 15-20 mm

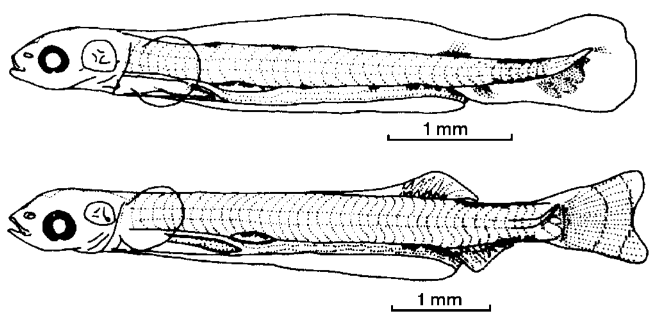
Pelvic fins develop and ventral finfold recedes. Peritoneum silvery. Body covered with pigments, densest dorsally. A line of pigments develops on the sides (medio-laterally) from the caudal peduncle towards the front. Scales develop about a month from fry stage or capture from shore waters. Fish begin to feed on the bottom and form more cohesive schools. 2-4 weeks.



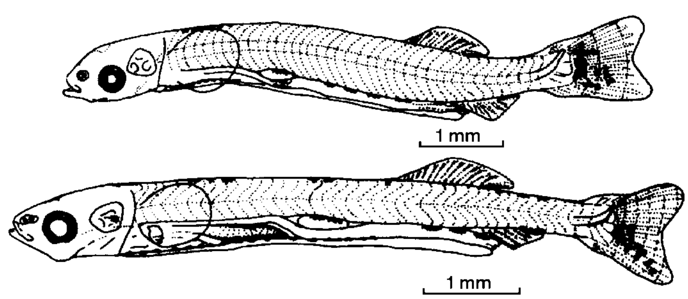
Stage I. Yolk sac larvae



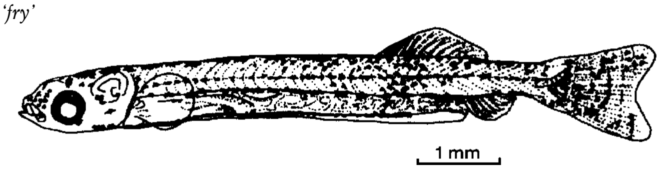
Stage II. Pre-flexion larvae



Stage III. Flexion larvae



Stage IV. Post-flexion larvae or 'fry'



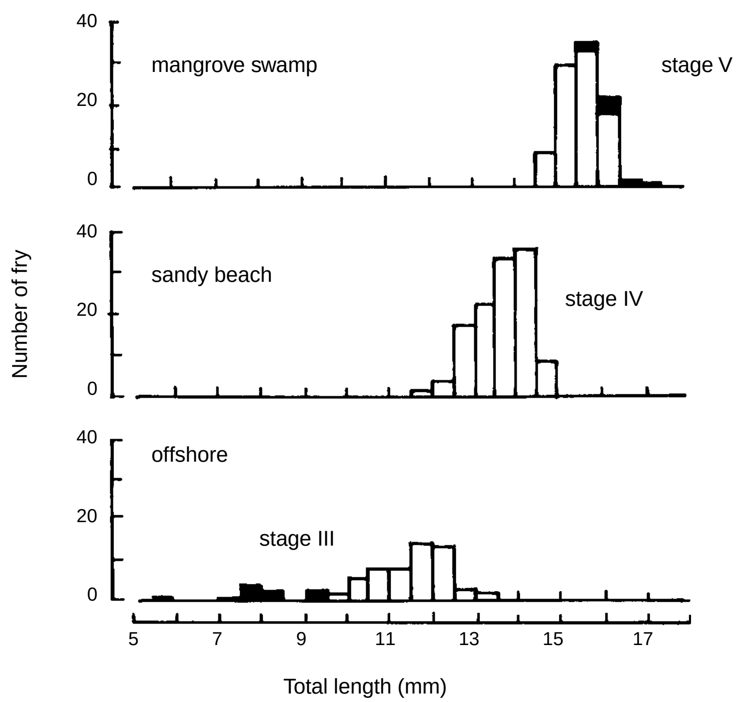
Stage V. Metamorphosis or transition stage *From Kumagai (1990).*

Larvae begin to feed when the eyes are fully pigmented, the mouth is open, and the yolk is nearly all used up. Larvae catch zooplankton by means of vision. Diatoms and copepods are the staple food of fish larvae at sea. Over the following two weeks, milkfish larvae develop stronger skeletons and fins and the ability to maintain position in the water column and even swim against weak currents. Younger larvae less than 10 mm long travel with the plankton that are carried around by wind and water currents at sea.

Larvae of stages I to IV have been collected from the open sea by plankton net tows. Off western Panay, 71 milkfish larvae 3-17 mm long were collected from stations 5-325 m deep and 0.1-6 km offshore. The distribution of the larvae change with developmental stage. Yolk-sac, pre-flexion, and flexion larvae occur both far and near shore, mostly near the surface but also at 20-30 meters deep; post-flexion larvae occur only near the surface and only near shore.

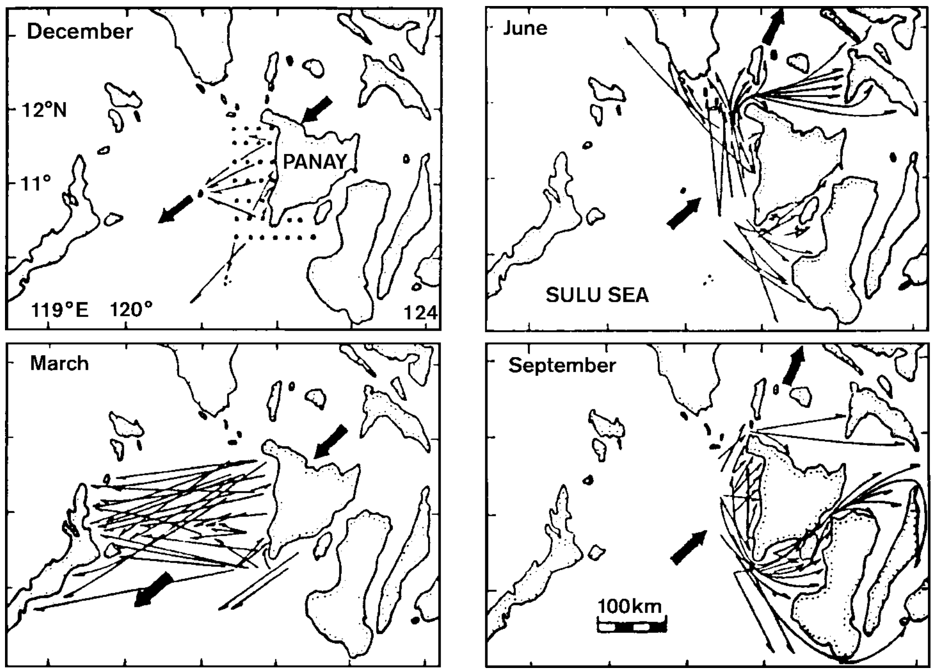
About 1,500 milkfish larvae 5.8-14.6 mm long were also obtained with a plankton net attached to the cod end of an *otoshi-ami* set offshore in 30-meter deep water in Pandan, Antique in 1976-77. During this sampling for larvae in the *otoshi-ami*, simultaneous sampling was done at the surf zone. Greater numbers of younger milkfish larvae occurred offshore and these during periods before the new moon and full moon. Greater numbers of older milkfish larvae occurred at the surf zone after the new moon and full moon.

The size distribution of milkfish in offshore waters, surf zone, and inland waters indicates migration of larvae inshore. These migrating larvae use both passive transport via surface or subsurface currents and active swimming, the latter possible only at 10 mm total length and two weeks of age, that is, the fry stage.



Size distribution of milkfish in three habitats: 500 m offshore near a coral reef, surf zone of a sandy beach, and mangrove swamp. Younger stage III larvae occur with stage IV fry (open bars) off the reef. Only Stage IV fry occur at the surf zone. Stage V milkfish are found only in the mangrove swamp. From Kumagai (1990).

The mechanism of larval transport from the spawning grounds to the fry collection grounds is not well understood. Drift cards released and recovered off Antique, a productive collection ground, indicate that the surface currents, and probably larval transport, are strongly affected by the prevailing winds. In March and April when the surface currents flow generally away from the coast, milkfish *semilya* appear along the Antique coast; in June-October, the currents flow north along the coast and the *semilya* continue to be available at the collection grounds.



Sea surface currents off western and southern Panay as determined by drift cards released and recovered over four quarters in 1977-1978. The trajectories are shown by the thin arrows, and the prevailing winds by the bold arrows. Larval transport is likely aided by the sea surface currents and the resulting subsurface currents. From Kumagai and Bagarinao (1979).

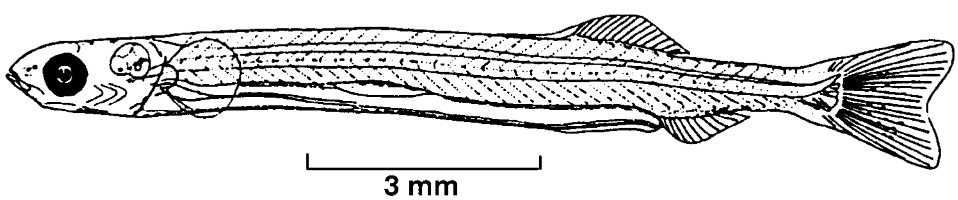
Plankton sampling off Antique indicated that young milkfish larvae offshore may be in subsurface waters and may then be carried inshore as surface waters move offshore – in some sort of upwelling effect. Perhaps this upwelling effect explains why most milkfish fry grounds are on the west coast of islands, the prevailing winds in the Philippines being from the east or northeast.

Milkfish larvae are just one component of the highly diverse plankton community in tropical seas. In Pandan Bay, some 120 other species of fish larvae occur with milkfish at the offshore station and 70 species at the surf zone, with about 60 species common to both stations. Many of these other species are also migratory during the life cycle and occupy the same nursery grounds as milkfish. Many of them are also caught and wasted during milkfish fry gathering (see Chapter 3).

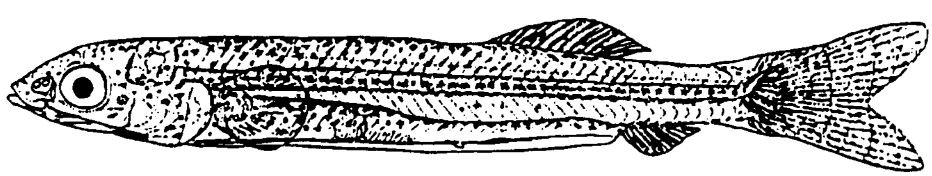
'Fry' and metamorphosis

Milkfish 'fry' or 'seed' (*semilya* in Tagalog and Cebuano, *kawag-kawag* in Ilonggo) are post-flexion larvae approaching metamorphosis and the end of the pelagic interval. Those caught in the surf zone and shore waters in the Philippines, Taiwan, Japan, and elsewhere are all 10-17 mm long, 14-29 days old (average 13-14 mm, 20 days). These 'fry' are on their way to inland nursery grounds.

Metamorphosis in milkfish involves morphological, physiological and behavioral changes that happen over 2-4 weeks. The transparent surface-swimming larvae change into pigmented (dark above and silvery below) bottom-living juveniles. The ventral finfold disappears, the pelvic fins appear, and scales develop. The skeleton ossifies completely. The eyes become more sensitive in the dark. The fish begin to feed on bottom organisms, whatever is abundant in the habitat. Metamorphosing milkfish have been collected with juveniles only from coastal wetlands.



Milkfish 'fry' from shore waters, 10-17 mm total length, with big black eyes, transparent body, straight gut, and a line of pigments on the ventral edge of the body from the throat to almost the end of the gut.



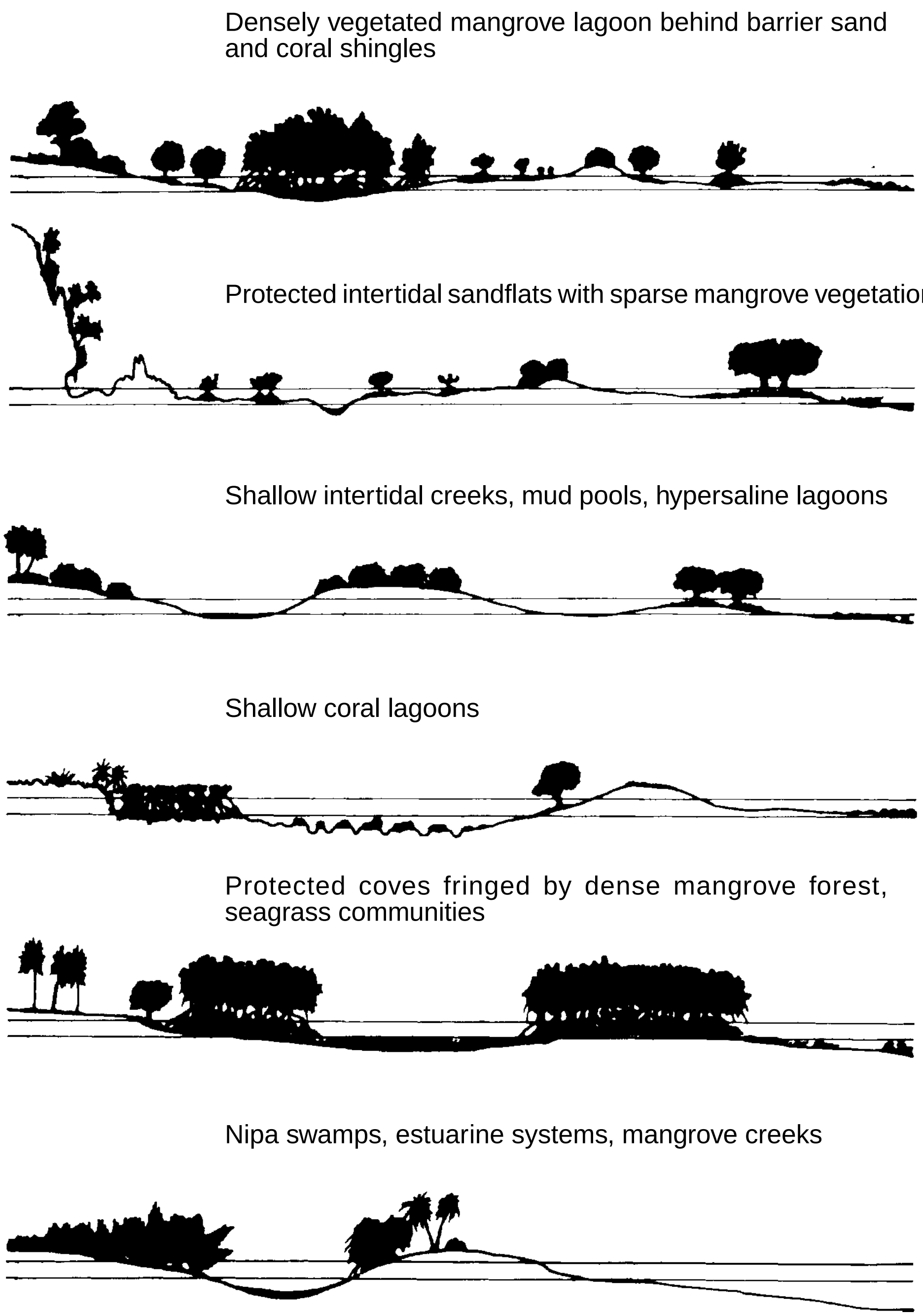
Metamorphosing, pigmented 'fry,' 15-20 mm, with pelvic fins and silvery scales.

Drawings by S. Kumagai.

Juveniles (bangus)

Milkfish larger than 20 mm have acquired the characteristic shape and definitive structures of the adult of the species and are considered juveniles. Juvenile milkfish spend a lot of time at the bottom (demersal), eat many kinds of food (omnivorous), and swim together in schools.

Juveniles up to 30 cm long have been found in habitats with rich food deposits and protected relatively shallow waters. Among these are mangrove forests, nipa swamps, river mouths, estuaries, and lagoons.



Milkfish nursery grounds: shallow depositional habitats that harbor juveniles. From Buri (1980).

In a 1.6-hectare mangrove lagoon in Naburut Island off northeastern Panay, milkfish fry were found to enter with the high tides of spring tide periods, grow into juveniles, stay there for 4-5 months until they are about 25 cm long, and then leave, again with the highest tides during new moon and full moon. Milkfish in this mangrove lagoon grew at rates of 3-4 cm per month, comparable with those of pond-grown as well as wild juveniles in other localities. This lagoon harbored a rich mangrove community, but it is gone now. It was going to be converted into ponds, but after the trees were cut down, the project was abandoned.

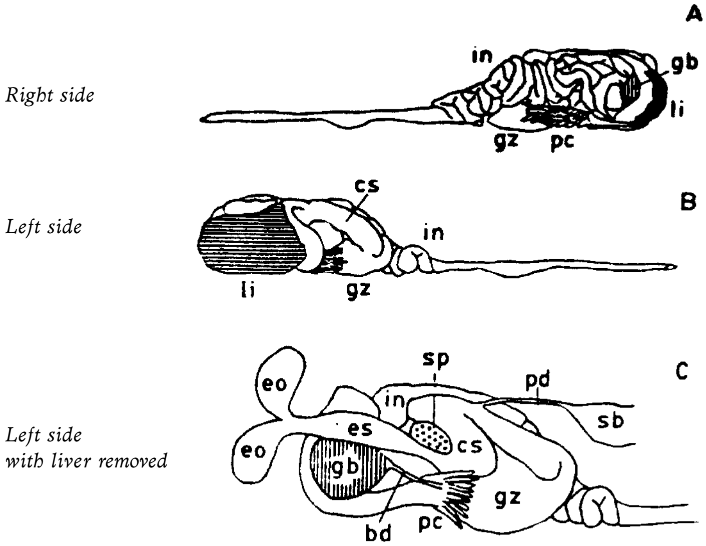
In a 111-hectare mangrove forest reserve in Pagbilao, Quezon, juvenile milkfish can be found in the large estuarine rivers that flank the forest, in the permanently saline creek within the forest, and in the shallow bay and seagrass beds seaward of the forest.

The mangrove forest reserve in Pagbilao, Quezon, as seen along Pansalbangon River, 1995. Juveniles of many species live in and around this mangrove reserve.

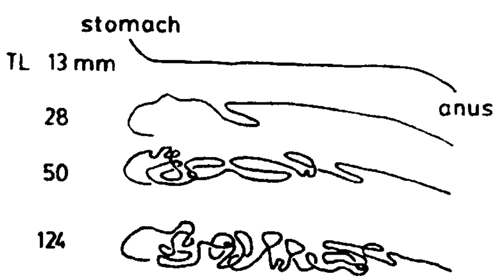
Larger juvenile milkfish may inhabit large coastal lagoons and freshwater lakes where they stay for years but do not reach full sexual maturity. Shallow-water depositional habitats appear to be obligatory for juveniles, but freshwater habitats are optional (used if available). In oceanic archipelagos where freshwater bodies are few, most milkfish probably never see fresh water.

Habitat area, depth, and connection with the sea determine the maximum size and duration of stay of milkfish in these nursery grounds, where food is not limiting. Eventually, juveniles and sub-adults go back to sea once they reach the size limit supportable by the habitat.

During the juvenile stage, the digestive tract develops into well-defined pharyngeal sacs, esophagus, stomach, gizzard, numerous pyloric caeca, and very long intestine.

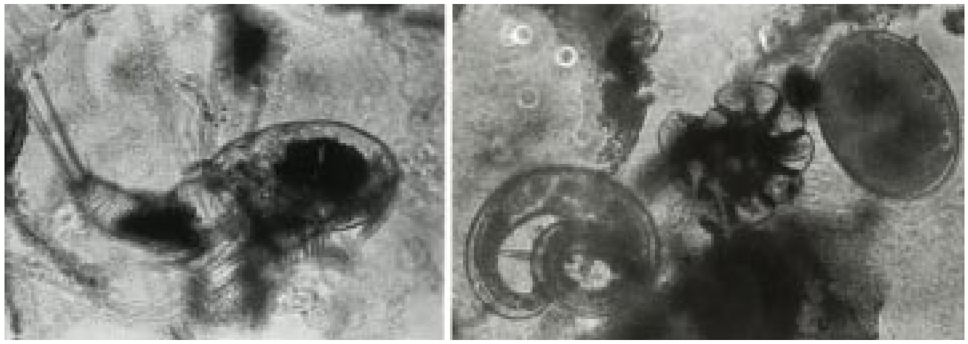


Digestive system of milkfish: in, intestine; gb, gall bladder; pc, pyloric caeca; li, liver; gz, gizzard (pyloric stomach); cs, cardiac stomach; eo, epibranchial organ; es, esophagus; sp, spleen; sb, swimbladder; pd, pneumatic duct; bd, bile duct. From Kinoshita (1981).



Elongation and convolution of milkfish gut with growth.

Abdominal cavity of adult milkfish, showing esophagus, stomach, intestine (and ovaries).



Copepods, nematodes, and foraminiferans in the gut of juvenile milkfish, Sri Lanka, 1984.

Juveniles in the wild eat a wide variety of food, including *lablab*, a bottom-growing natural food made up mainly of cyanobacteria or blue-green algae, diatoms, filamentous green algae, copepods, and small worms. Detritus (decomposed particulate organic material) often makes up the bulk of the gut contents of wild juveniles.

In the nursery grounds, milkfish lives with 70-130 other species of fish, shrimps, crabs, molluscs, other invertebrates, and various marine plants. Milkfish is thus part of a complex community and food web, in which it is potential prey, predator, grazer, or competitor. For example, milkfish and mullets almost always occur together in coastal wetlands; they have very similar food items, mainly the abundant detritus.

Milkfish caught with grouper, mullet, sea bass, and rabbitfish in the mangroves in Negombo, Sri Lanka, 1984.

Milkfish caught with other fishes from the mangroves in Legaspi, Albay, 1983.

In the Philippines where many coastal wetlands have been converted into ponds and fishing pressure on the inshore milkfish fry is intense, wild juveniles are found only in small numbers. However, there is a municipal fishery for juvenile milkfish in Laguna de Bay, other lakes, and coastal waters, when large numbers of farmed fish escape from pens, cages, and ponds during storms.

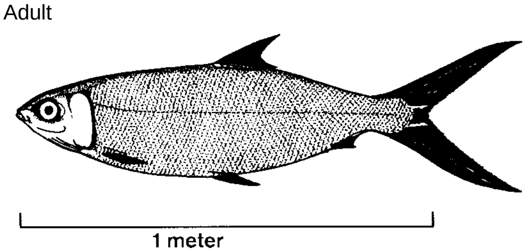
The table below contains size data for milkfish larvae, juveniles, and adults that may be useful for future studies. The length-weight data on adults caught off Antique, Iloilo, and Mindoro would be difficult to obtain again now that fishing is prohibited. The length-weight regressions allow computation of weights when only lengths have been measured, or vice-versa. The length regressions allow interconversions of total, fork, and standard lengths.

Sizes, length-weight regression and length regressions of milkfish at different stages. From Bagarinao (1991).

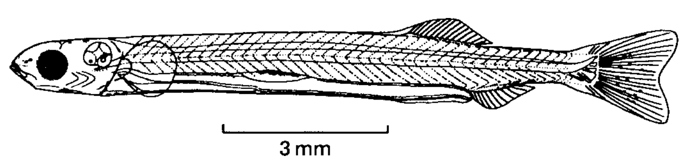
Locality	Stage, sex	n	Length range (cm)	Length mean±sd (cm)	Weight mean±sd (kg)	Length-weight regression
Pandan Bay 1975-77	males	196	FL 61-85	74±4	6±1	W = -4.03 $FL^{2.58}$
	females	162	62-95	79±5	7±2	
Tigbauan 1976-78	males	46	FL 66-97	76±6	6±1	W = -4.51 $FL^{2.83}$
	females	49	63-94	80±6	8±2	
Naujan Bay 1970	males	37	TL 65-94	84±7	5±1	W = -4.76 $TL^{2.82}$
	females	21	65-95	91±8	6±2	
Naburut Is. 1977-78	juveniles	225	FL			W = -5.30 $FL^{3.24}$
Ponds 1975-76	juveniles	240	FL			W = -5.21 $FL^{3.18}$
			TL			W= -5.15 $TL^{3.03}$
Hamtik 1980	fry	20	FL 1-1.5			W = -3.93 $FL^{4.16}$
			Length regressions:			
Pandan	adults	41	TL = 14.22 + 1.05 FL			
			TL = 20.25 + 1.03 SL			
			FL = 6.35 + 0.98 SL			
Naburut Is	juveniles	225	TL = -0.40 + 1.23 FL			
			TL = -0.22 + 1.34 SL			
Hamtik	fry	20	TL = 0.006 + 1.030 FL			
			TL = 0.105 + 1.125 SL			
			FL = 0.251 + 1.079 SL			

Body weight W: kg for adults, g for juveniles, mg for fry.
Fork length FL, total length TL, and standard length SL: cm for adults and juveniles, mm for fry.

Adult



Postlarva



Drawings by S. Kumagai

Clay pots containing milkfish fry brought to the ponds, 1927. From Herre and Mendoza (1929).

Transporting milkfish fingerlings by boat, 1927. From Herre and Mendoza (1929).

Modern bodega for storing and trading semilya, Iloilo 1995.

Chapter 3

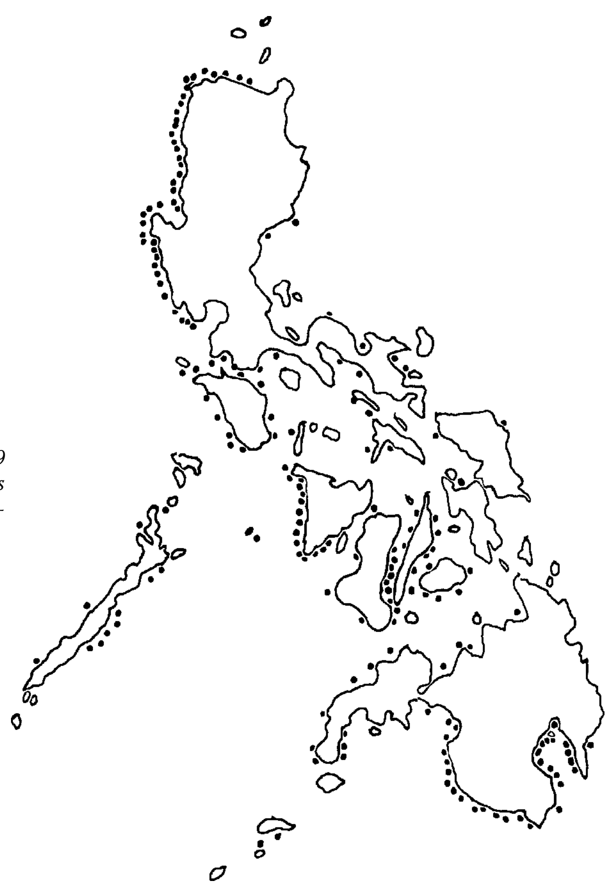
The *Semilya* Fishery

The milkfish fry of the Philippines are essentially an open-access common property resource. The national government through Act 4003 of 1932 empowered coastal towns to grant fry ground concessions in the form of exclusive rights of first purchase of *semilya*. Access to fry gathering was not restricted in any way, but gatherers had to sell to the designated concessionaire. Concessionaires were free to dispose of *semilya* as they pleased, provided they complied with the government auxiliary invoices required for interregional shipment of *semilya*. Since concessions required large capital, vertical integration of the milkfish industry was well established – fry gathering, distribution and marketing, and nursery and grow-out rearing were often funded by the same people or group.

Since the Local Government Code was implemented in 1992, many fry ground concessions have been discontinued, and free access granted.

Fry grounds

Milkfish fry grounds are found mostly on the west coasts of islands in the Philippines. The more productive fry grounds are in Ilocos Sur, Ilocos Norte, Zambales, Batangas, Palawan, Mindoro, Antique, Negros, Zamboanga, Cotabato, and Davao.



••• *Milkfish fry grounds in 1969 (from Ohshima 1973). New surveys are needed to ascertain the condition of the fry grounds now.*

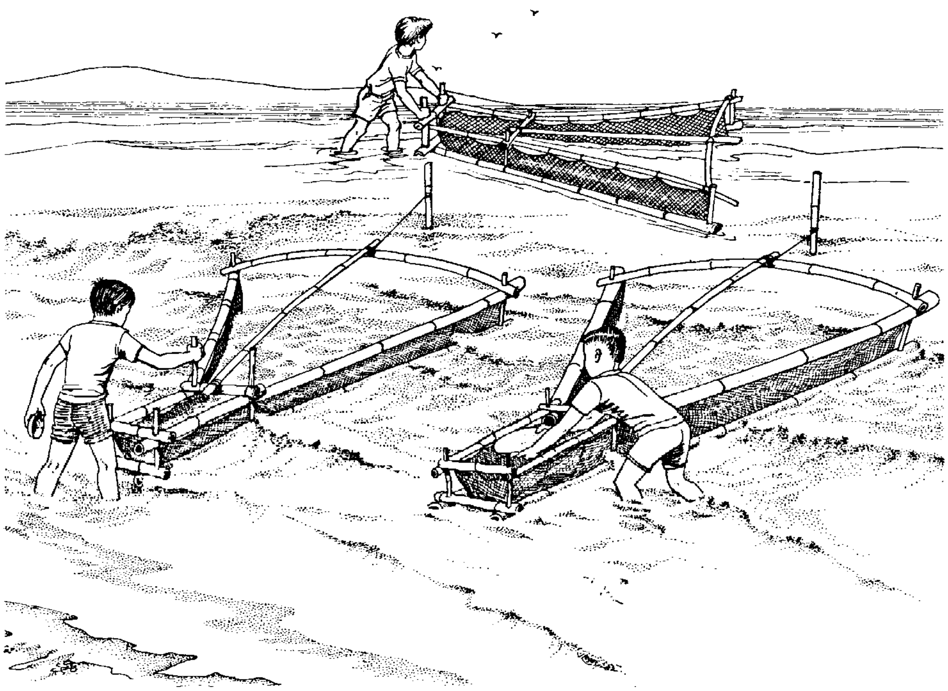
Most fry grounds are sandy beaches with gentle slopes, but some are gravelly or rocky with steep inclines. The greatest catches are obtained right at the surf zone, but *semilya* are also abundant near creeks or river mouths during flood tides. Many fry grounds adjoin human communities, and there is thus pressure on the habitat, and sometimes conflicts of use between tourism, fisheries, and human settlements.

Fry gathering in the mangroves outside the ponds, Iligan, 1998.

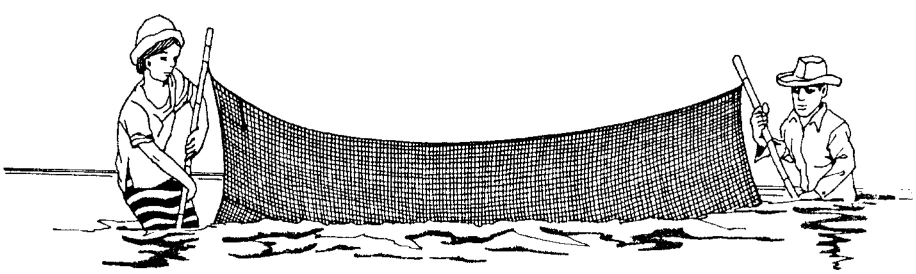
Fry gathering at a multi-use sandy beach in Iloilo. (A commercial postcard.)

Fry gears

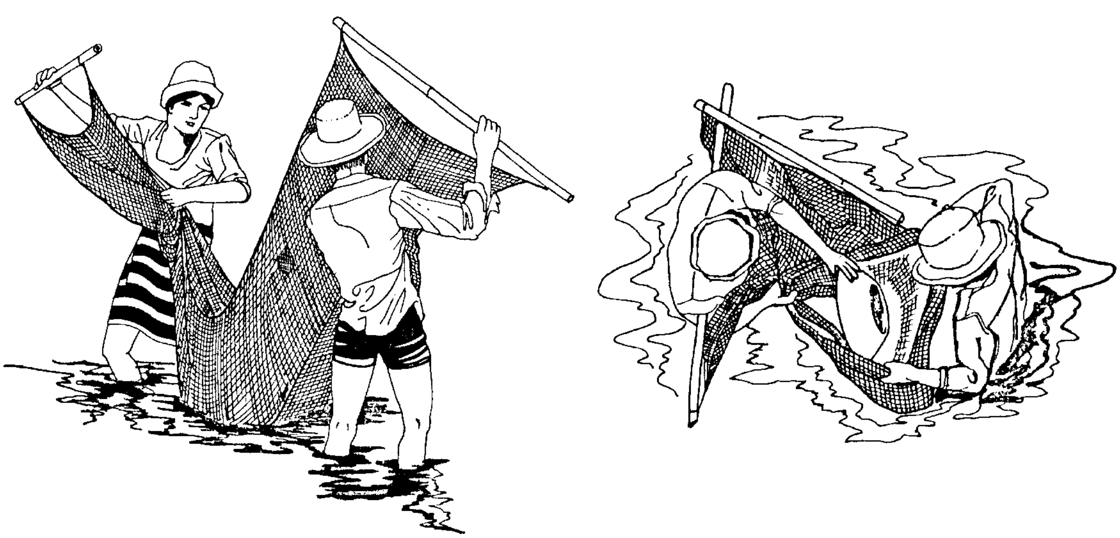
Semilya are gathered by various fine-mesh seines and bag nets of indigenous designs in the Philippines, Taiwan, and Indonesia. Some fry gears have been used in the Philippines for a hundred years and are very efficient. The most commonly used fry gear are the push net 'sweeper' and the dragged seine *sagyap*.



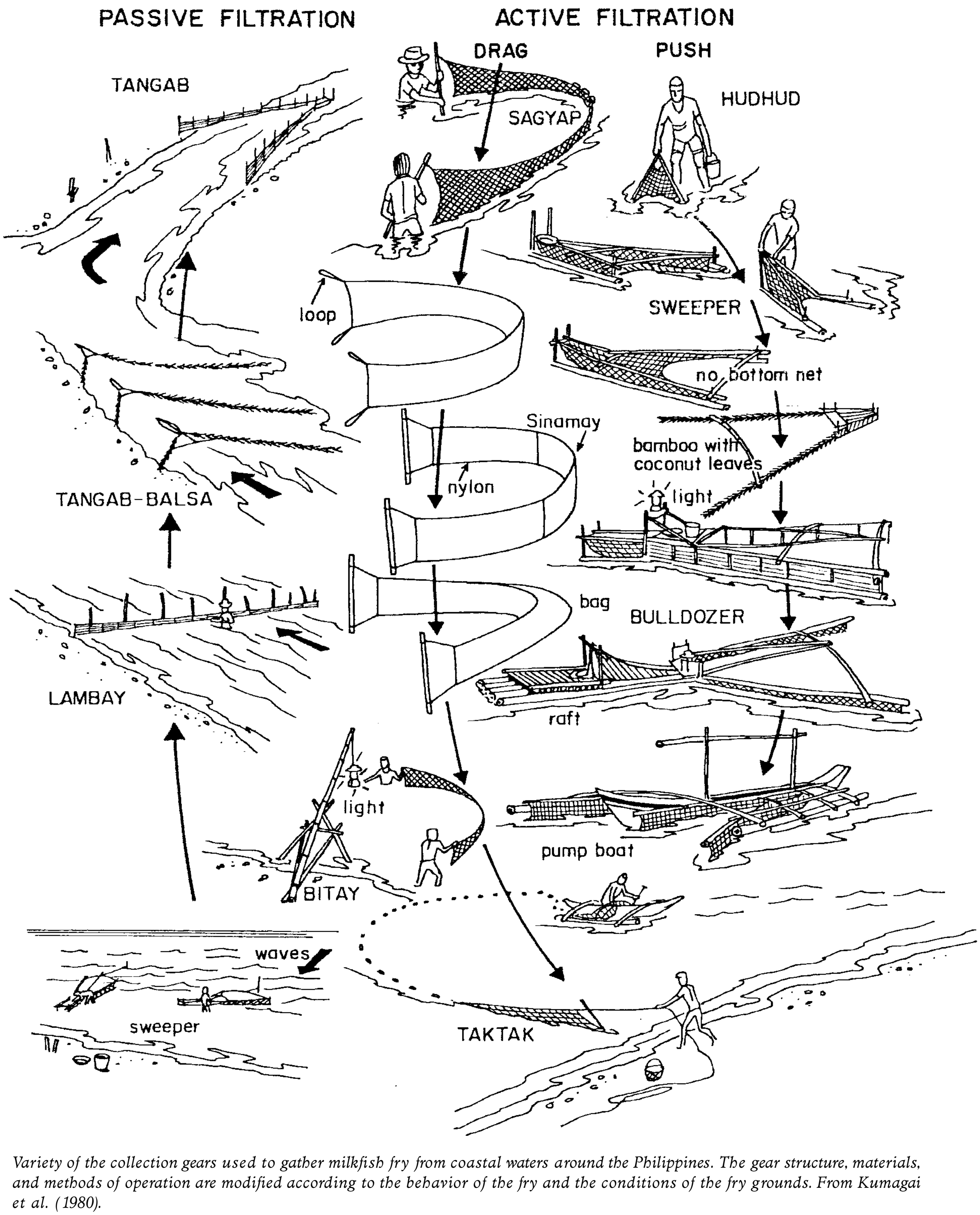
'Fry sweeper' pushed as an active gear, or fixed to stakes as a stationary gear. From Kumagai et al. (1980).



The two-man dragged seine or sagyap*. From Kumagai et al. (1980).*



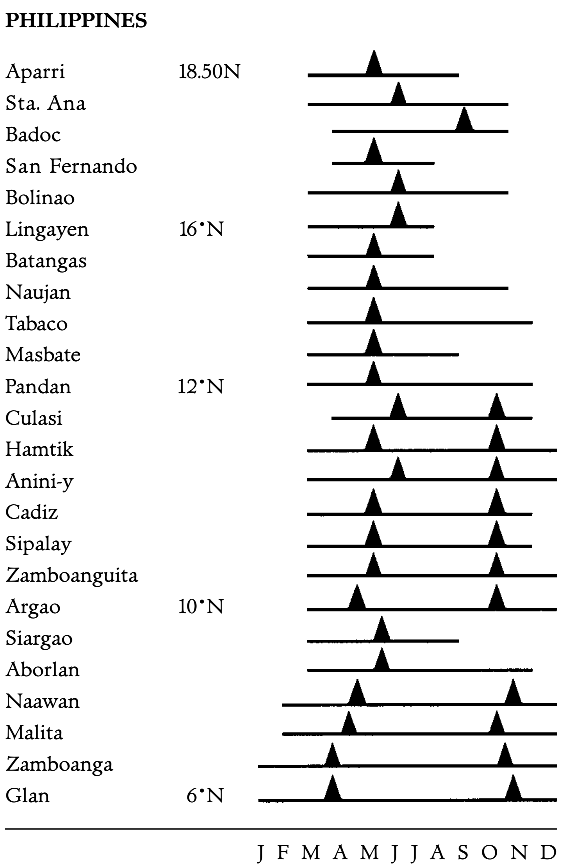
Most fry gears are operated in the surf zone and at entrances to coastal wetlands. These gears work on the principle of either active or passive filtration of *semilya* from a large volume of water. Currents and waves move water and *semilya* through the gear, or the gear is moved by muscle or motor power through the water. Injury and mortality rates of *semilya* during capture are generally low, 1-8% by different gears, and only reach 20% in 'sweepers' operated during rough seas.

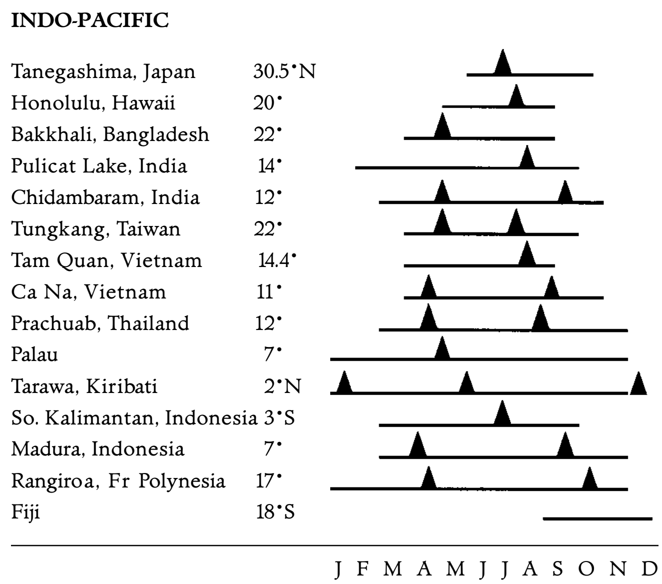


Variety of the collection gears used to gather milkfish fry from coastal waters around the Philippines. The gear structure, materials, and methods of operation are modified according to the behavior of the fry and the conditions of the fry grounds. From Kumagai et al. (1980).

Fry season

Milkfish spawn year-round at locations near the equator, but for shorter periods (3-6 months) at higher latitudes up to about 23°N or 23°S. As a result, the fry season in localities near the equator is nearly year-round with two peaks, and the fry season becomes progressively shorter with a single peak at higher latitudes.





Seasons of milkfish fry occurrence in the Philippines and some localities in the Indo-Pacific. Horizontal lines show duration of season, triangles indicate peaks. From Bagarinao (1991).

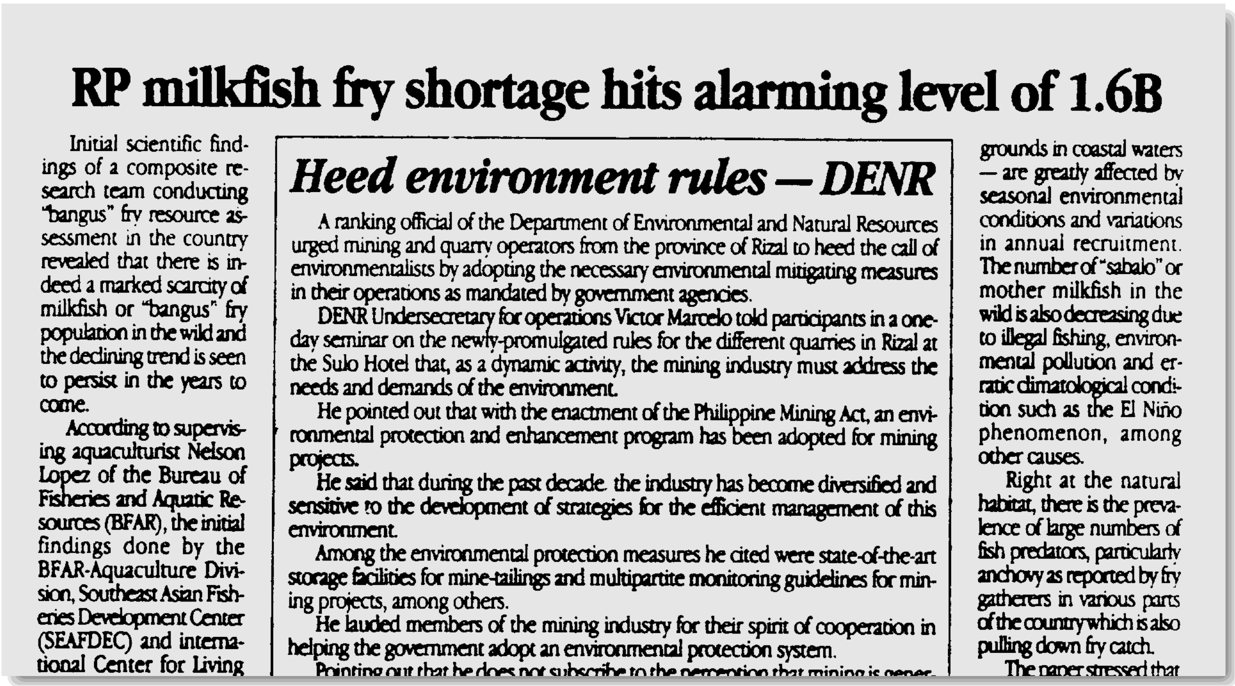
For example, in Glan, Cotabato (6°N), *semilya* can be collected almost the whole year, with peaks in April and October. In Hamtik, Antique (11°N), fry gathering lasts from March to November, with peaks in May and October. In Santa Ana, Ilocos Norte (18°N), the season is April to October, with a peak in June.

The fry occurrence patterns are correlated with the seasonal pattern of solar radiation at different latitudes during the year. Milkfish fry seasons are longer in areas with higher annual sea surface temperatures.

The seasonality and lunar periodicity of fry occurrence and abundance are determined directly by the seasonality and lunar periodicity of spawning, but may be modified by sea currents, monsoon winds, presence of rivers, and the shape of the coast. *Semilya* arrive in shore waters in patches (or pulses in time) but are distributed uniformly along considerable stretches of beach, only loosely aggregated and not schooling. The stronger water currents during flood tide and high tide concentrate the *semilya* and result in higher catches during these periods.

Fry catch

Milkfish *semilya* are abundant and low-priced during the spawning season, but scarce and highly priced during the off months. The problem of mismatched timing between fry availability, low price and pond stocking schedules is commonly perceived as "fry shortage."



RP milkfish fry shortage hits alarming level of 1.6B

Initial scientific findings of a composite research team conducting "bangus" fry resource assessment in the country revealed that there is indeed a marked scarcity of milkfish or "bangus" fry population in the wild and the declining trend is seen to persist in the years to come.

According to supervising aquaculturist Nelson Lopez of the Bureau of Fisheries and Aquatic Resources (BFAR), the initial findings done by the BFAR-Aquaculture Division, Southeast Asian Fisheries Development Center (SEAFDEC) and international Center for Living

Heed environment rules — DENR

A ranking official of the Department of Environmental and Natural Resources urged mining and quarry operators from the province of Rizal to heed the call of environmentalists by adopting the necessary environmental mitigating measures in their operations as mandated by government agencies.

DENR Undersecretary for operations Victor Marcelo told participants in a one-day seminar on the newly-promulgated rules for the different quarries in Rizal at the Sulo Hotel that, as a dynamic activity, the mining industry must address the needs and demands of the environment.

He pointed out that with the enactment of the Philippine Mining Act, an environmental protection and enhancement program has been adopted for mining projects.

He said that during the past decade the industry has become diversified and sensitive to the development of strategies for the efficient management of this environment.

Among the environmental protection measures he cited were state-of-the-art storage facilities for mine-tailings and multipartite monitoring guidelines for mining projects, among others.

He lauded members of the mining industry for their spirit of cooperation in helping the government adopt an environmental protection system.

Pointing out that he does not subscribe to the perception that mining is gener-

grounds in coastal waters — are greatly affected by seasonal environmental conditions and variations in annual recruitment.

The number of "sabalo" or mother milkfish in the wild is also decreasing due to illegal fishing, environmental pollution and erratic climatological condition such as the El Niño phenomenon, among other causes.

Right at the natural habitat, there is the prevalence of large numbers of fish predators, particularly anchovy as reported by fry gatherers in various parts of the country which is also pulling down fry catch.

The paper stressed that

Unfortunately, there are no good records of the milkfish fry catch despite the long history and economic importance of the industry. Some estimates of the fry catch are here shown for the Philippines as a whole, and for selected provinces or regions.

The fry catch was estimated at 1.35 billion in 1974 and 1.16 billion in 1976, both adequate to meet the annual requirements. Allegations of fry shortage in 1976 were based on the underestimation of catch and an overestimation of stocking requirements (10,000 fry/ha for 176,000 ha of ponds) coupled with the price increases of *semilya* and fingerlings due to an expanded fishpen area.

The milkfish fry catch was estimated at 1.24-1.4 billion in 1991-1992, still adequate to meet the estimated demand of about one billion *semilya.* Complaints of fry shortage persist, and the government still does not collect fry catch data systematically.

A 1996-1998 Bangus Fry Resource Assessment by BFAR, SEAFDEC, PCMARD, and ICLARM showed that fry production is on the decline, due to pollution, loss or degradation of coastal habitats, overexploitation of fishery resources, and decline in *sabalo* population. The national fry catch could not be determined, but the total current demand was placed at 1.65 billion milkfish fry a year. The fry supply is highly seasonal and is unable to cope with increasingly year-round demand.

The milkfish fry catch in the Philippines as a whole, and for selected localities or fry grounds. From Bagarinao (1997).

Place of collection	Year	Quantity (million)
Philippines	1958	344
	1963	540
	1973	466
	1974	1,350
	1976	1,116
	1991	1,241
	1992	1,400
Ilocos Norte, I. Sur, La Union, Pangasinan	1962	6
	1963	76
	1970	70
	1973	29
Mindoro	1962	22
	1963	69
	1973	7
Batangas	1962	7
	1963	25
	1973	4
Palawan	1963	32
	1973	10
Bicol	1963	14
	1973	5
Panay Island	1962	46
	1963	181
	1973	72
	1974	92
	1975	120
Iloilo	1963	12
	1975	18
Antique	1962	43
	1963	141
	1975	88
Cebu	1962	46
	1963	74
Negros Occidental, N. Oriental	1963	22
	1973	24
Zamboanga del Sur, Z. del Norte	1973	19
Misamis Occidental, M. Oriental	1973	14
Cotabato	1962	27
	1963	21
	1973	63

On the other hand, about 700-800 million fry are caught from the wild in Indonesia each year, and 130 million fry in Taiwan.

Fry identification

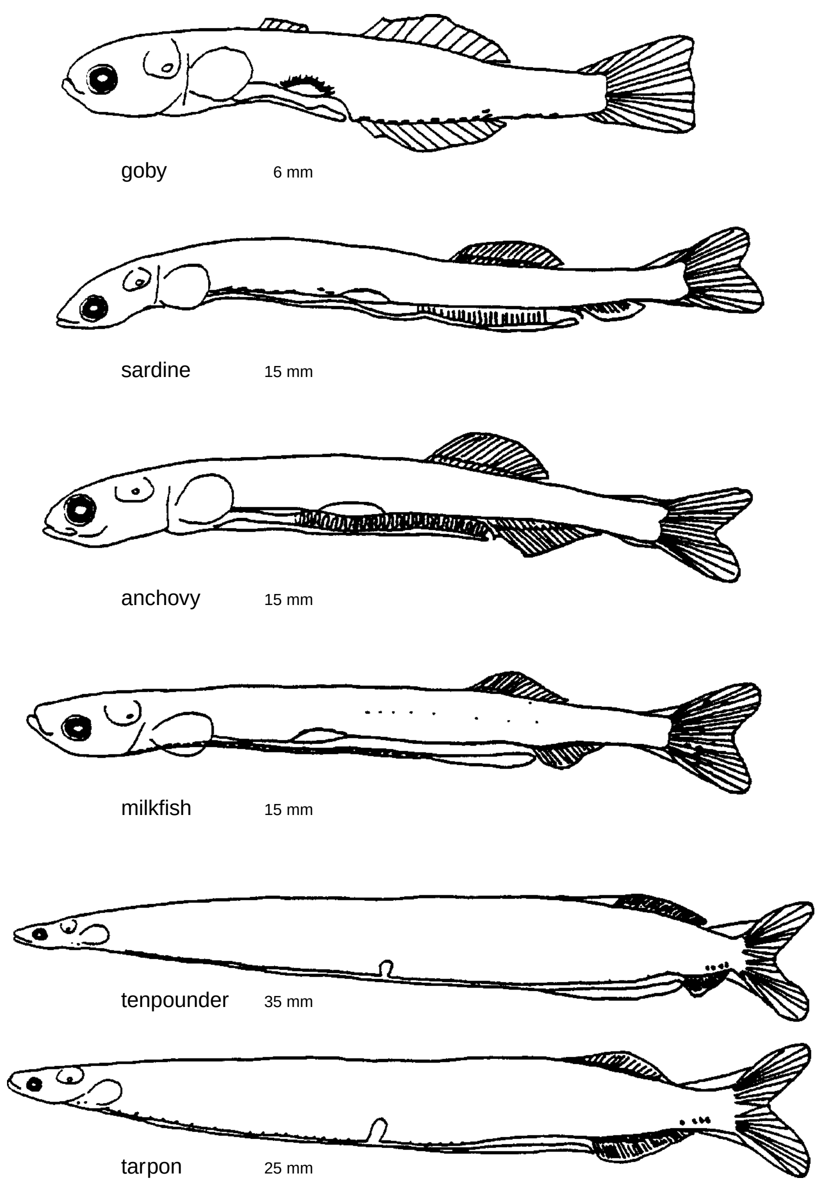
Milkfish *semilya* from shore waters have large black eyes, elongate transparent bodies, and a single line of black pigments on the ventral edge. In the holding basin, *semilya* can be readily picked out by their large eyes and energetic schooling and circling behavior. Milkfish *semilya* stay alive after other species in the same catch have died.

Semilya may be confused with the transparent larvae of gobies *biya*, anchovies *dilis*, sardines *tamban*, tarpon *buanbuan*, and tenpounder *bidbid.*

Goby larvae may be shorter or longer than *semilya*, but have two short dorsal fins and a prominent inflated swimbladder.

Anchovy and sardine larvae have transverse foldings in the gut, clearly seen under the microscope, whereas *semilya* have simple straight guts.

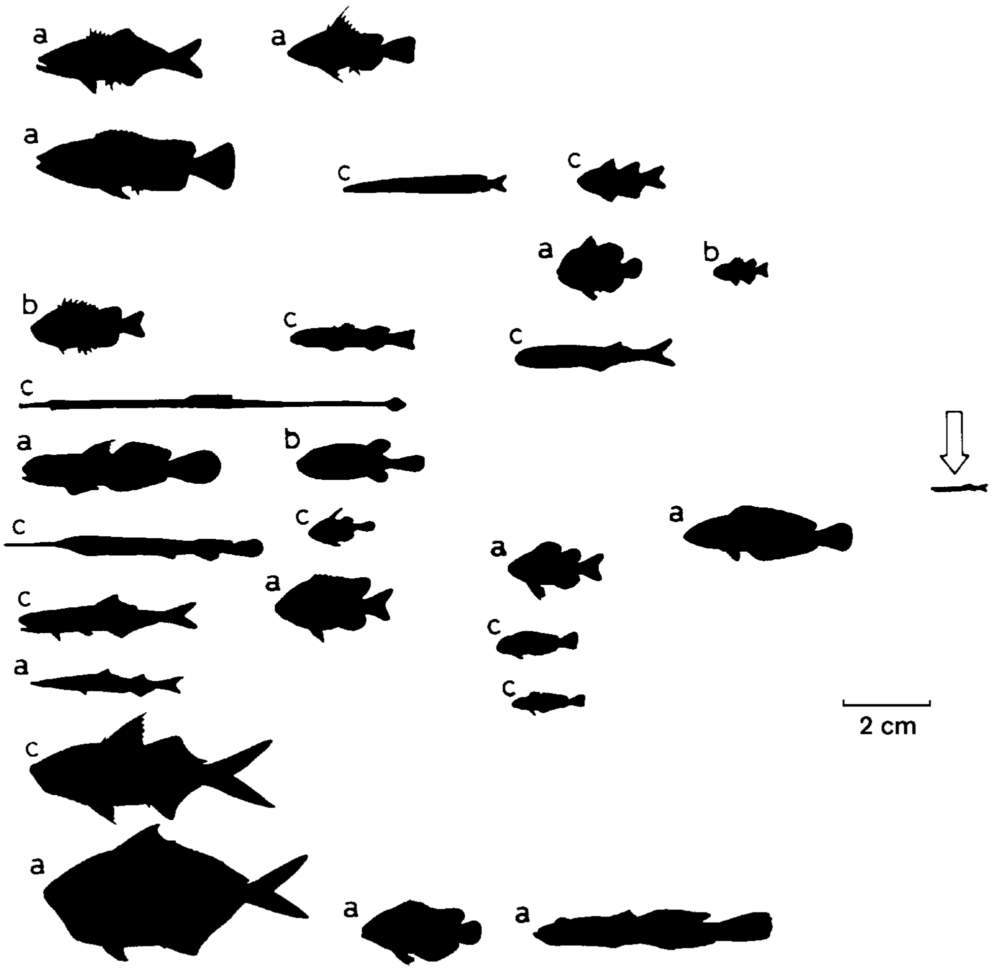
Tarpon and tenpounder larvae have longer (25-35 mm), deeper, flatter, ribbon-like, slightly amber bodies, and smaller eyes than *semilya.*



Milkfish fry and similar-looking larvae in shore waters. From Bagarinao et al. (1987).

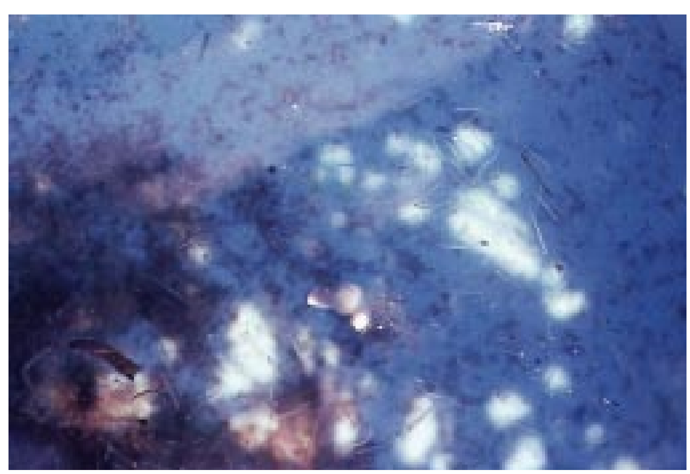
Tenpounder and tarpon larvae prey on *semilya* and must be separated from them as soon as possible. So must the juveniles of tiger perch, glassfishes, gobies, and several other species.

The catch of milkfish fry gears in shore waters and coastal wetlands includes many other species that could also be used for aquaculture, for example, mullets, rabbitfishes, snappers, groupers, and shrimps.



Larvae of other fish species may be collected with milkfish fry (at arrow). Some of these other species are big enough to eat (a) or injure (b) milkfish fry; but others (c) can not. Larvae and juveniles drawn to scale. From Buri and Kawamura (1983).

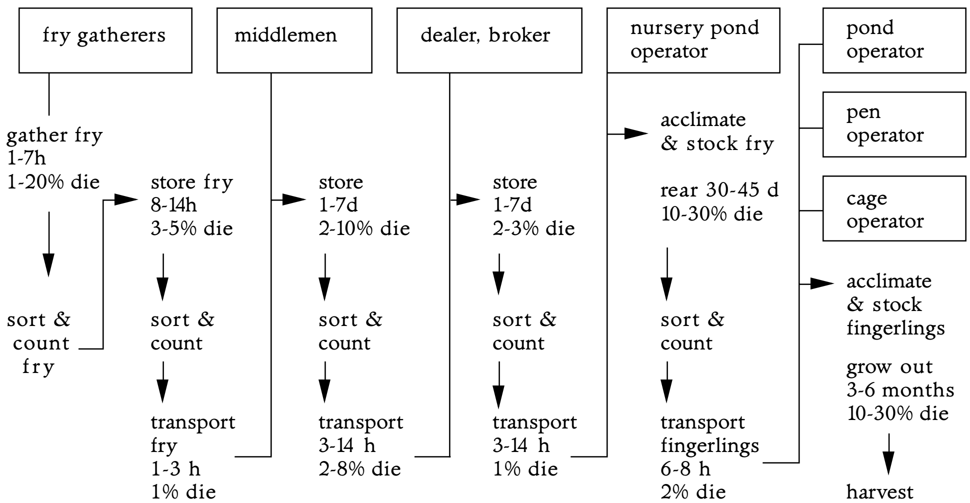
Picking out milkfish fry.



Milkfish fry from the wild are transparent, with big black eyes, and brisk swimming behavior.

Fry handling

The handling of fry from the fry grounds to the grow-out farms, from the gatherers to the farmers, is shown below. The fry change hands two or more times, and each time they do, they are sorted and counted, transported, and stored for different periods of time. *Semilya* are a highly perishable commodity and some of them die during gathering, storage, transport, nursery rearing, and grow-out.



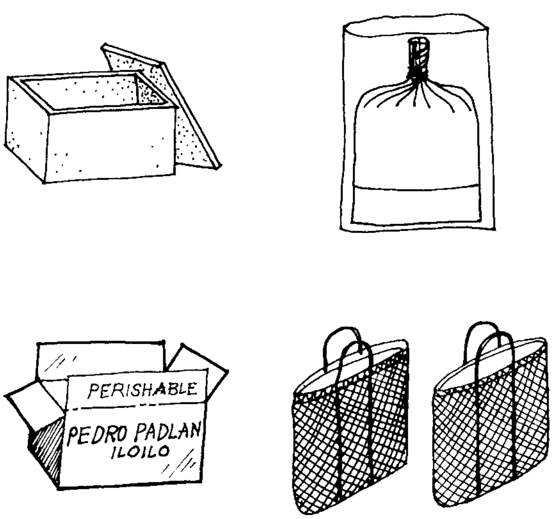
Flow of milkfish fry from the gatherers to the nursery ponds and the fingerlings to the grow-out ponds, pens, and cages. Shown are the many times the fish are sorted and counted, the duration (in hours or days) of storage and transport and the % mortality during the period.

The *semilya* are counted individually by the fry gatherers for sale to concessionaires, but this becomes impractical when dealing with large numbers. Thus, dealers use the imprecise visual estimation technique. Several lots of 1,000 *semilya* are counted out, and the rest of them are distributed into lots of similar apparent densities. *Semilya* are bought and sold in indivisible lots of 1,000 and are counted every time they change hands.

The lack of a method for counting large numbers of *semilya* creates mistrust between buyers and sellers at all levels in the marketing chain. Buyers usually ask sellers to include an additional allowance or *pasobra* of up to 20% to cover mortality and possible undercounting. *Pasobra* makes it very difficult to ascertain the quantity and quality of *semilya* sold at a given price. And since *pasobra* is usually fixed at a specified amount, it does not encourage the gatherers nor the dealers to take greater care to reduce stress on the *semilya.*

Milkfish fry are stored in clay pots or plastic basins.

Manual counting of fry and visual estimate of densities leave much room for mistakes.



Fry are packed and transported in oxygenated water in plastic bags placed in pandan *bags or in styrofoam boxes. From Bagarinao et al. (1987).*

The technologies for fry storage and transport are generally effective, although perhaps not yet optimized. *Semilya* are stored in a cool place in plastic basins or clay pots at 100-500 per liter, in water of 10-25 ppt, which is renewed daily. Dealers may store *semilya* for 1-7 days depending on the demand. *Semilya* can be maintained on wheat flour or cooked chicken egg yolk for 1-2 weeks, but soon begin to die despite continued feeding.

For transport, 4,000-8,000 *semilya* are packed in 3-10 liters of 12-22 ppt water in strong plastic bags inflated with oxygen. The plastic bags are placed in *pandan* bags for land and sea transport, and in styrofoam boxes for air transport, which may take 1-14 hours. Mortality increases with time in transport and non-use of oxygenated water.

Before the *semilya* are released into ponds, pens and cages, they are first acclimated over several hours by allowing the salinity and temperature of the transport water to gradually come close to those of the farm. Proper acclimation during stocking is crucial to survival of *semilya*.

Socioeconomic value

An up-to-date valuation of the milkfish fry industry and the supporting coastal ecosystem is badly needed. The fisheries statistics of the Philippines include no data on the *semilya* fishery.

The *semilya* industry was worth P57.4 million in 1976 and about 26,000 families or about 166,400 people derived income from fry gathering in 1978. Fry gathering made up 15-37% of the household income of these families in 1974. An additional 779,375 man-days are devoted to counting, sorting, storage, transport, and marketing to move the *semilya* from fry grounds to fishponds.

Fry gatherers are local residents, mostly men with elementary education and families with six children, the older ones of whom help in fry gathering. In some fry grounds, women and children are more numerous. Fry gatherers spend three months gathering, six months in other occupations, usually fishing, but are unemployed the rest of the time.

Women make up a large fraction of the work force engaged in fry gathering and trade. Mactan Island, 1983.

Hamtik, 1978.

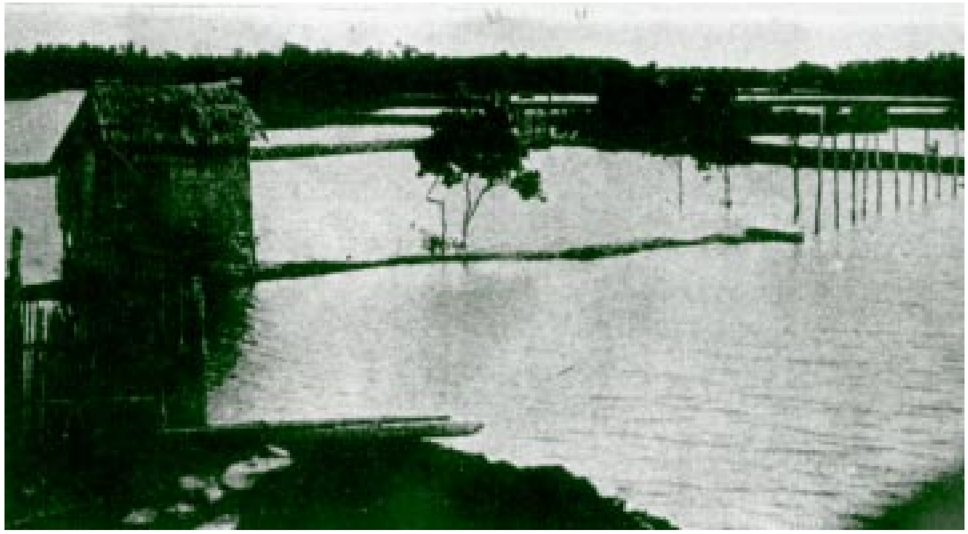
A family of gatherers obtained an average of 40,000 *semilya* in 1974, and 31,000 *semilya* in 1992. The average cost of *semilya* from the wild was P121-148 per thousand in 1974-1992. But during slack periods, and especially recently, prices can be as high as P1 for each fry.

Most milkfish fry grounds were fished and regulated through concessions granted by the municipal governments to the highest bidder for terms of up to five years. The most productive fry grounds fetched concession fees of P100,000-250,000 in 1976. Concessions were a form of indirect tax on fry gatherers; they provided an average 13% of the 1976 incomes of 35 municipal governments, and as much as 50% of the income of Hamtik and other towns in Antique.

As important as milkfish fry gathering is to the national economy, it contributes substantially to the depletion of fishery resources. Larvae and juveniles of other fishes and crustaceans are captured with *semilya* and killed incidentally, or more often, dumped on the beach sand to avoid repeated catching and sorting. This loss of larvae has not been quantified, but is certainly large in terms of both numbers and biodiversity.

Fry gatherers tend to have big families.

The many faces of fry gatherers.



Milkfish pond of Dr. Pio Valencia in Mactan Island, Cebu, circa 1927. From Herre and Mendoza (1929).

Carlos Palanca estate, Hagonoy, Bulacan, 1927. From Herre and Mendoza (1929).

Milkfish pond with a low dike and mangroves in the background, Barotac Nuevo, Iloilo, circa 1927. From Herre and Mendoza (1929).

Chapter 4

Palaisdaan from *Bakawan*

The first fish ponds for marine fishes were made by walling up the narrow entrance to a bay or inlet. An opening was left so that fishes carried by the incoming tide could freely enter, after which it was closed by a gate that prevented the exit of fish but allowed the interchange of water. There was little control over the stocking of ponds by this method, and the results were a matter of chance.

The greatest development of ponds like this was in the Hawaiian islands. The origin of these ponds is lost in antiquity; most of them were made by building walls of lava across the narrow entrance to a bay and placing a sluice gate at a convenient opening. Some of these ponds were very large, 200 ha or more, and the principal fishes grown were mullet and milkfish. Some of the lava ponds that were built 200-300 years ago were used until the 1970s, but most have been abandoned or turned to other uses.

The same principles were used in the construction of fishponds in Indonesia, the Philippines, Taiwan, and perhaps other localities. But changes were made through time. In Indonesia, the extensive nipa swamps along the coasts were first exploited for thatch and for the nipa sap turned into alcoholic drink. Nipa swamps close to populated areas were converted into fishponds by constructing a dam or dike to impound the water at high tide. Just when and where ponds were first built in nipa swamps could not be ascertained, but it was about 600 years ago. Ancient Javanese laws codified about 1400 AD punished "him who steals fish from a *tambak*" or saltwater fishpond.

Eventually, people in the more advanced regions adopted a set method of collecting the desired fry and stocking them in specially constructed ponds. There came into existence in Batavia, Surabaya, Madura, Java, Singapore, and Manila an enormous fishpond industry whose extent and importance was realized by only a few people outside the industry.

Conversion of mangroves to fishponds

The people soon realized that nipa and mangrove swamps were convenient places to build ponds in: there were extensive areas then available, the clay soil retained water, and the tides supplied the ponds with water and fish and shrimp 'fry.' Nipa palms were cut off and sold, and the stumps rotted quickly and were easily removed. Mangrove trees were hard wood, larger, more difficult to cut, not easily killed, and very laborious to remove; where mangrove trees were abundant, pond construction was more expensive.

But mangroves were prized as fuelwood and charcoal. Nipa, mangroves, and coconut were often planted on the dikes of Javanese ponds, but elsewhere, mangroves were not allowed to grow in ponds because the roots spread quickly and the fruits dropped and rooted in the ponds.

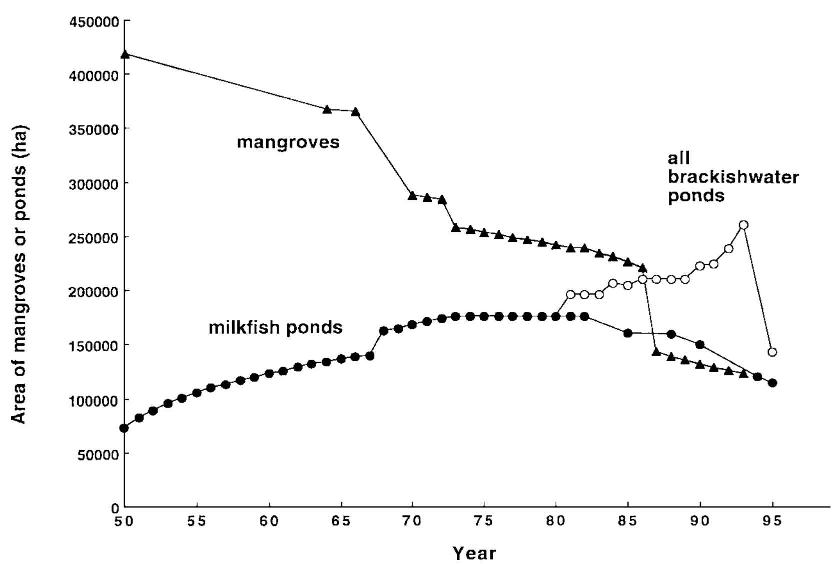
Brackishwater milkfish ponds in the Philippines are called *palaisdaan* in Tagalog, *punong* in Ilonggo, *pokok* or *lapat* in Ilocano, and *tangke* in Cebuano. Most of them were excavated from nipa and mangrove or *bakawan* swamps.

Fishponds in the Philippines probably started on the shores of Manila Bay. There have also been fishponds around Iloilo and Mactan Island for a long time. For centuries, these fishponds were of the primitive type dependent on chance stocking. This ancient type pond persisted in Mactan Island until 1921, when Dr. Pio Valencia, a Tagalog practising medicine in Cebu, stocked his pond with a quantity of fry that he had purchased, and at the end of the season, sold his milkfish harvest for 500 pesos, to the great astonishment of the local people. Later, Dr. Valencia bought more ponds and made improvements until he had a fine farm. It is not known what happened to Dr. Valencia's farm.

In the 1920s, the largest milkfish ponds in the Philippines were around Manila Bay, in Pampanga, Bulacan, and Bataan, and the most skillful practice was in Malabon, just north of Manila. A system of ponds under one management sometimes contained hundreds of hectares, such as the Carlos Palanca estate in Hagonoy, Bulacan, and the Ayala estate in Macabebe, Pampanga.

The milkfish industry has been responsible for the significant loss of valuable nipa and mangrove swamps and forests (or simply 'mangroves'). Early this century, the Philippines had about 500,000 hectares of mangroves. In the 1920s, fish ponds were concentrated around mangrove-lined Manila Bay. In 1926, the Bureau of Forestry issued 390 permits to operate 3,042 ha of fishponds in mangrove areas. Before World War II, about 61,000 ha of brackishwater ponds already existed.

After the war, the Bureau of Fisheries was established to take charge of the development of both fisheries and aquaculture. In 1950, some 418,382 ha of mangroves still existed, together with 72,753 ha of fishponds. Over the next 25 years, the pond area increased about 4,000 ha each year and mangrove area decreased about 6,400 ha yearly. The milkfish ponds remained at 176,232 ha from 1976 until 1982, then decreased to 114,796 ha in 1995. But the total pond area increased to 261,402 ha in 1993 and mangroves shrank to 117,700 ha in 1995.



Areas of mangroves and brackishwater ponds in the Philippines, 1940-1995. All ponds were milkfish ponds until about 1980. The area used for milkfish was reduced even as the total area increased to accommodate shrimp farming. From Bagarinao (1998).

The Fisheries Statistics of the Philippines used to carry a section called "Swamplands Available for Development" which promoted the wrong idea that mangrove swamps were waste lands or idle lands that required conversion into fishponds to be productive.

Milkfish ponds in the Philippines are either privately owned or leased from the government under a renewable 25-year Fishpond Lease Agreement (FLA). As of December 1995, there were 3,975 FLAs, with 1,303 of these in western Visayas. Privately owned ponds are exempted under Republic Act 7881 from the Comprehesive Land Reform Law. Unlike rice lands, large fish ponds can not be broken up into smaller lots to be sold to tenants or farm workers.

Brackishwater ponds are valuable real estate, and good management adds to their value. Estimates of the economic rent of ponds (the value of products derived from them) range from P515 to P3,296 per hectare per year. Yet, the lease for FLAs has long remained at a very low P50 per hectare per year. BFAR increased the lease for government-owned ponds to P1,000 in 1992 but pond operators have successfully lobbied for a deferment of this new lease rate.

The mangrove forest is cleared when ponds are made.

Mangroves are also killed off by siltation and pollution from mining effluents, or lost to reclamation for settlements. The large reclamation area that now includes the ports and industrial and commercial establishments of Manila, Cebu City, and Mandaue City used to be mangrove forests.

Indeed, both mangrove areas and fish ponds have been converted to other uses. Rizal province, which included much of Metro Manila today, had 3,193 ha of milkfish ponds in 1927 but only 752 ha in 1981. In the mid-1970s, the Dagat-dagatan Saltwater Fishery Experiment Station in Malabon closed after 35 years of research in milkfish farming – it closed due to industrial pollution, siltation, and urbanization.

The Cultural Center of the Philippines stands on land reclaimed from former mangrove forests.

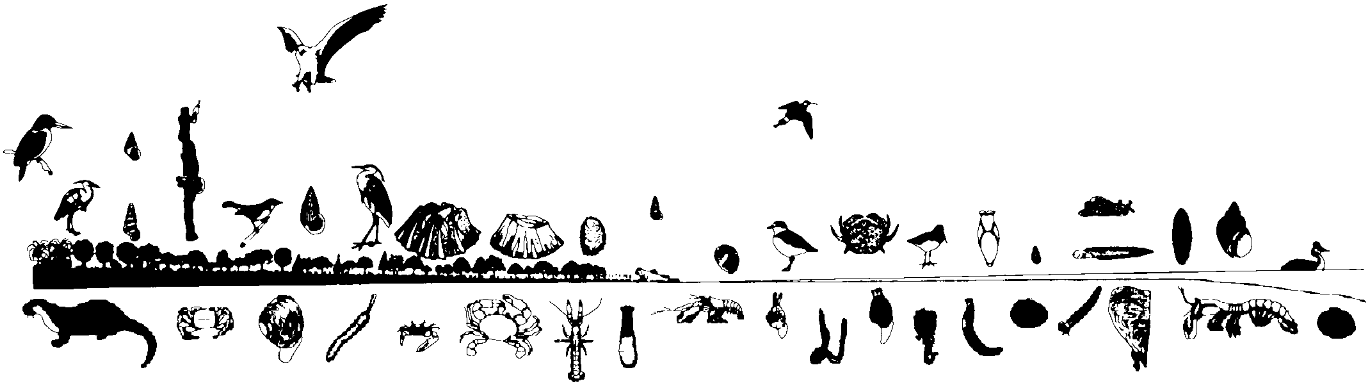
Biodiversity in the mangroves

Intact mangrove forests include a great variety of mangrove trees, palms, shrubs, vines, algae, and fungi. Mangroves provide habitats, food, and protection for many species of fishes, snails and clams, shrimps and crabs, snakes, birds, insects and many other creatures. An incomplete species count in Philippine mangroves includes about 500 species.

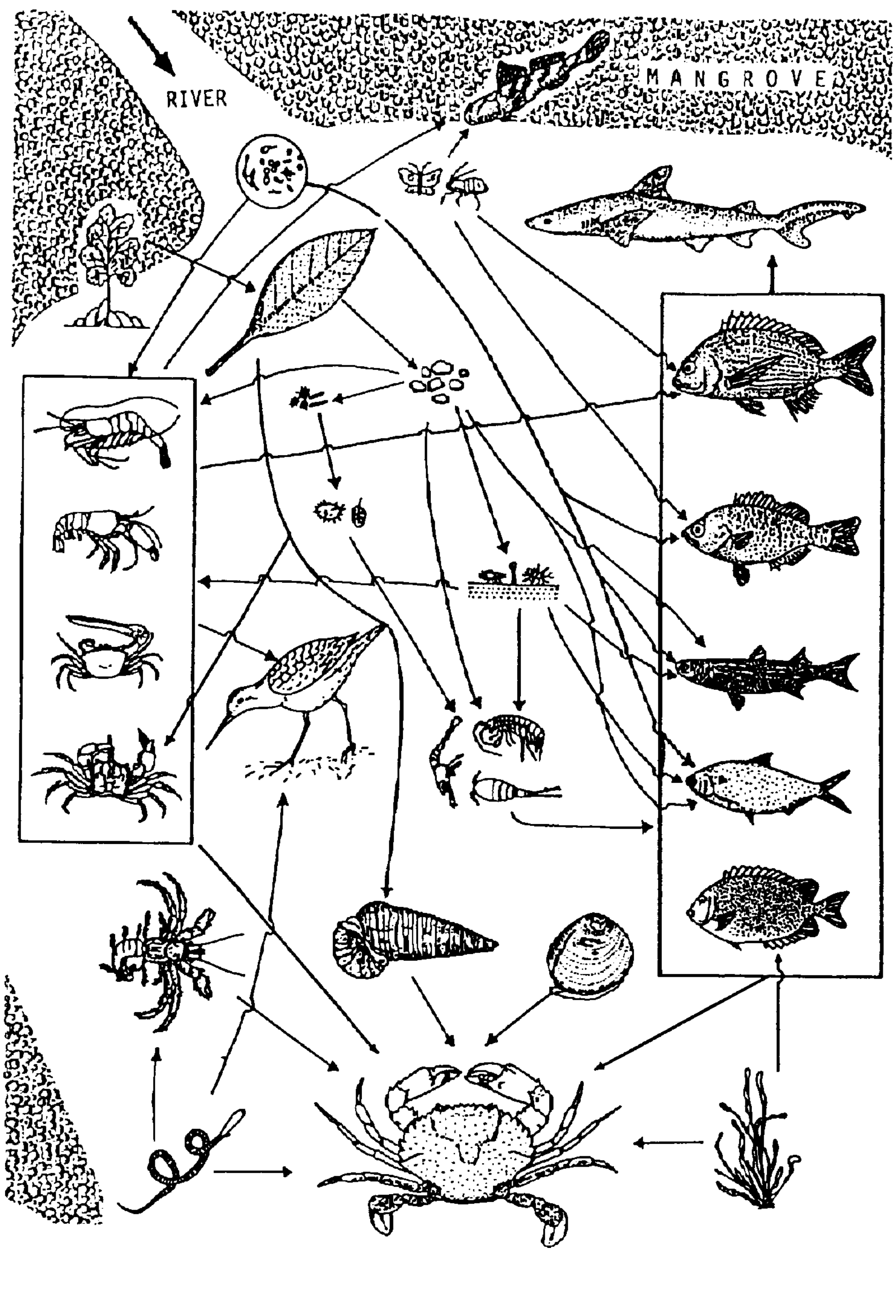
Fruiting plants	82	Fishes	128	Birds	32
Mollusks	63	Reptiles	16	Algae	73
Crustaceans	54	Mammals	5		

Mangroves in Bugtong Bato, Ibajay, Aklan, 1998.

From Tan (1992)



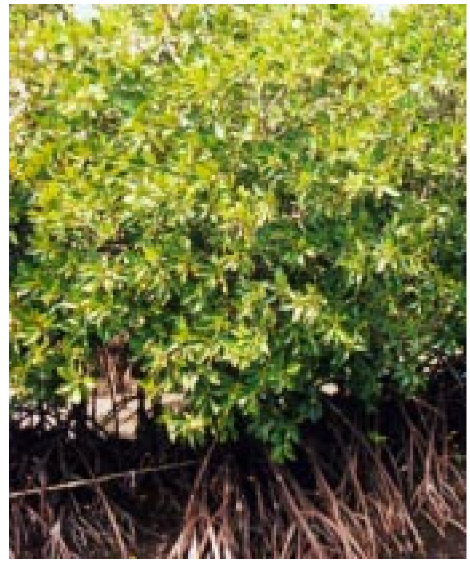
Part of the mangrove community and biodiversity in Hong Kong. From Morton (1979).



The organisms in the mangrove ecosystem interact in complex ways, including food webs such as shown. Most of the production resulting from these interactions is harvested by fisheries. From Shokita (1989).

Ceriops tagal *or tangal is a source of red tannin for dyeing the local alcoholic drink,* tuba.

Nypa fruticans *or nipa provides roof thatch material, an alcoholic drink, and fruits.*



Rhizophora *spp. or bakawan provides fuelwood, fence material, and house posts.*

The enormous biodiversity in the mangroves provides both forestry and fisheries products for human use, employment, and economic development. Mangrove trees are harvested for timber, dyes, resin, firewood, etc. Nipa leaves are used for roofing. Fishes, shrimps, crabs, and mollusks are harvested from the mangroves by large numbers of small-scale fisherfolk, including women and children. Some mangrove plants and animals have medicinal value.

Mangroves are nursery grounds of milkfish and many other species of commercial fishes, shrimps and mollusks.

Some of the many species of shrimps, fishes, and mollusks in the mangroves of Pagbilao Bay, Quezon, 1995.

Ecosystem goods and services

Ecosystems like mangroves and the organisms that live in them provide humans various products and essential life-support services that make the planet habitable and the large human populations possible. Ecosystem services ensure clean air, pure water, and a green and productive earth. Natural ecosystems support cities, agricultural farms, and aquaculture farms. These goods and services disappear when ecosystems and biodiversity are lost.

Mangroves and adjacent coastal ecosystems are interconnected and interdependent in structure and function. Mangroves adjoin rivers and agricultural land upstream, and seagrass-seaweed beds and coral reefs downstream. These ecosystems have their distinctive habitats and resident plants and animals. They also share species at different stages of the life cycle, as well as organic matter and dissolved nutrients.

MANGROVE SWAMPS

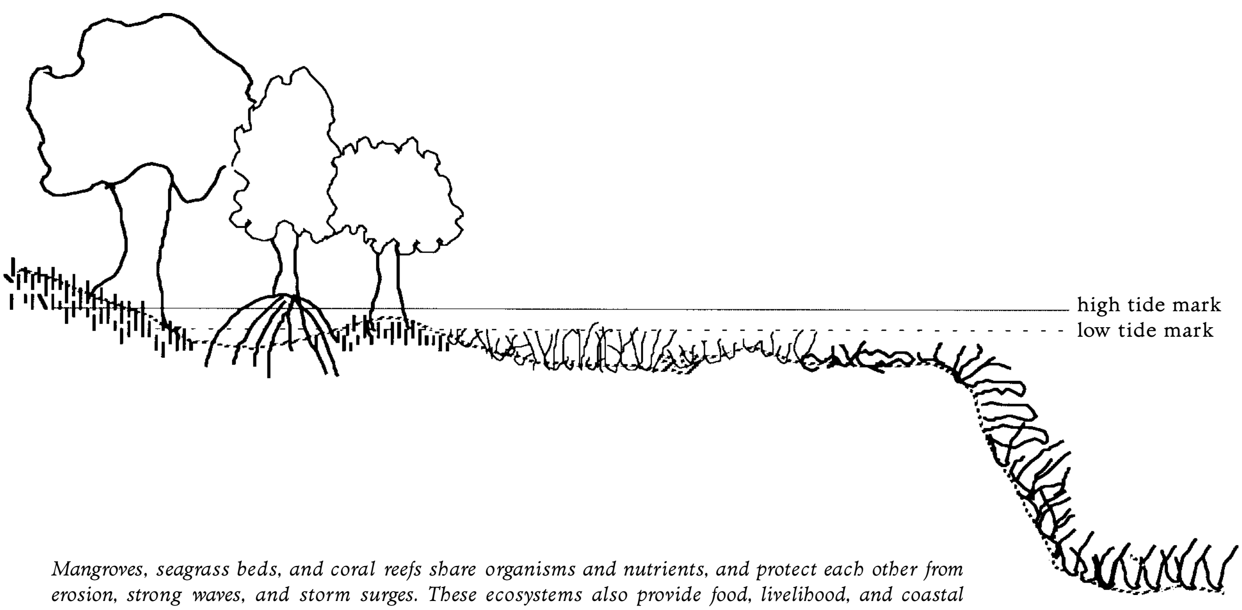
- collect debris and silt, build land
- protect coral reefs and seaweed & seagrass beds from siltation
- absorb nutrients from upstream
- nursery grounds
- produce leaf litter and nutrients
- protect coastal communities from strong winds
- provide food, wood, other goods

SEAGRASS & SEAWEED BEDS

- bind shallow-water sediments
- absorb nutrients
- nursery grounds: provide food, habitat, and refuge to juvenile animals
- feeding and breeding area

CORAL REEFS

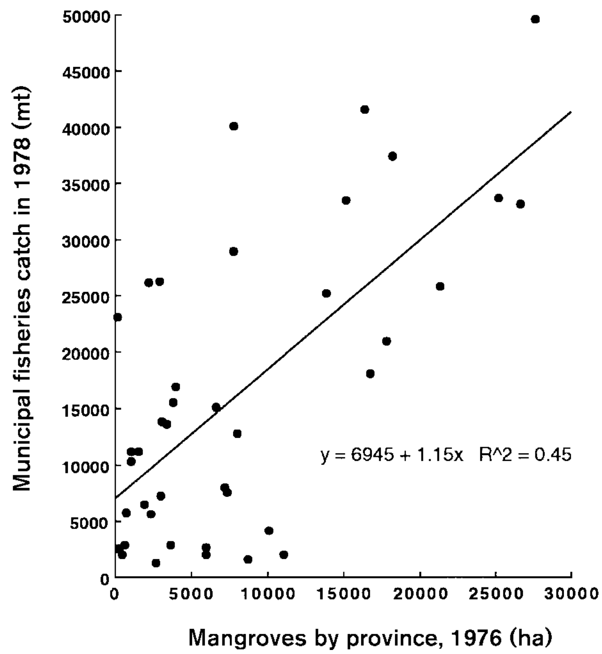
- habitat for enormous biodiversity
- feeding and breeding grounds
- absorb and recycle nutrients
- protect the coastal zone from storm waves
- provide food, medicine, ornaments



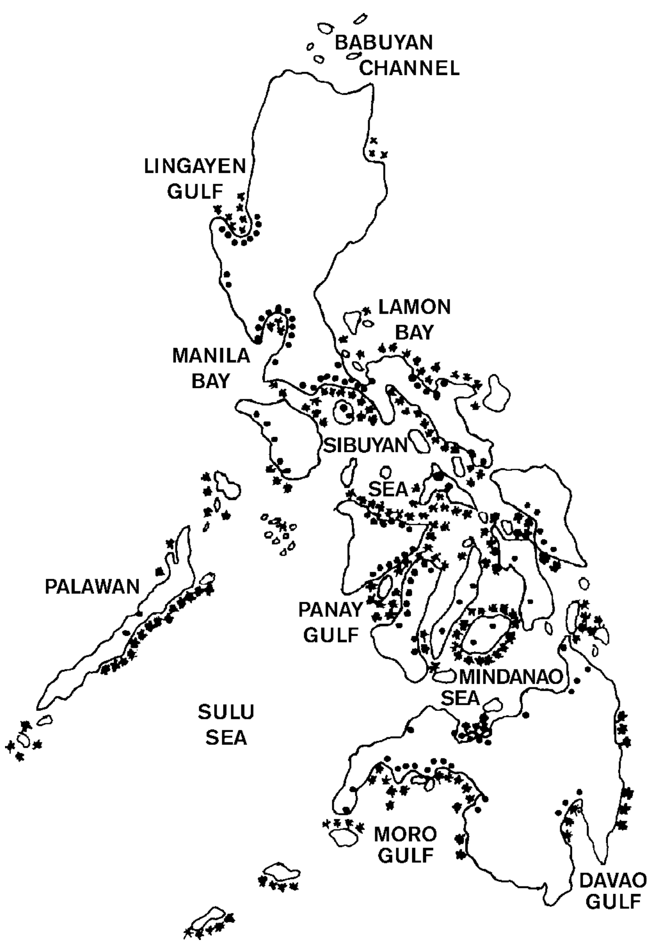
Mangroves, seagrass beds, and coral reefs share organisms and nutrients, and protect each other from erosion, strong waves, and storm surges. These ecosystems also provide food, livelihood, and coastal protection for human communities. From White (1987).

Loss of mangroves, or any of the major coastal ecosystems, increases the vulnerability of the coastal zone to strong winds, storm surges, erosion, siltation, and excessive nutrient loading. Ponds without a mangrove buffer zone are destroyed by several of the 20 typhoons that hit the Philippines each year.

Loss of mangroves means loss of fishery and forestry products, income, and jobs for many coastal inhabitants. The major fishing grounds in the Philippines are in, or adjacent to, what used to be extensive mangrove forests and swamps, mostly converted to fish and shrimp ponds. The catches from municipal fisheries in 40 provinces in 1978 were highly correlated with the areas of existing mangrove swamps at the time.



Annual catches from municipal fisheries in 40 provinces in 1978 were positively correlated with the area of existing mangroves in 1976. From Camacho and Bagarinao (1987).



Several of the major fishing grounds in the Philippines are adjacent to mangroves xxx and fishpond areas • • •

Indeed, recent studies have shown that mangrove forests and swamps left alone can be as productive as the better managed fish and shrimp ponds. Thus, fisheries harvests should be limited to new growth and must leave intact the basic structure of the mangrove community. Clearcutting the mangrove forest for firewood or conversion into fishponds is a poor way of using mangrove resources. The sustainable way is to harvest the interest (new production) and leave the capital (the mangrove ecosystem) to produce more interest for the next harvest.

Hanging net to catch jumping mullets in the mangroves, New Washington, Aklan, 1997.

Oyster farm and fish cages in the mangroves, Dumangas, Iloilo, 1994.

Salambaw *in the mangroves, Pagbilao Bay, Quezon, 1995.*

Fish corral near the mangroves, Pagbilao Bay, Quezon, 1995.

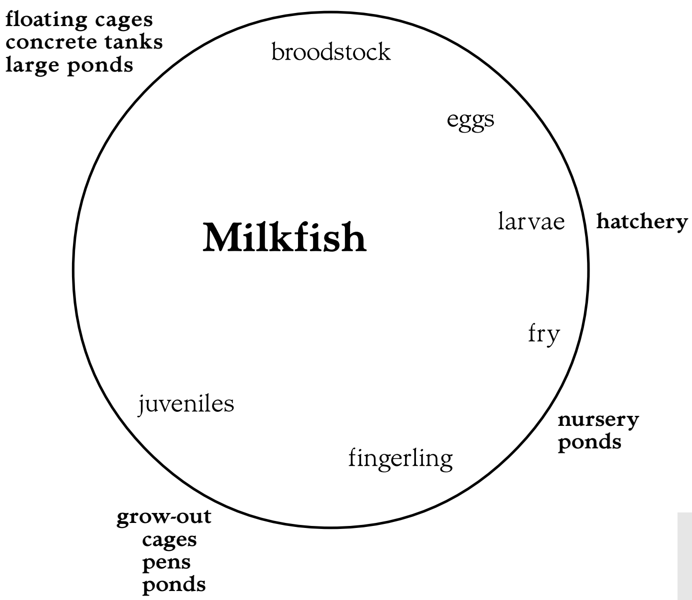
A family of fishpond workers in the Philippines, circa 1900s. From Seale (1908).

Marketing milkfish in Java, Indonesia. From Schuster (1960).

Chapter 5

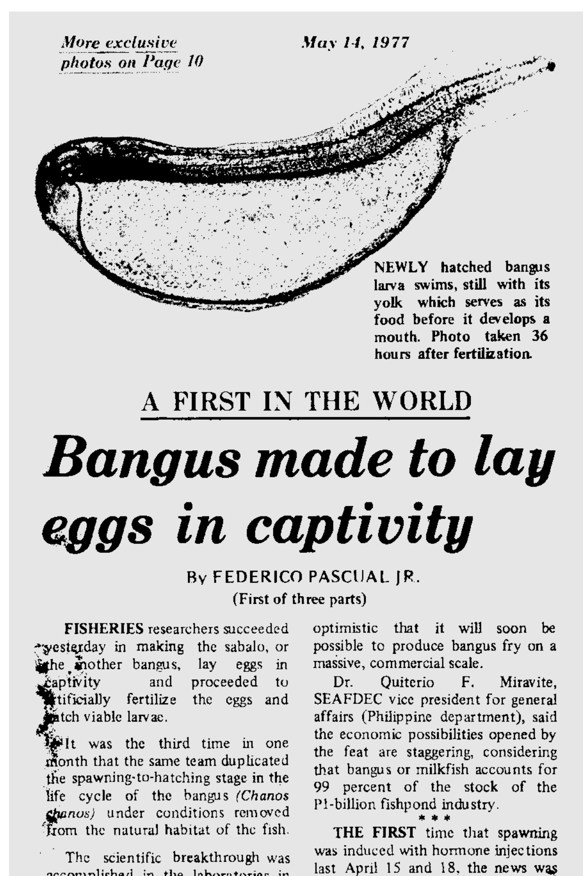
Milkfish in Aquaculture

Milkfish can now be maintained over the whole life cycle in size-specific culture systems. Eggs are spawned by captive broodstocks, then hatched and reared to fry stage in the hatchery. The harvested fry are grown in nursery ponds, then stocked in grow-out pens, ponds, and cages. Most juveniles are harvested for the market. Large juveniles may be grown into broodstocks in cages, tanks, and ponds, where they may spawn.



Successful induced spawning and larval rearing of milkfish were first accomplished at SEAFDEC AQD in 1976-1978. The first generation cycle of milkfish in captivity was completed at AQD when the offspring of a wild female induced to spawn in 1978 in turn spawned in 1983.

Since then, milkfish have matured and spawned in floating cages, ponds, and concrete tanks in the Philippines, Taiwan, Hawaii, and Indonesia.



More exclusive photos on Page 10

May 14, 1977

NEWLY hatched bangus larva swims, still with its yolk which serves as its food before it develops a mouth. Photo taken 36 hours after fertilization.

A FIRST IN THE WORLD

Bangus made to lay eggs in captivity

By FEDERICO PASCUAL JR.

(First of three parts)

FISHERIES researchers succeeded yesterday in making the sabalo, or the mother bangus, lay eggs in captivity and proceeded to tificially fertilize the eggs and atch viable larvae.

It was the third time in one month that the same team duplicated the spawning-to-hatching stage in the life cycle of the bangus *(Chanos chanos)* under conditions removed from the natural habitat of the fish.

The scientific breakthrough was

optimistic that it will soon be possible to produce bangus fry on a massive, commercial scale.

Dr. Quiterio F. Miravite, SEAFDEC vice president for general affairs (Philippine department), said the economic possibilities opened by the feat are staggering, considering that bangus or milkfish accounts for 99 percent of the stock of the P1-billion fishpond industry.

* * *

THE FIRST time that spawning was induced with hormone injections last April 15 and 18, the news was

Holding facilities for milkfish brood-stock: floating sea-cages in Igang, Guimaras, 1995.

Concrete tanks in Tigbauan, Iloilo, 1998.

Large earthen-bottom ponds in Naujan, Mindoro, 1997.

Broodstocks and spawners

Large juvenile milkfish may be stocked, fed, and maintained as broodstocks in floating sea cages in protected coves, in large deep concrete tanks on shore, and in large, deep, fully saline ponds. In the Philippines, only SEAFDEC AQD, a few government stations, and a few companies own milkfish broodstocks.

The Philippine government launched the National *Bangus* Breeding Program (NBBP) in 1981 to verify on a national scale and in various ecological conditions the technologies developed by SEAFDEC AQD for broodstock management, breeding, and hatchery. The NBBP was implemented by the Bureau of Fisheries and Aquatic Resources at 12 pilot sites in the 12 regions of the country, with technical assistance from SEAFDEC AQD and financial assistance from the International Development Research Centre (IDRC) of Canada. IDRC provided three-year funding for the NBBP sites in Pangasinan, Zambales, Bohol, and Davao to ensure adoption of the technology.

Some 3,668 adult milkfish were maintained in the NBBP floating sea-cages. But logistic and administrative problems hounded the NBBP and BFAR finally decided in 1995 to sell the broodstocks to the private sector.

In 1995, the Philippine government launched Project Sabalo, which called for the private sector to develop their own broodstocks. SEAFDEC AQD fast-tracked the transfer of the broodstock and hatchery technology to the private sector. Several milkfish farmers have since established their own broodstocks in response to SEAFDEC AQD's campaign.

Broodstock cages, formerly of the NBBP Davao City, now privatized, 1997.

Milkfish farmers in the Philippines behaved quite differently from those in Taiwan and Indonesia and did not take any initiative in milkfish propagation until very recently, probably because wild *semilya* are still abundant. In contrast, Taiwanese farmers developed their own broodstocks in their ponds and did some spawning trials even before their government fisheries institution succeeded in doing so. On the other hand, Indonesia has an annual festival where the biggest and most beautiful milkfish gets a prize; this festival served as incentive for pond owners to grow large milkfish. Many of these large pond-grown milkfish were bought by the government and developed into broodstocks.

Broodstocks reach sexual maturity in five years in large floating cages, but may take 8-10 years in ponds and concrete tanks. First-spawning captive spawners tend to be smaller, on average about 70 cm long and 3 kg in body weight, than adults caught from the wild. As a result, first-time spawners produce less eggs than wild adults, but larger and older captive spawners produce as many eggs as wild adults of similar size. Captive breeders about 8 years old and 6 kg in average weight produce 3-4 million eggs.

As many females as males are kept in each broodstock facility to maximize egg production and fertilization rates. Handling is minimized because milkfish are very excitable and stressed fish do not spawn. However, broodstocks in large enough water volumes, with good water quality and plenty of room for swimming, become tame enough to be petted.

Harvest of young broodstock from ponds, weighing, and transport, Negros, 1998.

Spawning of milkfish in the SEAFDEC AQD floating sea-cages occurs at various times from April to October, with peaks in May-July. These periods coincide with the natural spawning season of milkfish around Panay. Spawnings of milkfish in the ponds in Taiwan and in tanks in Indonesia also coincide with the natural season.

Spawning in captivity is not clearly related to particular lunar periods. On days when spawning occurs, the fish may feed less but show increased swimming activity, chasing, occasional leaping, and slapping of water from late afternoon to early evening, becoming more pronounced from 20:00 h. Spawning usually takes place around midnight, but daytime spawning sometimes occurs.

AQD's broodstocks in floating sea-cages in Igang have spawned every season since 1980, and those in concrete tanks in Tigbauan since 1990. The oldest milkfish in cages at SEAFDEC AQD are 20 years old and still spawning.

Formula of SEAFDEC AQD's practical diet for milkfish broodstock. From FDS (1994).

Ingredient	Amount (g/100 g dry diet)
Fish meal	20
Soybean meal	43
Rice bran	25.5
Bread flour	4
Cod liver oil	2
Vitamin mix, commercial	1.5
Dicalcium phosphate	4
Proximate composition:	
Crude protein	37.6
Crude fat	8.7
Crude fiber	3.9
Nitrogen-free extract	36.4
Ash	13.4

Broodstocks grow well on pelleted diets with 36% protein and 6% lipid, given at 3% of body weight per day in the morning and afternoon. A practical diet formula for broodstocks is given here. This broodstock diet was developed based on the known nutrient requirements of milkfish. Practical diets for milkfish larvae and juveniles were similarly based.

Nutrient requirements of milkfish. From FDS (1994).

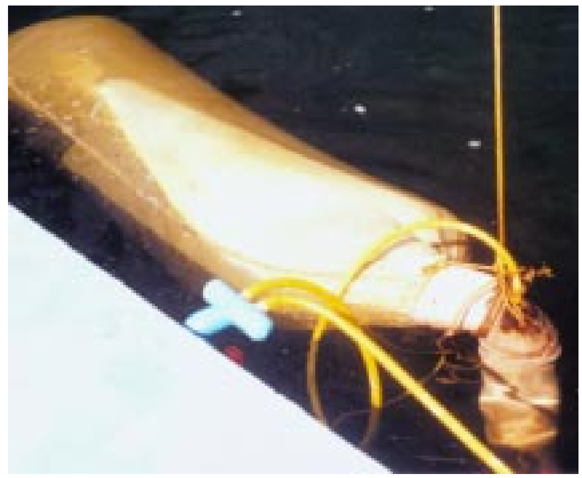
Nutrient	Requirement (% of dry diet)	
Lipid		7-10
Essential fatty acids	w-3 PUFA	1-1.5
Carbohydrate		25
Digestible energy	2500-3500 Kcal/kg	
Protein	fry	40
	juveniles	30-40
	protein: energy ratio	44
Essential amino acids	(% of protein)	
arginine	5.2	
histidine	2.0	
isoleucine	4.0	
leucine	5.1	
lysine	4.0	
methionine + cysteine	2.5 (cysteine 0.8)	
phenylalanine + tyrosine	4.2 (tyrosine 1.0)	
threonine	4.5	
tryptophan	0.6	
valine	3.6	

Eggs from broodstock facilities

Milkfish broodstocks spawn spontaneously and the eggs are fertilized as soon as they are released. The eggs must be collected soon after spawning or they would be eaten by cardinal fishes, anchovies, silversides, other species, and by the milkfish spawners themselves, within the confines of the tanks, cages, or ponds.

An efficient egg collector has been devised for circular floating sea-cages. Concrete tanks and ponds use airlift pumps or overflow systems that collect the eggs into plankton nets.

Egg collection device in circular cage.



Milkfish eggs filtered in plankton net in broodstock tanks.

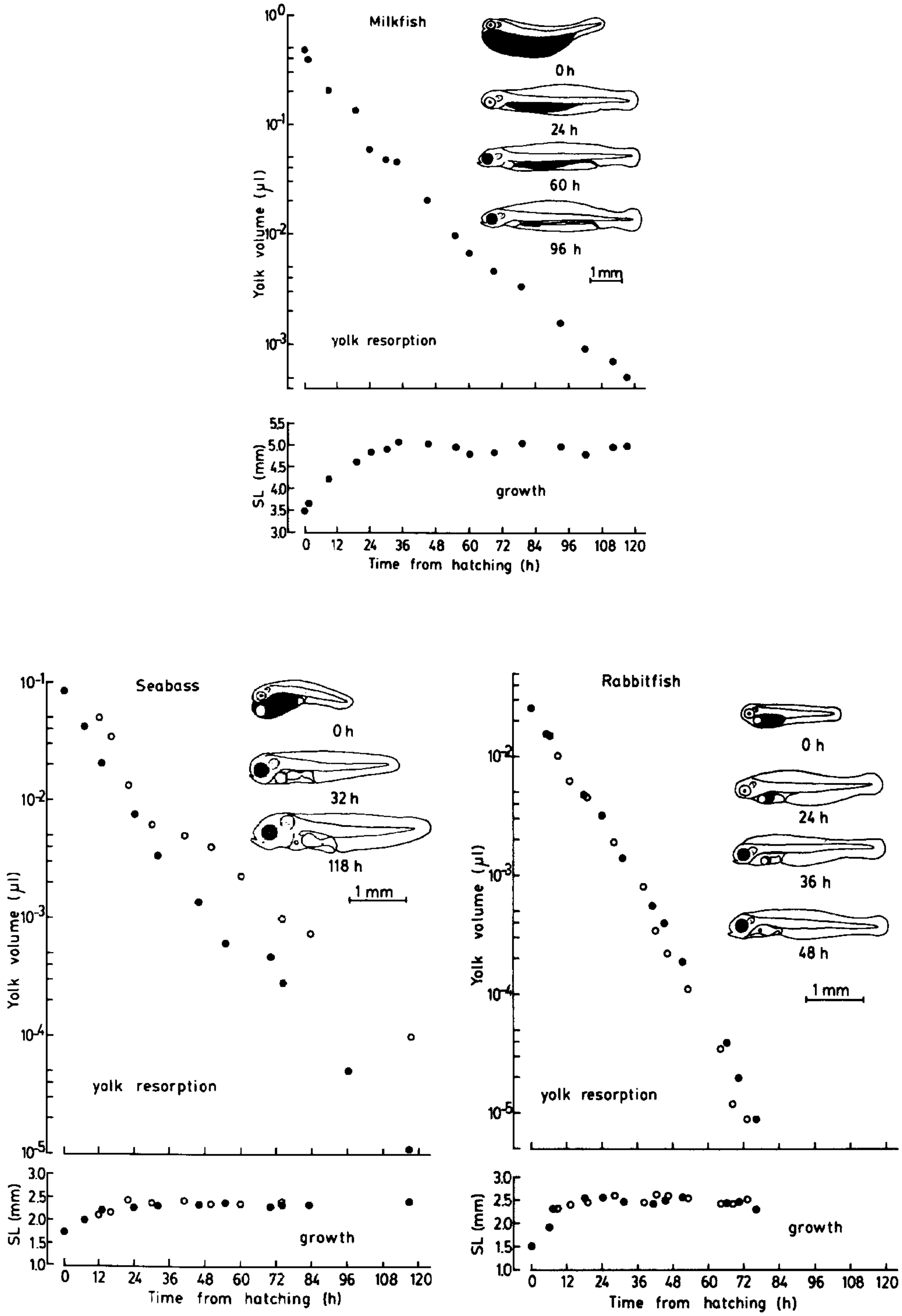
The eggs are taken to the hatchery for incubation and hatching. Eggs are better transported during the C-embryo stage, which is most resistant to stress. They are packed with oxygen in plastic bags at densities of 10,000-12,000 per liter. The water temperature is kept at about 24-26°C by putting the bags on an ice bed inside *pandan* bags or styrofoam boxes.

Good eggs remain transparent and suspended in the water column; dead eggs sink to the bottom. About 70-80% of the good eggs from captive broodstocks hatch, usually after about 24 hours. Viability of eggs is high when the broodstocks are well fed and healthy and the eggs are transported and handled carefully.

Good eggs stay suspended, bad eggs sink.

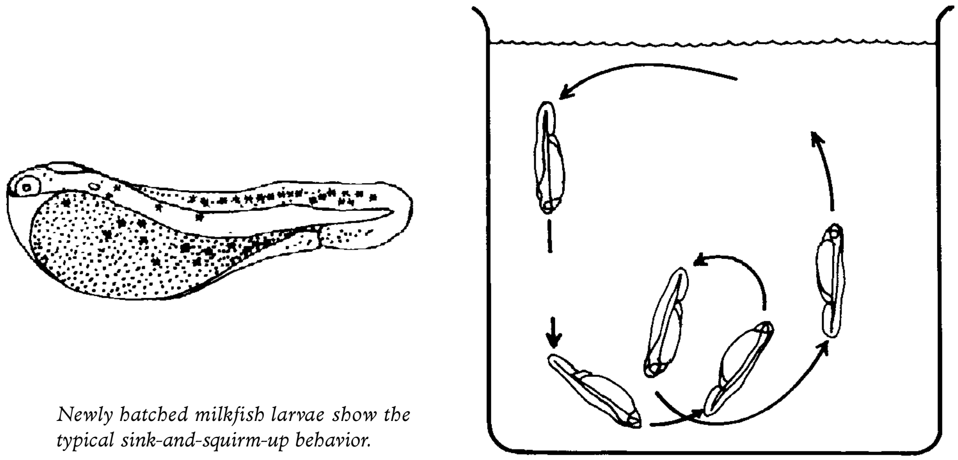
Larvae in the hatchery

At hatching, milkfish larvae are 3.5 mm long with a large yolk sac. During the next 24 hours, the larvae grow to 5 mm and use up 90% of the yolk. Egg size, larval size at hatching, amount of yolk, and initial mouth size are greater in milkfish than in many other tropical marine fishes, such as the sea bass *Lates calcarifer*, and the rabbitfish *Siganus guttatus.*

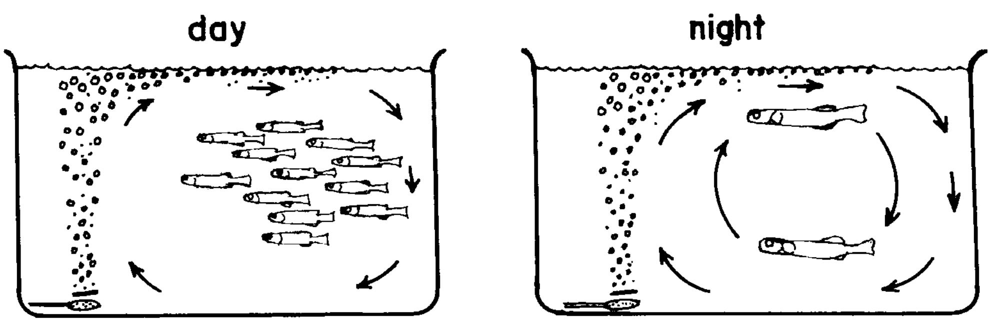


Yolk resorption and growth of milkfish larvae at 26-30°C, compared with those of seabass larvae and rabbitfish larvae, which are much smaller at hatching, have less yolk, but have oil globules. From Bagarinao (1986).

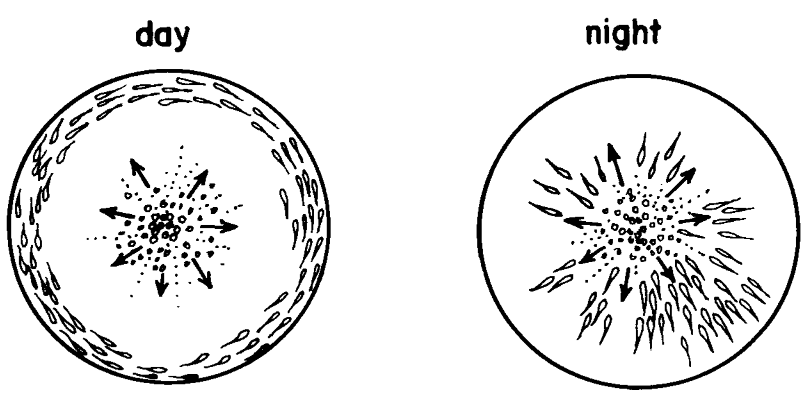
Yolk-sac larvae float passively in the water column, sink slowly because of the heavy yolk sac, and intermittently squirm back up to the surface. As larvae grow over the next three weeks in the hatchery, swimming behavior changes.



Newly hatched milkfish larvae show the typical sink-and-squirm-up behavior.



Side view of larvae and rearing tanks: Stages II and III larvae orient to the aeration bubbles and maintain position in the rearing tanks during the day, but drift with the current at night.

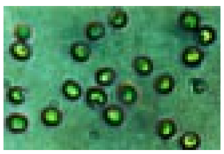


Top view of larvae in rearing tanks: Stage IV larvae swim around in brisk schools during the day, but swim slowly against the current at night. Larvae and tanks not to scale. From Liao et al. (1979).

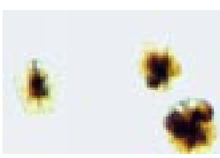
Larvae begin to feed on the third day when the eyes are fully pigmented, the mouth is open, and some yolk is still present. Rotifers *Brachionus* are given to first-feeding milkfish in the hatchery and brine shrimp *Artemia* nauplii are used for the two-week old larvae.

Milkfish larvae feed during the day. As larvae grow older, they feed at lower light intensities and in greater amounts; three-week old larvae can feed in the dark. Larvae become full after 2-3 hours of feeding and the food is digested after 5 hours.

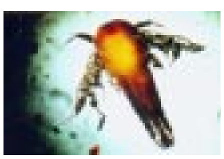
It is relatively easy to rear milkfish larvae in the hatchery by means of the feeding and water management scheme developed by SEAFDEC AQD, shown below. At a stocking density of 30 hatched larvae per liter, about 30% survive to harvest at day 21.



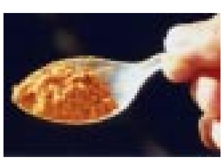
Chlorella, *a green microalga used to feed the rotifers and added to the larval rearing tanks to condition the water.*



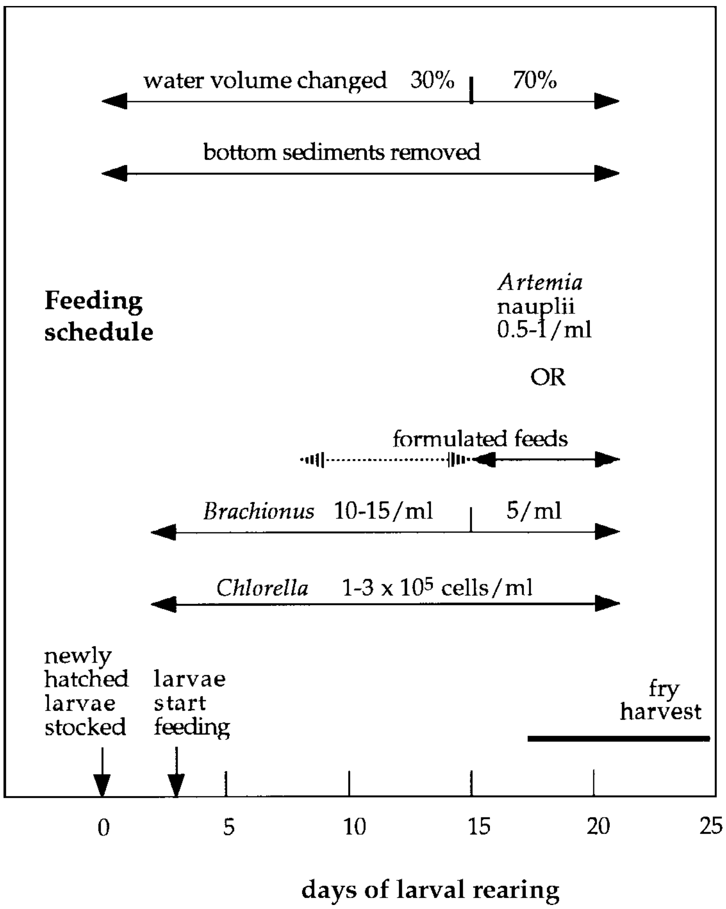
Brachionus, *a marine rotifer used to feed fish larvae.*



Nauplii (larvae) of the brine shrimp Artemia salina



Microparticulate artificial diets for milkfish larvae.



Water management and feeding scheme in the milkfish hatchery. Artemia *nauplii can now be replaced with microparticulate artificial feeds. Fry may also be harvested several days before or after day 21.*

Two-week old larvae can be weaned to artificial diets alone; younger larvae accept diets given with natural food. Various larval feeds of very fine particle size are now available to partially replace or supplement the natural food organisms used in larval rearing. Several of these larval feeds are available from Japanese or Taiwanese companies at high dollar prices.

A practical diet has been formulated at SEAFDEC AQD for milkfish larvae. This practical diet (particle size less than 250 µm) is recommended for use in intensive hatchery tanks where the stocking density is 30 larvae/liter and where rotifers are maintained at densities of 7-8/ml. The diet is given starting day 7 at a rate of 8 grams per ton rearing water per day. The feed is given four times a day at 09:00, 11:00, 13:00, and 15:00. The feeding rate is increased to 12 grams per ton per day on day 15 until harvest.

Formula of practical diet for milkfish larvae at 7-21 days in the hatchery. From FDS (1994).

Ingredient	Amount (g/100 g dry diet)
Fish meal	33
Soybean meal	18
Squid meal	10
Shrimp meal *(alamang)*	12
Bread flour	6.69
Cod liver oil	8
Vitamin mix, commercial	3
Mineral mix	3
DL-alpha-tocopherol acetate	4
Lecithin	1
Butylated hydroxyanisole	0.05
Beta-carotene	0.25
Kappa-carrageenan	5
Proximate composition:	
Crude protein	46.3
Crude fat	11.4
Crude fiber	5.6
Nitrogen-free extract	27.3
Ash	9.4

Most milkfish hatcheries operate at the intensive level, with stocking rates of 30 larvae per liter and feeding as described above. Semi-intensive hatcheries are now being verified – these have larger larval rearing tanks, where natural food (rotifers, diatoms, copepod nauplii) are first grown before the larvae are stocked.

The milkfish hatcheries at SEAFDEC AQD. Chlorella *culture tanks shown in the foreground.*

Culture of rotifers with Chlorella*.*

Hatching of brine shrimp cysts to produce nauplii.

Culture of rotifers with yeast.

At harvest, hatchery-reared milkfish larvae are of various sizes. Many are darker and more robust than shore-caught fry, others are as long and transparent, but some are smaller. Confined in containers, both hatchery-reared and wild fry are strong swimmers that go around in cohesive groups or schools.

Harvest in a milkfish hatchery.

Hatchery-reared fry are mostly dark and more advanced in development.

Milkfish with opercular deformities.

Some hatchery-reared milkfish show deformities after metamorphosis, during the nursery phase—deformed branchiostegal rays, cleft branchiostegal membrane, and deformed opercular bones and exposed gills. But deformities are negligible where nursery ponds have enough natural food and good water quality. Growth and survival (80-93%) are similar for wild and hatchery-reared milkfish in nursery ponds and in grow-out ponds.

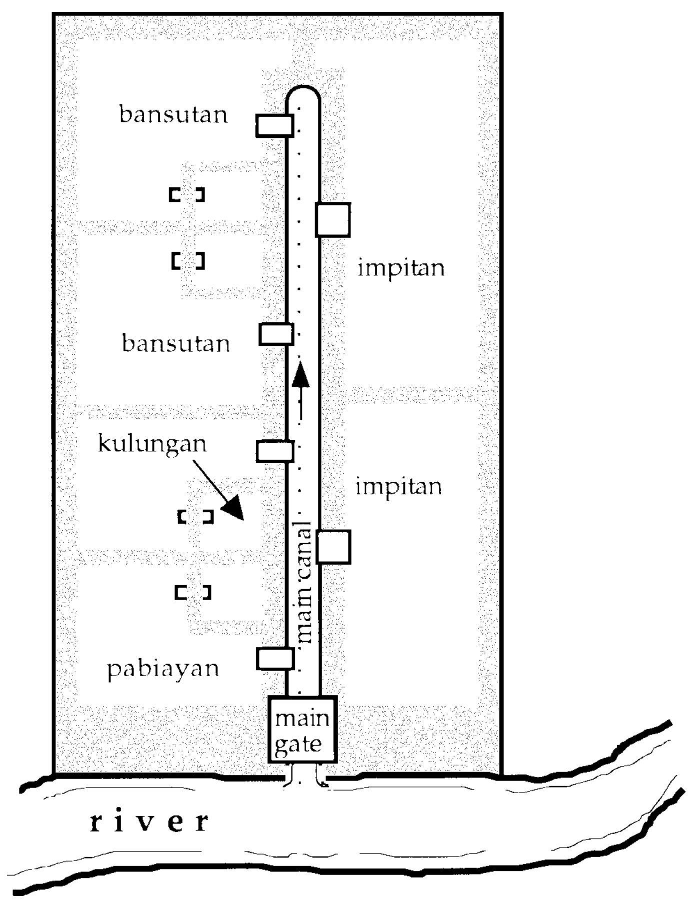
Semilya and fingerlings in nursery ponds

In milkfish farming, *semilya* from the wild or from the hatchery are first grown into 'fingerlings' for 1-2 months in nursery ponds, then for another 3-4 months in grow-out ponds. Fingerlings may be grown to, and sold at different sizes called *dampalit* (2-4 cm, 1-3 g), *hatirin* (4-7 cm, 3-6 g), and *garongin* (7-15 cm, 5-10 g), Some fry dealers double as nursery pond operators; they keep the low-priced or unsold *semilya* from the peak season and sell the fingerlings at a much higher price during slack periods.

Dampalit, Malabon, Rizal has historically been the center of the fingerling industry; it supplied the needs of grow-out ponds around Manila Bay. Many pond operators in Pangasinan, the Visayas, and Mindanao grow their own fingerlings in small nursery ponds incorporated in their pond systems, but some operators in Bulacan specialize in fingerling production only.

The methods and practices of growing fingerlings have not changed much over the past 70 years. Nursery ponds are typically shallow and range 500-5,000 m^2 in area, or 3-5% of the area of a complete pond system. The nursery pond proper, called *pabiayan, semilyahan,* or *palakihan*, has a small catching pond called *kulungan* at the corner, a few transition ponds called *impitan* or *bansutan*, and a system of water supply canals. The ponds are prepared to grow *lablab*, then stocked with 100,000-500,000 fry/ha. Transfer or harvest of fish is done at night or late afternoon when it is cool.

Fingerlings that could not be sold or transferred to grow-out ponds may be kept in the *bansutan* at densities of 10-15/m^2. Under crowded conditions with limited food, the fish are stunted but do not die. When later transferred to grow-out ponds, stunted fish compensate and grow just as fast as non-stunted fish. This stunting technique allows farmers to buy *semilya* in bulk during the peak season and to stock fingerlings several times during the year. But stunting entails a loss in productivity in terms of time.



A typical nursery pond system for milkfish. The nursery pond proper (pabiayan) *has a small catching pond* (kulungan), *a few transition ponds* (impitan *or* bansutan), *and a system of water supply canals coming from the river.*

Raising fingerlings in hapa nets inside ponds.

Nursery rearing of milkfish has also been done in suspended nylon *hapa* nets installed in brackishwater ponds or lagoons, and in freshwater lakes. The *hapa* net method requires an adequate plankton supply, otherwise fine feeds must be provided. Fingerlings have also been raised in concrete raceways in fresh water.

Fingerlings are packed and transported in plastic bags, about 10-60 per liter of water, depending on size. Nursery ponds in Bulacan transport fingerlings to Laguna de Bay in live-fish boats or *petuya* that can each carry 50,000-120,000 fish, depending on the boat size, fish size, expected weather, and fishpen location. Mortality averages 2% after 4-6 hours transport in a *petuya*.

Petuya *for fingerling transport.*

Before the *hatirin*, *dampalit*, or *garongin* are released, they are first acclimated over several hours to the salinity and temperature of the farm. Gradual acclimation is very important, especially where fingerlings come from low-salinity ponds and stocked in marine cages and pens.

Live fingerlings used to be exported (over 2.2 million in 1979) to Taiwan to fill the requirement of ponds there, but this export was stopped in 1985. The flow was reversed in recent years when hatchery-reared fry were imported from Taiwan and Indonesia by some of the large nursery pond operators.

Live or frozen fingerlings are also used as bait in tuna fishing. Taiwan farmers supply fingerlings to tuna fleets, but some bait boats obtain fingerlings from the Philippines.

Bangus grow-out in brackishwater ponds

Milkfish fry or fingerlings are stocked and grown out in different farming systems (ponds, pens, and cages) to sizes of 200-400 grams body weight. At these market sizes, milkfish are called *bangus* in Tagalog, *bangrus* in Ilonggo, or *kugaw* in Cebuano.

Milkfish farming in ponds now includes a wide range of practices and systems ranging from traditional extensive to modern intensive. However, there is no information on how many farmers are engaged in which farming system, and in particular, the proportion now operating at semi-intensive to intensive levels. Some shrimp farms now stock milkfish fingerlings at rates of 10,000-30,000/ha, encouraged by the increased demand for milkfish, the availability of commercial feeds, and the need to use existing shrimp ponds and recover losses from shrimp farming.

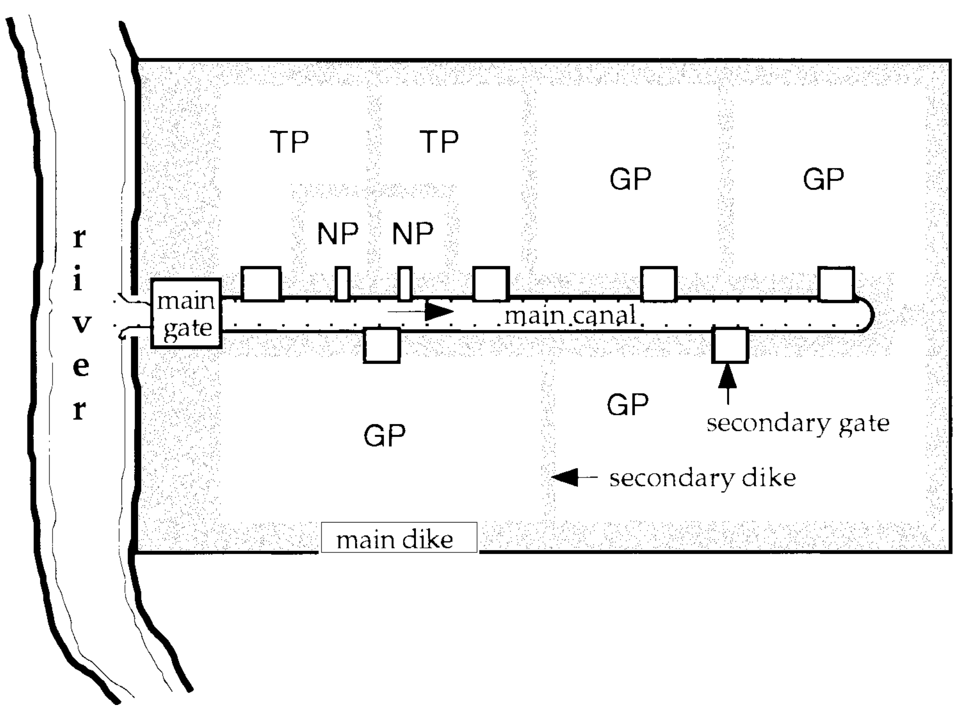
Milkfish farming intensities in brackishwater ponds in the Philippines. From Cruz (1995) and Bagarinao (1998).

Farming intensity, methods	Stocking rate (*fingerlings/ha)	Food supply	Water depth (cm)	Pond size (ha)	Water management	Crops a year	Expected yields (mt/ha-yr)
Extensive shallow-water straight-run		natural food grown with or without organic fertilizers					
1) traditional	1,000-2,000	*lumut* (needs freshwater)	40-60	2-50	tidal exchange	1-2	0.5-0.6
2) improved	2,000-3,000	*lablab* (needs lots of sun)	40-50	2-50	tidal exchange	1-2	0.7-1
Modified extensive		natural food grown with organic & inorganic fertilizers, plus supplemental energy-rich feed					
1) deep-water, plankton	3,000-5,000	plankton (unpredictable growth)	60-100	1-10	tidal exchange	1-2	0.5-1.7
2) multi-size stocking**	3,000	*lablab* + plankton or *lumut*	80-100	1-10	tidal exchange	2-3	1.5-2
3) modular or progression	3,000	*lablab* + *plankton*	40-50	1-10	tidal exchange	6-8	2-3
Semi-intensive	7,000-12,000	*lablab* for 30-45 days, then protein-rich feed	40-50, then 75-120	1-5	tidal, with supplemental pumping	2-3	2-4
Intensive	20,000-30,000	'complete' feed only	100-150	0.1-1	mainly pumping, with aeration	2-3	4-12

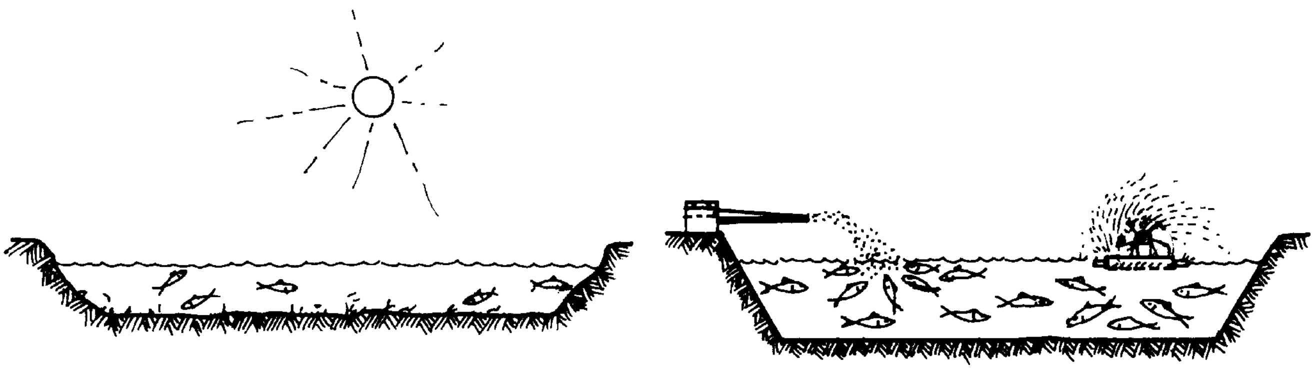
Lumut is filamentous green algae, *lablab* is cyanobacterial mat with diatoms, small invertebrates
* Fingerlings usually 2-5 g
** Sizes: 2-5 g, 10-25 g, 30-60 g, 80-120 g each group at 1,000/ha

Extensive ponds with lumut, Negros, 1997.

Most milkfish ponds in the Philippines are still of the extensive type, with large shallow pond units, tidal water exchange, natural food, minimal use of fertilizer and other inputs, low stocking rates, and no diseases. A half-meter deep pond stocked with 3,000 fingerlings/ha has only 0.6 fish/m^3; compare this later with stocking rates in intensive ponds, pens, and cages. Usually, the dikes and gates are not well made, the pond bottom is not levelled, and the water supply system is inadequate. Extensive ponds may still have a complex community structure, and various other species may be harvested with milkfish. Aside from the cost of land, not much capital is required to operate extensive ponds.



An extensive pond system has large grow-out ponds GP that receive fish from transition ponds TP, that in turn receive fingerlings from the nursery ponds NP. Canals bring in water from the river-estuary. There is ideally a 20-meter mangrove strip between the river and the ponds.



traditional extensive ponds

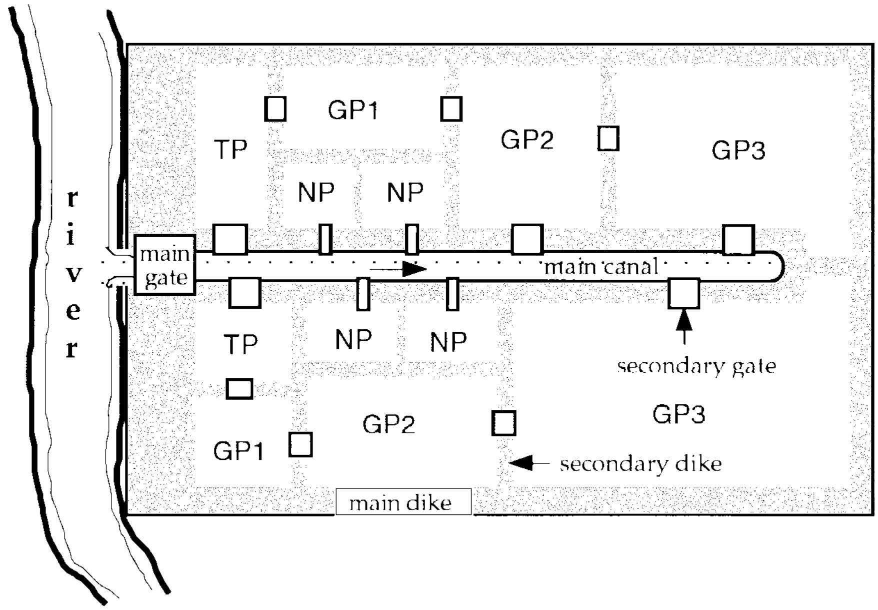
- large but shallow pond units
- 30-40 cm deep
- organic and inorganic fertilizers added
- natural food grown under the sun
- low stocking rate
- tidal water exchange
- no aeration
- maximum yield 1 mt/ha-yr

modern intensive ponds

- smaller pond units
- 100-200 cm deep
- 'complete' pellet feeds given
- stocking rate 5-10x higher
- water pumps used
- paddlewheel aerators
- max yield 4-12 mt/ha-yr

In pursuit of higher yields, some farmers have converted extensive into intensive ponds, or built intensive ponds from ground zero. But not all extensive ponds can be turned intensive, even where capital is available. There may be no electricity in the area, or the water source is not adequate, or the farmers have other priorities. Thus, most milkfish ponds have remained extensive or have turned modified extensive or semi-intensive.

Such farms increase the carrying capacity of the ponds in various ways. Ponds are made deeper to increase the water volume. Water exchange efficiency is improved by widening or properly positioning the gates, by providing a separate drain gate, or by using water pumps. The oxygen supply is improved by maintaining good phytoplankton growth and by providing paddlewheels for aeration. Stocking rates are increased, with fish of one size or several sizes. Natural food is grown and used for 30-45 days of the crop cycle and good-quality diets are used thereafter. Moderate stocking rates and feeding rates reduce the threat of oxygen depletion, toxic gases, and diseases. The pond ecosystem is kept in balance with the larger supporting ecosystem, and pollution of the surrounding water bodies is minimal. High yields and moderate capital and operating costs allow a profitable return on investment within a short period.



A modular pond system has grow-out ponds GP of three sizes, in the ratio of 1:2:4 or 1:3:9, that receive fish from the transition ponds TP, that in turn receive fingerlings from the nursery ponds NP. Canals bring in water from the river-estuary. There is ideally a 20-meter mangrove strip between the river and the ponds.

The modified extensive modular system allows 6-8 crops and yields of 2-4 mt/ha per year and has been proven to be profitable. The rearing ponds are built as modules of size ratios 1:2:4 or 1:3:9. The nursery ponds and the transition ponds together comprise 6-10% of the total farm area and are stocked with a whole year's *semilya* requirement. The grow-out ponds are prepared with *lablab* in time for each stock transfer. Fingerlings are stocked in module 1 and grown for 30-45 days, moved to module 2 and grown for another 30-45 days, then transferred to module 3 and grown, sometimes on formulated feeds, until harvest. After each stock transfer or harvest, the ponds are prepared again. The usual stocking rate is 12,000 fingerlings/ha in module 1, but when the fish are moved into the larger module 2, the density is only 6,000/ha, and only 3,000/ha in module 3. Calculated per unit water volume for 50 cm deep ponds, the stocking rate is 2.4 fish/m^3 in module 1 when the fish are small, but only 0.6 fish/m^3 in module 3 when the fish are grown.

Comparison of profitability of modular versus straight-run extensive pond systems.
From Agbayani et al. (1989).

	Modular ponds	Straight-run ponds
Number of crop cycles or harvests a year	6	2-3
Production (kg/ha) per harvest	314	545
Revenues (P/ha) per harvest, 1985-86	6,599	11,445
Total cost (P/ha) per cycle, 1985-86	4,615	7,676
Net income before tax (P/ha) per harvest	1,984	3,769
Net income before tax (P/ha) per year	11,904	7,538-11,307
Income tax (P), 1985-86	786	696
Net income after tax (P/ha) per year	11,118	6,842-10,611
Investment requirement (P), 1985-86	18,216	18,946
Return on investment (%)	61	36-56
Return on equity (%)	122	72-112
Payback period (year)	1.34	1.64
Revenues	39,596	34,335
Variable cost	16,668	14,028
Marginal revenues from modular system	5,261	
Marginal cost	2,640	
Net benefit	2,521	

A small number of milkfish farms now operate at the intensive level, with deeper, generally smaller pond units, high levels of all inputs (seed, feeds, water, energy), and as a result, high yields. Intensive ponds have concrete gates, sometimes concrete dikes, levelled pond bottoms, elaborate water and oxygen supply systems, and automatic feeding machines. Oxygen depletion is a constant threat, and sulfide, ammonia, and diseases can become problems. Chemicals and antibiotics are usually used. Intensive ponds require huge capital investments, large maintenance and operating budgets, and technical manpower. Effluents from intensive ponds pollute the surrounding water bodies, and the ponds themselves. Intensive ponds have a highly simplified and unbalanced community structure. A one-meter deep pond stocked with 30,000 fingerlings/ha has 3 fish/m^3 throughout the crop cycle. At the end of the cycle, when fish average about 300-400 grams, the biomass would be about 1 kg/m^3.

Large intensive ponds, Sarangani, 1997.

Intensive pond with feeder, Negros, 1997.

Pond operations usually include the following phases: pond preparation and stocking, nursery phase, transition phase, grow-out, and harvest. But some farms do not have nurseries and directly stock fingerlings. There are established methods for pond operations, but farmers practice a lot of flexibility and variability in their operations. The basic methods are outlined below:

Pond preparation

(Aim: to oxidize pond sediments, flush out toxic substances, kill pests, improve water quality, and encourage growth of natural food)

1. Drain the pond, remove debris, and level the pond bottom.
2. Dry the ponds until the soil cracks (1-2 weeks).
3. Install fine-mesh nets at the gates to prevent loss of stock and entry of predators.
4. Fill the pond with water 5-15 cm deep, then drain the water out after 3 days.
5. Repeat drain-and-dry cycle once or twice if necessary.
6. Broadcast lime. Lime plus urea or ammonium sulfate together act as pesticide.
7. Broadcast organic fertilizer such as chicken manure (2 tons/ha).
8. Broadcast inorganic fertilizers such as urea (20 kg/ha) and ammonium phosphate (50 kg/ha) 2-3 days later.
9. Fill the pond with water gradually to 5 cm deep, then 10 cm, then 15 cm.
10. *Lablab* will grow if the pond conditions are right.
11. Fill the pond to 30-40 cm when *lablab* is well established.

Fish transport or transfer, acclimation, and stocking

1. Transport or transfer fry or fingerlings early morning or late afternoon.
2. Drain the pond slowly and drive the fish gently into other ponds.
3. If fish must be packed in bags, allow them to empty the guts. Use clean water and add oxygen in packing.
4. Allow fish time to acclimate to the temperature and salinity of the new pond.
5. Stock fish of one size for one-time harvest, or several sizes for multi-harvest.

Feeding

1. Maintain the growth of natural food by applying fertilizers during the crop cycle.
2. No need to feed fish in ponds with adequate natural food.
3. Give supplemental diet or 'complete' feed when natural food is inadequate.
4. Transfer growing stocks to larger, newly prepared ponds with natural food.
5. Use appropriate feeding rates and schedules for the size of fish.
6. Do not feed fish when dissolved oxygen in the ponds is less than 3 ppm.

Water renewal and stock monitoring

1. Watch the pond to detect changes and fish distress.
2. Change pond water every two weeks or whenever necessary.
3. Sample the stock and monitor growth.

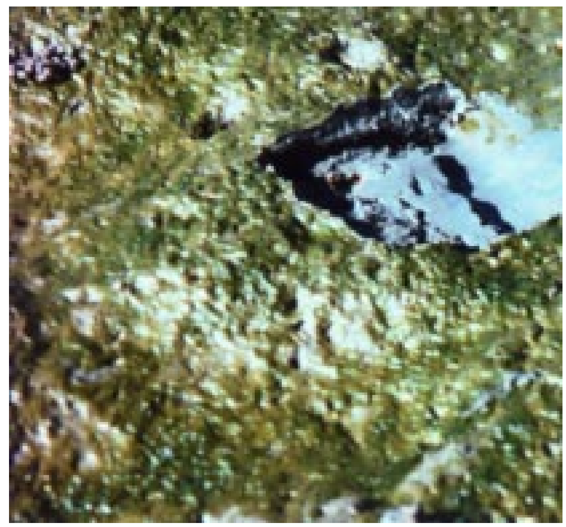
Harvest

1. Check market situation and milkfish prices.
2. Drain ponds slowly and harvest the fish at night or early morning.
3. Seine the fish, or use water currents to draw fish into a clean harvest area.
4. Place harvest in chilling tank with two blocks of ice for each ton of fish.
5. Pack, transport, and sell fish chilled or quick-frozen to maintain freshness.

Draining and plowing the pond before a crop cycle.

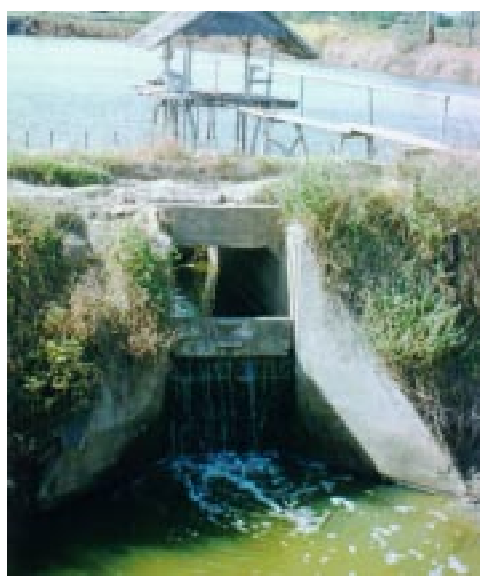
Pond bottom must be dried to cracking.

Applying fertilizers, lime, etc.

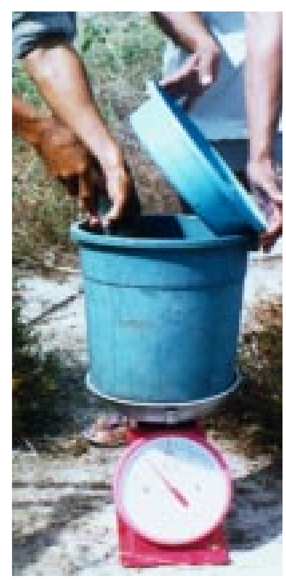


Lablab *starting to grow on pond bottom.*

Acclimating the fingerlings before release.



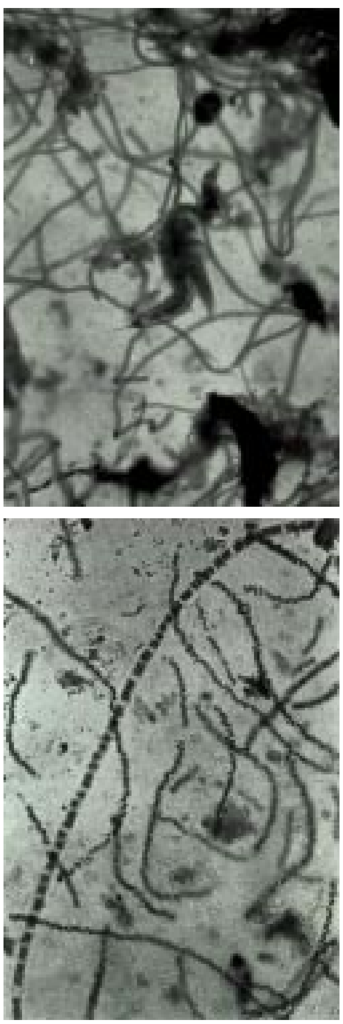
Water renewal is very important.



Monitoring fish growth.

In shallow-water nursery and grow-out ponds, milkfish grow best on *lablab*, a bottom-growing natural food.

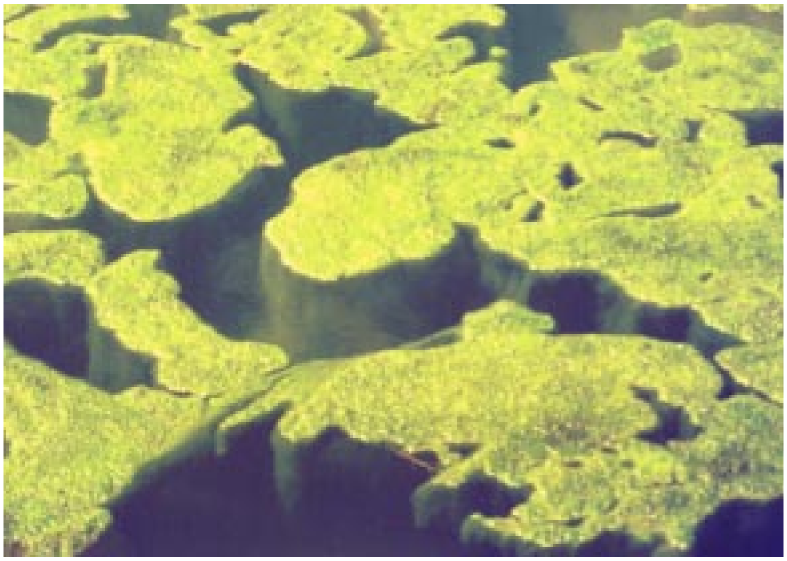
Lablab: what do we know about it?



Lablab components seen under the microscope.

- One of the natural food in ponds (others: *lumut, digman, kusay-kusay,* plankton)
- A benthic mat with various components:
  - unicellular, colonial and filamentous blue-green algae or cyanobacteria *Lyngbya, Oscillatoria, Phormidium*
  - a great variety of diatoms (*Navicula, Pleurosigma, Nitzschia,* etc.)
  - some unicellular or very fine threads of green algae
  - bacteria
  - many protozoans
  - minute worms
  - copepods and other small crustaceans
- Cyanobacteria dominate in fertilized ponds, but diatoms take over in unfertilized ponds
- In organically fertilized ponds, contains 952 cal/m^2 or 3.8x more energy than in unfertilized ponds (253 cal/m^2)
- Has high protein digestion coefficients: 87% for the diatoms and 69% for the cyanobacteria
- Has a relatively high cholesterol content due to its animal components, high amounts of palmitic and palmitolic fatty acids
- Has low levels of polyunsaturated fatty acids
- Under some conditions, the benthic mat can detach and float
- *Lablab* has 6-20% protein, 1-2 kcal/g, 5-807% ash, and 1% lipid
- Preferred by all sizes of milkfish
- fingerlings 2.5 grams in body weight consume *lablab* equal to 60% of their body weight per day
- Juveniles 100-300 grams in body weight eat about 25% of their body weight
- Already cultivated and used in milkfish farming in the Philippines in the 1920s
- Cultivated by farmers to support milkfish for 30-45 days
- A hectare of nursery ponds with a good growth of *lablab* can support 300,000-500,000 fry for 4-6 weeks until they reach 4-5 cm
- A fertilized grow-out pond with *lablab* can support 500-700 kg/ha increment in total fish weight over 2-3 months
- About 25,000 kg/ha of *lablab* is needed to produce 2,000 kg/ha of milkfish
- Clay-loam and loam soils with pH 7-9 and more than 3% organic matter are favorable for the growth of *lablab* in milkfish ponds
- Shallow ponds allow the growth of *lablab* but limit the carrying capacity of the pond and the potential yield per hectare

Some ponds can not grow *lablab*, but instead a dense cover of *lumut* or filamentous green algae. Fresh *lumut* is mostly indigestible cellulose and thus of little value as food, but decomposed *lumut* with microbial growth can be used by milkfish.



Floating lumut *can cover the pond.*

Milkfish at automatic feeder.

In deep-water ponds and in pens and cages stocked with high densities of milkfish, the main food used is dry pellets produced by the many feed mills in the country. In the smaller farms, the feeds may be broadcast by hand, but in the larger farms, various forms of automatic feeders are necessary.

Commercial feeds are now used in milkfish ponds, Negros, 1997.

Formula of practical diet for juvenile milkfish in grow-out ponds. From FDS (1994).

Ingredient	Amount (g/100 g dry diet)
Fish meal	10.8
Soybean meal	23.8
Cassava leaf meal	13
Rice bran	27.9
Rice hull	15.5
Bread flour	5
Cod liver oil	8
Soybean oil	2
Proximate composition:	
Crude protein	24
Crude fat	9.3
Crude fiber	11.3
Nitrogen-free extract	43.5
Ash	11.9

A practical diet with 24% protein has been found optimal for milkfish growth, production, and profitability in semi-intensive ponds with natural food. This diet is recommended for use in ponds with stocking density of 7,000 fingerlings/ha. The diet is first given when the milkfish biomass has reached 300 kg/ha, about one month after stocking. The recommended feeding rate is 4% of biomass per day.

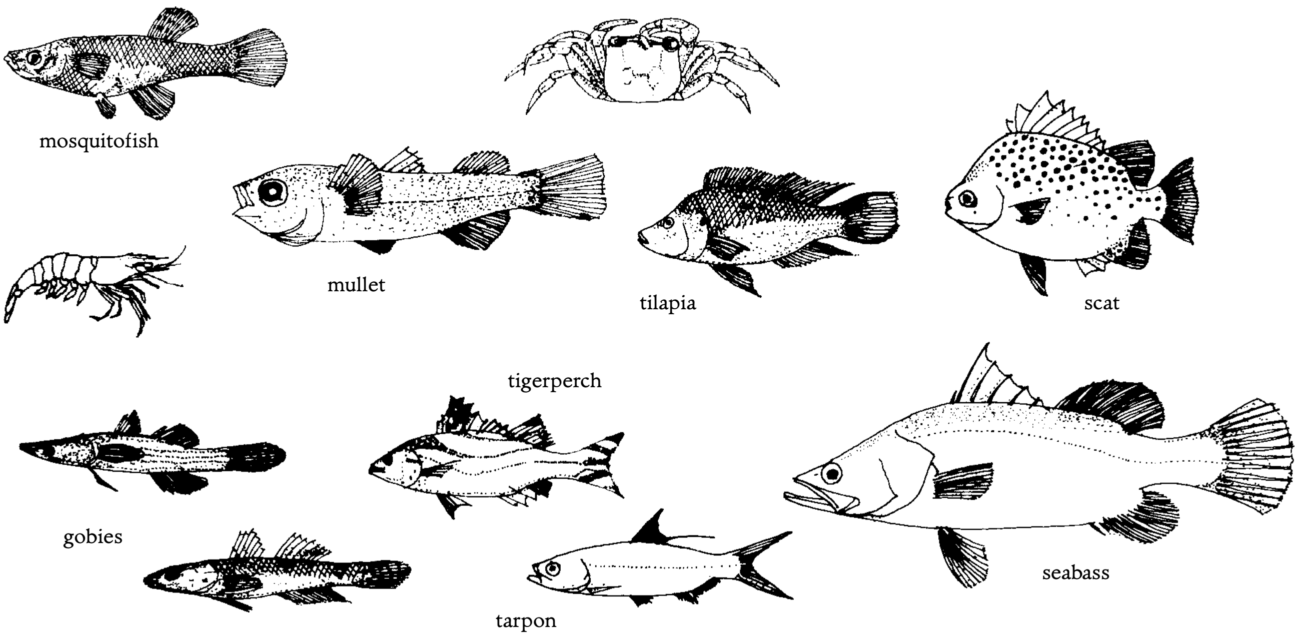
A similar feed with 27% protein used in ponds with 8,000 fingerlings/ha increased production when given at 4% of biomass 3x a day, up to a maximum of 38 kg/ha-day. At feeding rates more than 38 kg/ha-day and milkfish biomass more than 835 kg/ha, the dissolved oxygen falls below the lethal level of 1 ppm at dawn.

Milkfish stocks in ponds, and in pens and cages as well, must be provided enough oxygen to process their food, swim, and grow. Like most fish, milkfish gets oxygen in the dissolved form from the water that it passes over the gills. Farmers must estimate the total oxygen demand and balance it against the total oxygen supply in the farm and maintain a safe ambient oxygen level of 3 ppm.

Milkfish in ponds feed mostly around noon and in the afternoon. They prefer natural food during light hours, but take more feeds in the dark when both are present at all times. Milkfish stop feeding when dissolved oxygen falls below 1.5 ppm, but continue feeding in the dark when oxygen levels are greater than 3 ppm. Feeds given when the dissolved oxygen is less than 1.5 ppm is merely wasted. When dissolved oxygen is less than 1.5 ppm in the morning before photosynthesis gets going, the morning feed ration should be withheld.

Various kinds of feeds are now used for milkfish.

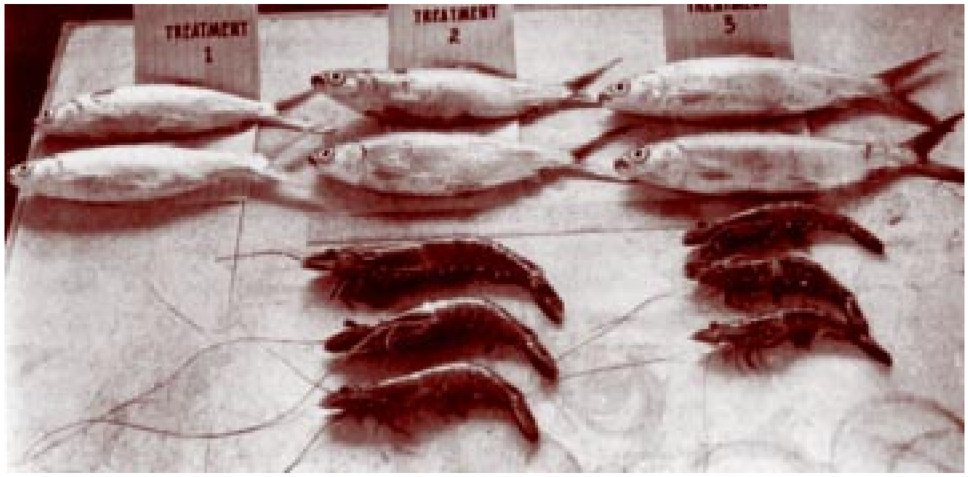
Milkfish ponds harbor many other species, including fishes, crabs, snakes, and birds that may prey on milkfish of appropriate sizes. Mullets, tilapias, rabbitfishes, scat, and mosquitofish may compete with milkfish for *lablab* and other natural food. Mosquitofish and tilapia often become abundant in ponds and cause reduction in milkfish yield.



The pond snail, suso *or* Cerithidea cingulata.

Various crabs, snails, polychaetes, and chironomid fly larvae are also considered pests in ponds because they destroy the pond bottom and dikes, or interfere with the growth of *lablab*. For example, the *suso* snail *Cerithidea cingulata* reaches counts of 700-7,000/m^2 and weights of 3-4 kg/m^2 in ponds.

The molluscicides Aquatin and Brestan were used for about 10 years to kill snails in milkfish ponds. These triphenyltin compounds persist in milkfish, water, sediments, and other pond organisms, and cause various health problems among farm workers. Thus, Aquatin and Brestan were banned by the Department of Agriculture in 1993.



Results of experiments of Eldani & Primavera (1981). Treatment 1, milkfish at 2,000/ha. Treatment 2, milkfish with tiger shrimp at 4,000/ha. Treatment 3, milkfish with tiger shrimp at 8,000/ha.

Milkfish can be grown in polyculture with tiger shrimp, white shrimp, mullets, whiting, sea bass, mudcrab, and Nile tilapia in brackishwater ponds, even integrated with poultry. Farmer experience and scientific experiments in polyculture showed great potential, but most farmers have opted for monoculture systems, unaware of the full advantages of a more balanced pond ecosystem.

Milkfish can also be grown in freshwater ponds, alone or in polyculture with tilapia, common carp, catfish, and snakehead, but this farming method has not been adopted widely for milkfish in the Philippines. In 1995-97, some 6,523 ha of freshwater ponds produced about 43,000 mt a year of Nile tilapia, carps, catfish, snakehead, and gourami, with only 7 mt of milkfish. In Taiwan, about 6,000 mt of milkfish comes from freshwater ponds (15-25% of total production).

Results of experiments in milkfish polyculture and integrated farming in the Philippines and India.

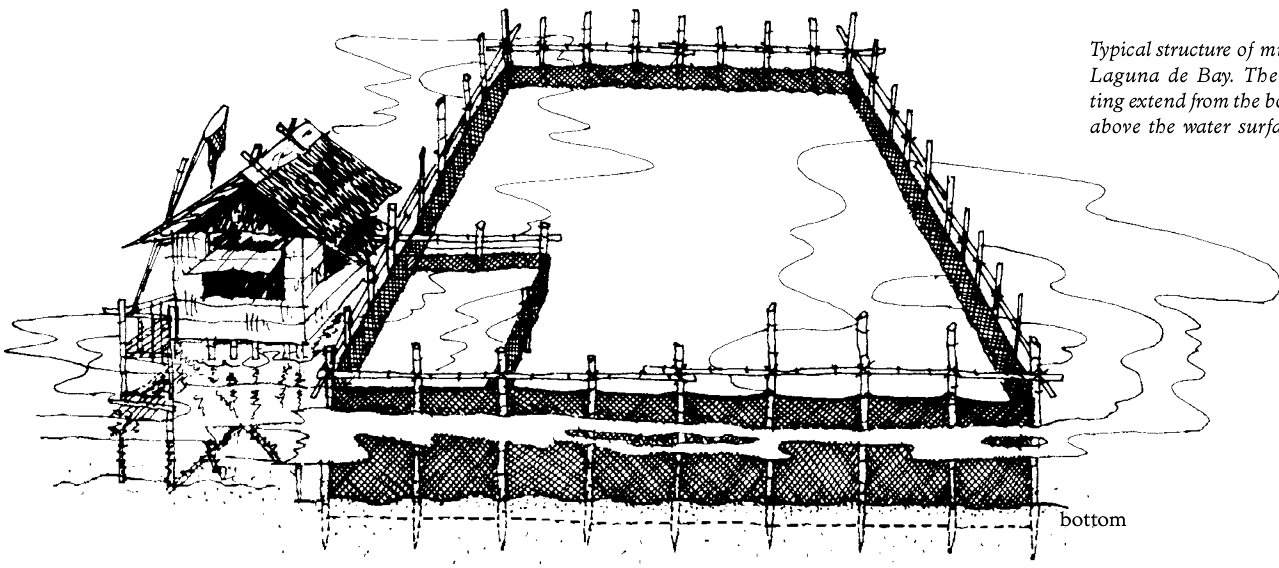
Experiment (Authors)	Milkfish + other species (#/ha)	Initial size (g)	Chicken manure (t/ha)	Total 16-20-0 (kg/ha)	Suppl feeds	Crop cycle (days)	Final size (g)	Survival (%)	Net yields (kg/ha- cycle)
Milkfish with tiger shrimp S in 500 m² brackish ponds (Eldani &Primavera 1981)	2,000M + 4,000-8,000S	2-5 2-4	2	250	none	120	157-201 36-47	90-96 47-54	281-376 + 88-176
Milkfish with tiger shrimp in 500 m² brackish ponds (Pudadera & Lim 1982)	2,000-4,000M + 6,000S	3-6 0.4	1	100	none	100	113-204 12-30	78-97 73-80	374-442 + 50-144
Milkfish, white shrimp S, and Nile tilapia N in 1000 m² brackish ponds receiving manure from 90 chicken (Pudadera et al. 1986)	2,000M 50,000S 5,000-20,000N + 90 chickens	2-3 0.007 9	direct from chicken	none	none	120 7-9 70-118	79-133 46-69 44-67	40-80 + 192-284 + 337-670	75-117
Milkfish with common carp C or catfish H in freshwater ponds (Grover 1973)	3,000M + 1,000C or + 1,000H	2 0.3 2.4	2	200	none	125	98-126 199 65	64-76 64 73	182-285 119 92
Milkfish, male Nile tilapia N, and snakehead D in 500 m² freshwater ponds (Cruz & Laudencia 1980)	5,000M + 1,000-3,000N + 50-150D	22-35 27-29 1	2	500 500	copra meal rice bran	130	72-135 95-152	80-94 97-100	137-376 + 148-283
Milkfish and mullets B in 450 m² saltwater ponds (James et al. 1984)	8,333M + 7,777B	2-21 2-3	0-3	none	rice bran + peanut oil cake	300 270	213-270 65-98	61-87 10-57	1,227-1,406 + 64-333

Grow-out in freshwater and marine pens

Fish pens are built in shallow waters with stakes and netting to enclose stocks within a usually large area. The fish can forage for food; they have access to the natural food at the bottom, and can also feed on plankton which may be abundant in eutrophic (plankton-rich) lakes and bays. In Laguna de Bay, which is eutrophic and 3 meters deep, pen operators stock 30,000-35,000 fingerlings per hectare (equal to 1 fish/m^3). Pen operators may also provide supplemental diets.

Milkfish pens started in Laguna de Bay in 1971 and the prescribed methods were rapidly adopted by the private sector. The pens increased in area up to 34,000 ha in 1982, but have since been reduced to about 14,000 ha in 1995.

Farming of milkfish, tilapia, and carps in Laguna de Bay increases the demand for natural food and oxygen and the supply of nutrients in the lake due to the large fish stocks, the feces, and the excess feeds. Algal blooms, hypoxia, and fish kills have become more frequent and more disastrous since the 1970s. On the other hand, fish pens provide shelter to other lake fishes and contribute to increased catches from the lake fishery.



Typical structure of milkfish pens in Laguna de Bay. The walls of netting extend from the bottom to 1-2 m above the water surface.

Milkfish pens in Ivisan, Capiz, 1999.

Milkfish pens in Lake Buluan, Mindanao, 1999.

Comparison of fish pond and fish pen. Values are for 1988 (US$1= P21). From Santos & Rabanal (1988).

CRITERIA	FISHPOND	FISHPEN
Development cost (P/ha)	From P30,000 upwards, averaging about P50,000 depending on layout and intensity	P40,000-P60,000, averaging P50,000 depending on desired layout and intensity
Acquisition cost (P/ha)	P40,000-P300,000 depending on location and extent of development	P20,000-P30,000, sometimes including stock
Depreciation period	Long, even up to 20 years, since improvements (dikes, gates, farm houses) last long	Short-lived with initial structures useful at most four years, with repairs starting as early as second year
Cost of inputs	Fingerling requirements about 10,000/ha-year; labor maximum 2/ha; minimal use of energy, feed, fertilizer and pesticide	Fingerling requirement about 60,000/ha-year; labor 6-10/ha; energy cost more; minimum feed, no pesticides
Fixed costs	Include realty taxes, fishery fees, or sublease of P2,000-P15,000/ha-year depending on location and development	Fee P1,000/ha since 1985
Productivity or yield	Maximum 3 mt/ha, minimum 300 kg/ha, average 700-1,000 kg/ha; 4-6 harvests per year	Range 4-5 mt/ha-year; turnover 1-2 crops per year
Cash flow	Moderate, depending on intensity of production	Massive, as productivity is relatively higher
Risk	Moderate, since some control of the environment is possible	High in dry season, algal bloom and fish kill may occur; rainy/typhoon season flooding and destruction of structures; poaching rate high
Project lifetime	If titled, reasonably long with maintenance; Fishpond Lease Agreement, 25 years renewable	Short, 2-4 years, but may be lengthened by massive maintenance
Control over environment	Production schedule partly controllable since one can manipulate use of inputs depending on weather	Minimal; can be at the mercy outside factors
Resale value	High, since improvements made are more or less permanent; convertible to real estate	Low, since without stock, pens are practically worthless
Use as collateral	Appraisal high and accepted if titled and developed; FLA acceptable in some financing institutions	Unacceptable due to high risk and low resale value; additional financing for improvements and operations must be secured by other personal assets

Marine pens for milkfish were started by the Department of Agriculture in shallow coastal waters in Alaminos, Pangasinan and Santo Tomas, La Union. The technology was so eagerly adopted by the private sector that fish pens proliferated rapidly around Lingayen Gulf, for a while even inside the Hundred Islands National Marine Park, and recently in the channel between Santiago Island and Bolinao town. Milkfish pens are also operated in Cavite, in Pagbilao Bay, Quezon, in Cebu, in Ivisan, Capiz, and in Lake Buluan in Mindanao.

Grow-out in freshwater and marine cages

Fish cages are smaller and more restricted enclosures that can be staked in shallow waters or set up in deep water with appropriate floats and anchors. The stocks can not feed off the bottom, can not forage enough, and must then be fed complete diets. Sea-cages for milkfish were started by the Department of Agriculture in 1994-95 and the technology was quickly adopted by businessmen in Batangas, Pangasinan, Davao, Bohol and Negros. Milkfish is now also farmed in freshwater cages in Taal Lake.

Stocking rates in cages are quite high. One farm in Pangasinan, for example, stocks 5,000 fingerlings in each cage 7 m x 12 m x 6 m deep (=10 fish/m^3). Other farms stock 50,000-100,000 fingerlings in Norwegian cages 12-19 m in diameter and 8 m deep (=44-55 fish/m^3). A farm in Batangas stocks 30,000 fingerlings in a rectangular cage 20 m x 50 m x 6 m deep (=5 fish/m^3). The operator in Taal Lake stocks 4,000-5,000 fingerlings in cages 5 m x 5 m x 5 m deep (=30-40 fish/m^3). At these very high stocking densities, the fish are living on the edge—the oxygen supply could very quickly run out, if not for the constant flow through of water across the cage.

Milkfish cages in a sheltered marine cove in Punta Linao, Davao Oriental, 1997.

Palawan Searanching Station, BFAR, Puerto Princesa, 1999.

Fish pens and cages must be properly sited to avail of good water quality, effective circulation, and adequate flushing of metabolites and excess feeds. Tidal flows and wind-generated waves and currents are necessary for maintenance of water quality, but strong winds and waves can cause structural damage. Where many farms congregate in the same "suitable" area and use large amounts of feeds, fish kills have happened and made operations unprofitable within a few years.

Milkfish cages at river mouth, Tagabuli, Sta. Cruz, Davao. Fish kills quickly ended the boom in 1996-97.

Marine cages for milkfish, open water, Davao Gulf, 1999. Photo by P. Cruz.

The perfect farmed fish

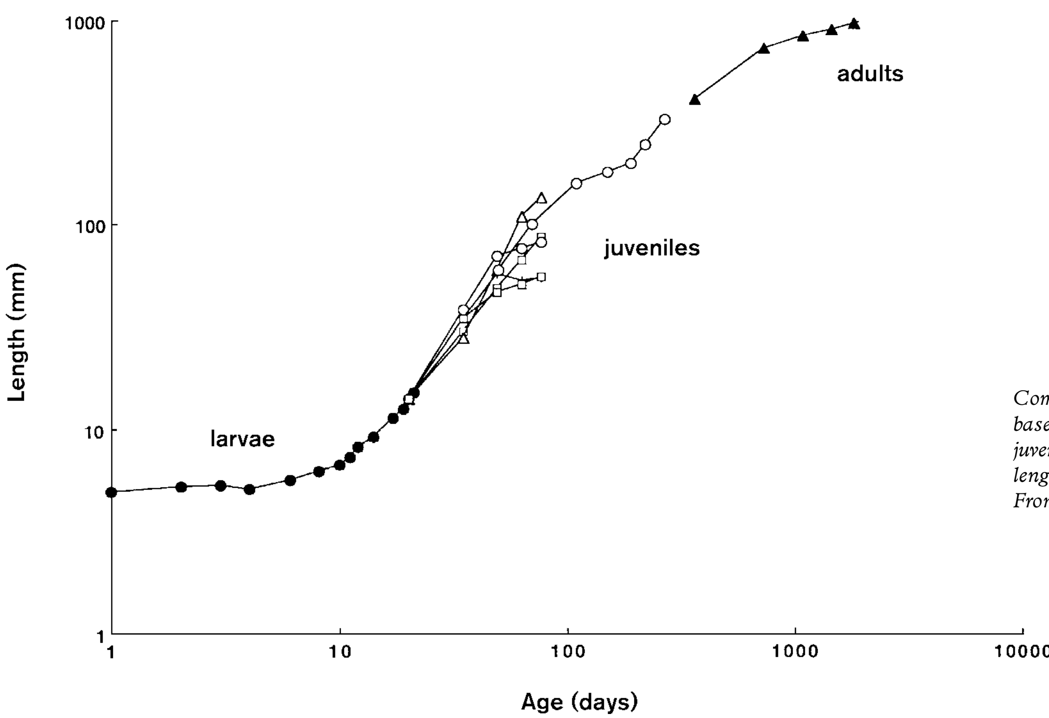
The long-standing success of milkfish farming has been due to the existence of suitable areas and clean water in southeast Asia, the large supply of seed postlarvae from the wild, the large domestic market for milkfish, the availability of skilled manpower and research and training support, and a combination of desirable qualities difficult to find in any other tropical fish: omnivorous feeding habit, adaptability to crowding, resistance to disease, wide tolerance to environmental factors, and fast growth rate.

Earlier sections in this book have discussed aspects of the large *semilya* fishery, the building of ponds in the mangroves, the natural food and formulated feeds taken by milkfish, and the amenability of milkfish to high-density stocking.

What about the growth rates of milkfish?

Growth rates of milkfish depend on the initial fish size, stocking rate, food and feeding, water and soil quality, and farm management. Of the *semilya* stocked in ponds in the Philippines, about 50% are harvested 4-6 months later, at sizes of 200-500 grams. Farmers aim to get body weight increments of 2-3 g/day in milkfish given formulated diets. Provided food is nourishing and water quality is good, growth of juvenile milkfish may be faster in fresh water than in sea water because of favorable osmoregulatory function and higher digestibility of food. Hatchery-reared and wild milkfish grow equally well in adequate grow-out systems.

Studies of juveniles and adults in the wild and of larvae, juveniles, and adults in captivity yield data for a composite milkfish growth curve. The growth curve is typically sigmoid (S-shaped), with the steepest slope (fastest growth) during the juvenile phase, the first year.



Composite growth curve of milkfish based on separate data for larvae, fry, juveniles, and adults. Note that both length and age are on logarithmic scales. From Bagarinao (1991, 1994).

Milkfish survives (but barely) oxygen levels down to 1 ppm, but will not feed much below 3 ppm. It is a tropical fish that can not tolerate temperatures much lower than 20°C. It tolerates a wide range of salinities given adequate acclimation. It can not live in sulfidic waters with more than 0.1 ppm hydrogen sulfide, nor in acidic waters below pH 5. It can tolerate ammonia and nitrite levels not found in ponds, except those with very high stocking and feeding rates.

Tolerance of milkfish to environmental factors, chemotherapeutants, and pesticides.

Environmental factors, chemicals	Range in farms	Tolerance of milkfish duration	limits	References
Water temperature (°C)	15-43		20-43	Lin 1969, Villaluz & Unggui 1983
Salinity (g/l)	0-158		0-158	Lin 1969, Crear 1980
Total ammonia (mg/l)	0-6	96 h	21	Cruz 1981
Nitrite (mg/l)	0-1	48 h	12-675	Almendras 1987
Dissolved oxygen (mg/l)	0.6-15		1	Hamsa & Kutty 1972, Schroeder 1997
pH of water	4-9.5		5-9	Bagarinao & Lantin-Olaguer 1998
Total sulfide (mg/l) (hydrogen sulfide mg/l)	0-132 (0-9)	96 h 4-8 h 2 h	2 (0.1) 5 (0.3) 6 (0.4)	Bagarinao & Lantin-Olaguer 1998
Abate temephos insecticide (mg/kg)		72 h	0.4-3.5	Tsai 1978
Sumithion 50 (mg/kg)		72 h	11	Tsai 1978
Dursban 4 (mg/kg)		72 h	0.15	Tsai 1978
Lebaycid 50 (mg/kg)		72 h	1.7	Tsai 1978
Potassium permanganate (mg/l)		96 h	1.5	Cruz & Tamse 1986
Formalin (mg/l)		96 h	230	Cruz & Pitogo 1989
Rotenone (µg/l)		96 h	25	Cruz-Lacierda 1992
		tilapia tolerance		
Aquatin 20 (mg/l)		96 h	2.6	Cruz et al. 1988
Brestan 60 (mg/l)		96 h	0.1	Cruz et al. 1988

mg/l = ppm, parts per million; µg/l = ppb, parts per billion; g/l = ppt, parts per thousand

The table also shows the tolerance of milkfish to several chemicals used in fish ponds: Abate temephos and various other insecticides against bloodworms (chironomid fly larvae), potassium permanganate for general disinfection, formalin against parasites and fungi, and rotenone against tilapia and other fish pests in ponds. The tolerance of milkfish to the pesticides Aquatin and Brestan used against snails has not been determined, but may be similar to the tolerance of tilapia.

Pesticide residues have been found in milkfish flesh (20-110 ppb endosulfan, endrin, DDT, heptachlor, aldrin) at higher levels than in pond sediments (10 ppb of thiodan, endosulfan, endrin, DDT, and DDD) in Leganes, Iloilo, in 1978. Triphenyltin (Aquatin and Brestan) residues have also been found in milkfish tissues, especially in the liver, at higher levels than in pond sediments, and higher than allowed by the World Health Organization.

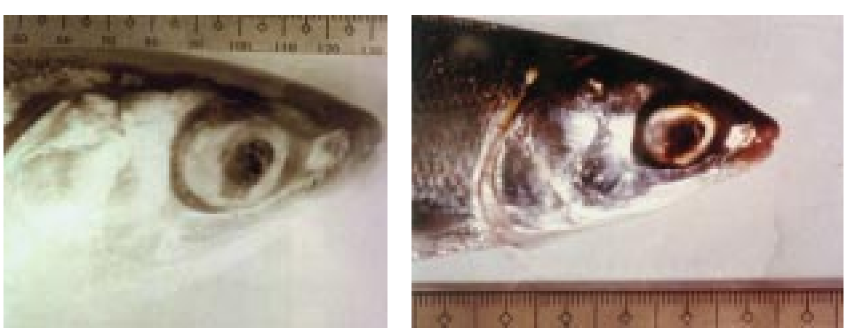
Milkfish is highly resistant to parasites and diseases, which break out only when milkfish are stocked at very high densities or stressed for long periods. Vibriosis may be triggered by cold temperatures, overcrowding, and poor water quality.

Diseases and parasites of milkfish. From Lio-Po (1984) and Lee (1995).

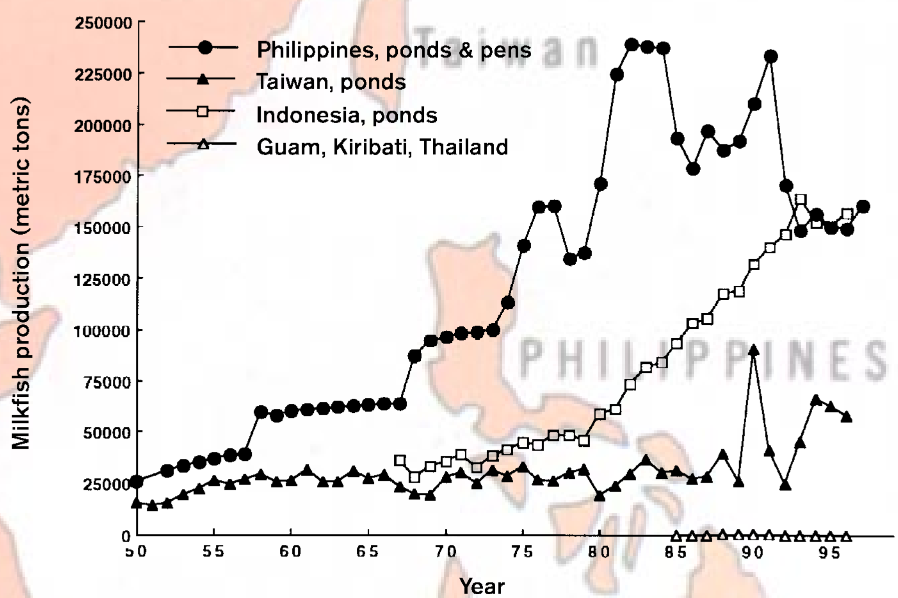
Diseases, parasites	Causative agent	Manifestations on milkfish
Red spot	*Vibrio anguillarum*	red spots and ulcers on body, esp. abdomen, anus swollen
Tail rot or fin rot	*Flexibacter columnaris*	frayed fins, hemorrhagic wounds, excess mucus on skin
Scale disease	*Vibrio parahaemolyticus*	protruding scales with pus-forming wounds
Blood poisoning	*Aeromonas hydrophila*	systemic infection esp. in milkfish in fresh water; skin ulcers, hemorrhage, loss of scales, bulging eyes
'Milky eye'	*Vibrio* sp., fungi	adipose eyelids of 1-2 eyes turn opaque white
Copepod parasites	anchor worm *Lernaea*, *Caligus* spp.	severe emaciation, secondary infections at attachment sites
Trematodes	*Haplorchis* spp.	metacercaria look like white grains on fish muscle

Diseases have not been much of a problem in extensive grow-out systems in the Philippines, but the situation may change with high-intensity farming, as in Taiwan. For example, the luminous bacteria *Vibrio harveyi* and *V. fischeri* are normally present in pond water and sediment and in milkfish guts, but cause no problems; these luminous bacteria reach high densities lethal to shrimps in intensive ponds in Negros.

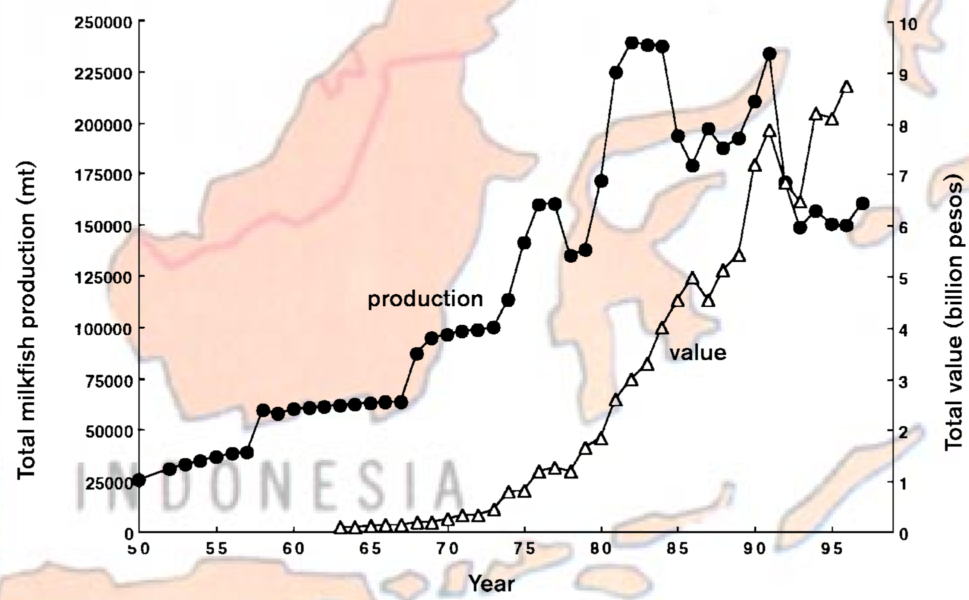
Prevention of bacterial infections consists mainly of keeping stock densities or biomass at less than 1 kg/m^3. Low dissolved oxygen, high ammonia, and rapid temperature and pH changes must be avoided. Fish must not be handled too much. Perhaps the single most important factor in health maintenance among fish in brackishwater ponds and coastal wetlands is the regular and frequent change in salinity which is lethal to most parasites and bacteria. Frequent salinity change does not happen in freshwater and marine farms, so greater care is needed to prevent diseases.



Milky eye and hemorrhagic eye in milkfish. From Muroga et al. (1984).



Global production of milkfish, 1950-1997. From Chong et al. (1984), BAS (1994), Lee (1995), FAO (1996), BFAR (1997).



Production and value of milkfish in the Philippines, 1950-1997. From Bagarinao (1998).

Chapter 6

Bangus Production Today

Statistics compiled by the Food and Agriculture Organization of the United Nations show that Asian (=global) milkfish production increased from 312,000 mt worth US$ 352 million in 1985 to 434,000 mt valued at US$ 623 million in 1990. But total production fell to 417,000 mt in 1991 and hit a low of 343,000 mt the next year. Nearly all the production comes from the Philippines, Indonesia, and Taiwan, but milkfish is also farmed on a very small scale in Guam, Kiribati, and Thailand.

The Philippines has been the leader in milkfish production for a long time. In 1990, the Philippines made up 48.6%, Indonesia 30.5%, and Taiwan 20.9% of the production; in 1992, the respective contributions were 49.8%, 42.8%, and 7.3%. In 1993, the Indonesian harvest surpassed that of the Philippines for the first time, and in 1994, the Philippines contributed only 39.2%, Indonesia 44.2%, and Taiwan 16.7% to the 401,000 mt of milkfish (valued at US$727 million) from farms.

In Taiwan, some 12,850 ha of ponds were used for milkfish in 1990 and yields averaged 7 mt/ha. Indonesia used 231,000 ha of ponds for milkfish in 1990 but achieved average yields of only 0.6 mt/ha. That same year, the Philippines produced 192,000 mt from about 150,000 ha of brackishwater ponds, and 19,000 mt from about 10,000 ha of pens, at average yields of 1.3-1.9 mt/ha.

Iloilo, 1980.

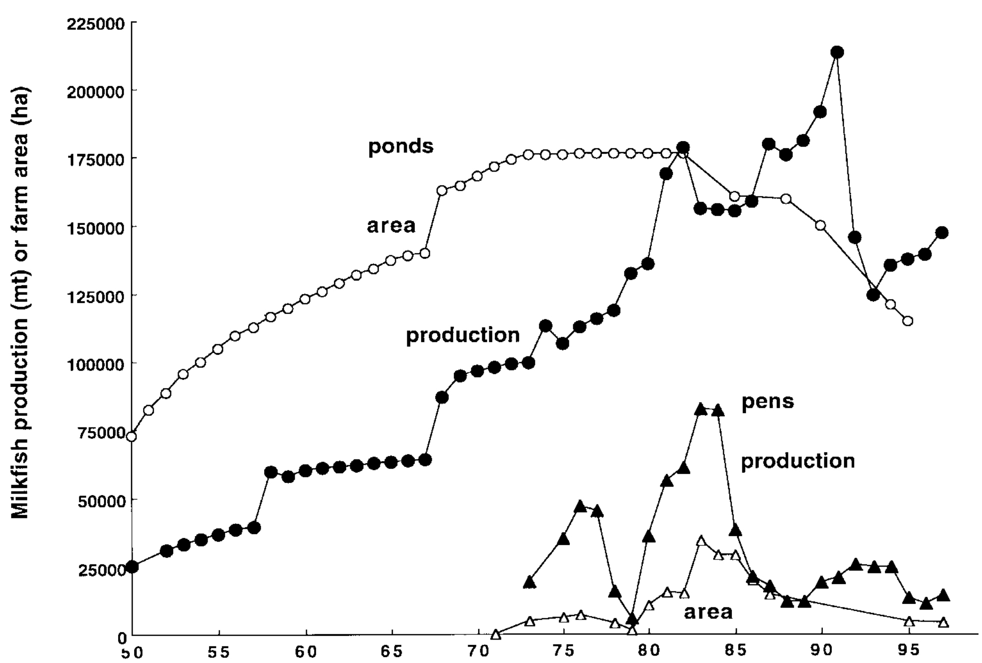
Production and value of bangus

The Philippines ranks among the top twelve fish producers in the world, with a total aquatic production of 2.767 million metric tons valued at P80.745 billion in 1997. That year, aquaculture made up 957,546 mt of the total volume and P27.417 billion of the total value of the production. In 1997, milkfish contributed 161,419 mt worth about P9 billion to the Philippines' food supply and economic growth.

Milkfish was the only aquaculture species in the Philippines until about 1975, and it all came from ponds. In 1950, some 24,500 metric tons of milkfish were harvested from the 72,753 ha of ponds. Production increased gradually with pond area over the years to a peak of 179,679 mt in 1982. Milkfish pond area has since then decreased markedly and brought down the production to a low of 124,510 mt in 1993, although there was a temporary peak in 1991.

Milkfish pens in Laguna de Bay were started by the Laguna Lake Development Authority in 1971. These freshwater pens contributed about 47,000 mt of milkfish in 1976 and as much as 82,000 mt in 1983-84. The harvest from the pens has since then collapsed with pen area to 11,700 mt in 1989, recovered over the next few years, but came back down to 13,000-14,000 mt in 1995-97.

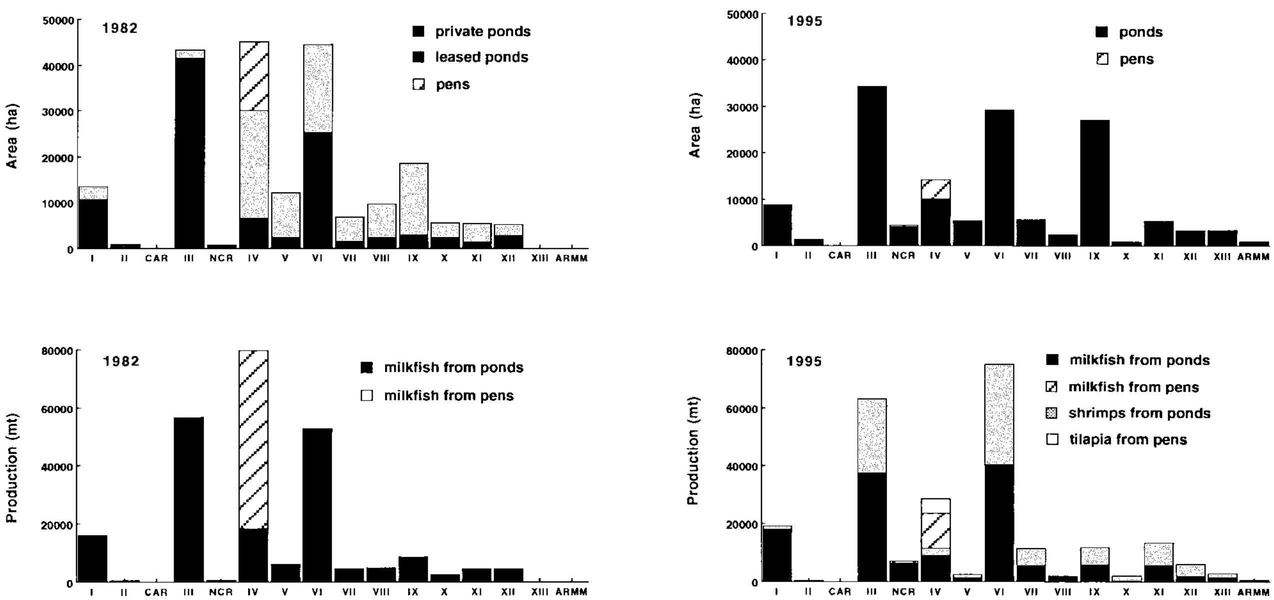
Total milkfish production from ponds and pens varied between 150,000-240,000 mt over the past 15 years. The milkfish production of 99,600 mt in 1973 was worth P434 million. The volume increased 2.5-fold and the value increased more than 18-fold between 1973 and 1991. As production fell in 1992-93, the industry made only P6-7 billion a year. But milkfish prices increased and the low production in 1994-97 was valued at P8-9 billion.



Milkfish pond area and production, 1950-1997, and pen area and production, 1971-1997, in the Philippines.

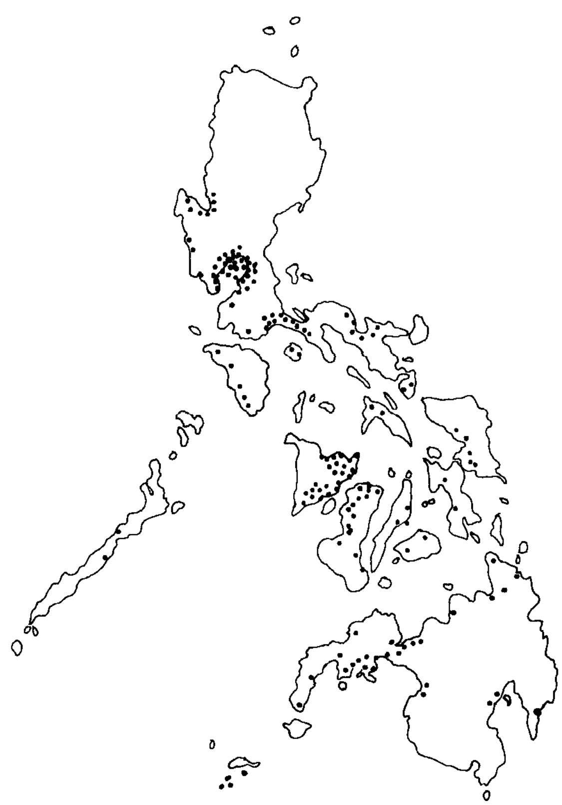
In 1995, the largest brackishwater pond areas were in Regions III (Bulacan, Pampanga, Bataan, 34,363 ha), VI (Iloilo, Capiz, Aklan, Negros Occidental, 29,393 ha), IX (Zamboanga, 27,304 ha), IV (Quezon, Mindoro, 10,168 ha), and I (Pangasinan, 8,726 ha). Accordingly, 112,000 mt or 81% of total milkfish production from ponds came from these five regions. Regions III and VI also produced nearly 60,000 mt of tiger shrimp, 67% of the country's total.

In eight regions, the areas of brackishwater ponds in 1995 were only to 25-80% of those in 1982. In six of the same regions, the milkfish harvests in 1995 were only 27-77% of those in 1982.



In 1995, most milkfish came from brackishwater ponds in Regions I, III, IV, VI, and IX, and from the freshwater pens in Region IV. Data from BFAR (1982, 1996).

In 1995, Region IV (Laguna de Bay) had 3,992 ha of freshwater pens that produced 12,000 mt of milkfish and 5,000 mt of tilapia. In 1982, 15,000 ha of pens produced 61,000 mt of milkfish. The latest BFAR statistics still does not show the large areas of marine pens and cages in Region I, producing milkfish.



Back in 1969, most ponds were in Lingayen Gulf, (Region I), Manila Bay (III), Tayabas Bay (IV), western Visayas (VI), and Zamboanga. Each dot about 1,000 ha. From Ohshima (1973).

Post-harvest handling, processing, and marketing

Milkfish of 200-400 grams are harvested and marketed mostly fresh or chilled, whole or deboned. Some milkfish farmers sell their fish right at the farm, where buyers pick up the harvest at a price pre-set with the pond owners. This is especially true where large harvests are sold to only one buyer. Most farmers deliver their harvests to various wholesale markets, where brokers sell the produce for them at 4% commission. Where brokers transport the fish to market, they charge a 5% commission. Thus, local marketing of 90% of the milkfish production is generally handled by brokers, who in turn distribute the fish to different market outlets, that is, to wholesalers, retailers, and consumers.

Milkfish in the harvest area.

Milkfish taken to chilling tank.

One good attribute of milkfish farming is that it supplies much needed fish protein for local consumption. The domestic markets, especially in Metro Manila, absorb most of the milkfish harvest. Most pond operators sell their produce within the province, but about 50% of the production in Pangasinan is sold in northern Luzon, and 20% of the production in Iloilo is sold in Metro Manila and other parts of Luzon. In 1978-1981, Region VI (mainly Iloilo) shipped 400-9,500 mt of milkfish outside the region.

Post-harvest operations and product utilization technologies have been developed for commercial application on milkfish. In 1978, the National Science Development Board published "Milkfish *(Bangos)* as Food" which details methods for handling, canning, other types of processing, and use of by-products of the milkfish harvest.

Chilling, packing, and transporting the milkfish harvest to market.

The quality of fish is best after harvest. Proper post-harvest handling minimizes fish spoilage by:

- lowering the temperature by chilling, icing, or freezing to increase shelf life
- minimizing contact of fish with dirty surfaces and handlers
- preventing physical damage (bruises, cuts) to fish
- shortening the time between harvest and utilization

Chilling lowers the temperature of fish to just above the freezing point of fish muscle at -1.1°C and delays spoilage considerably. Ice is the most widely used chilling agent: it is non-toxic and can come in direct contact with the fish, it has a large cooling capacity, it keeps the fish moist and glossy, it cushions the fish from the pressure of other fish, and the melt water washes away dirt and surface contamination when drainage is provided. It is important to make sure that safe and clean water has been used in making the ice. When packing fish, it is best to alternate layers of fish and ice. Fish must be kept at 0°C at all times.

Quick-freezing (in blast freezers) reduces the temperature of the fish from 0°C to -4°C in less than two hours and retains the quality of freshness not obtained with slow freezing (as in the common household freezer). At present, only a small part of the milkfish harvest is quick-frozen. Filipino consumers are prejudiced against frozen fish. In the past and even now, it is not unusual for the fish dealer to freeze unsold milkfish. This leftover fish is usually of poor quality and poor quality fish can not be improved by freezing! The Filipino consumer then blames the poor quality on the freezing. In fact, fish of high quality when quick-frozen becomes a high-quality product. Thus, only fresh milkfish should be quick-frozen or processed into value-added products.

If the fish are to be sold right away, freshness may be maintained better by packing them head up in slatted baskets that are well ventilated and well drained. Packing the fish horizontally layer after layer in closed containers without ice leads to fast spoilage.

Packing of milkfish in Iloilo, 1998.

Packing of milkfish in Taiwan. From Lee (1985).

The price of milkfish fluctuates with the prevailing fish supply. When the supply is high from April to October, prices are relatively low. Prices are usually high from December to March. Wholesale prices of fresh milkfish increased from P10/kg in 1981 to P56/kg in 1994, whereas retail prices rose from P12/kg to P67/kg during the same period. At present, whole milkfish sells at P50-150/kg retail, depending on the fish size and the market location. Deboned milkfish sells at P80-200/kg.

Whole bangus *in wet market.*

Many Filipinos of the younger generation, and certainly fish consumers in other countries, cannot enjoy milkfish because of the inconvenience of having to pick out so many bones from the meat. Deboning makes milkfish attractive to more consumers, but it is labor-intensive and costly. Indeed, deboning should be seen as a job opportunity for many people, who only have to be properly trained in sanitation and milkfish handling. Demand for 'boneless' *bangus* will certainly increase in the future.

Deboning of bangus *provides jobs to housewives.*

Smoking of bangus *can be done in the back yard.*

Increasingly more of the milkfish harvest is processed into value-added forms: smoked, dried, marinated (brined, sweetened, *hamonado*), fermented with rice *(burong isda)*, and canned or bottled in various styles: salmon style, sardine style, Spanish style, smoked in oil, etc. Canning procedures for *bangus* have been standardized, but canning does not seem not to be cost-effective at present. *Bangus chicharon* (crispy-fried skin) has recently hit the restaurants and are becoming very popular.

Some companies now produce frozen prime cuts of *bangus* bellies and backs, and even of heads and tails.

Per cent meat yield from *bangus* increases from 54% at 200 grams body weight to a maximum of 63% at 600 grams. Thus, one way to maximize production of milkfish meat, particularly for value-added processing, is to grow them to 600 grams. But growing large *bangus* seems not cost-effective for the Filipino farmer.

Smoked bangus

Bangus chicharon

Deboned or 'boneless' bangus and other value-added forms cost more but are preferred by busy people.

Milkfish is exported in different product forms: quick-frozen, dried, canned, smoked, or marinated. Milkfish exports rose from 38 mt of frozen fish valued at P106,000 in 1969 to a peak in 1986 but declined to 869 mt worth P65.5 million in 1990. Frozen fish made up about 95% of the total exports; and 84% of the exports went to the USA. In 1995, milkfish exports amounted to 1,068 mt valued at P188 million. Like any import, milkfish is inspected by the US Food and Drug Administration and if it does not conform with the strict specifications for fresh frozen fish, it is rejected.

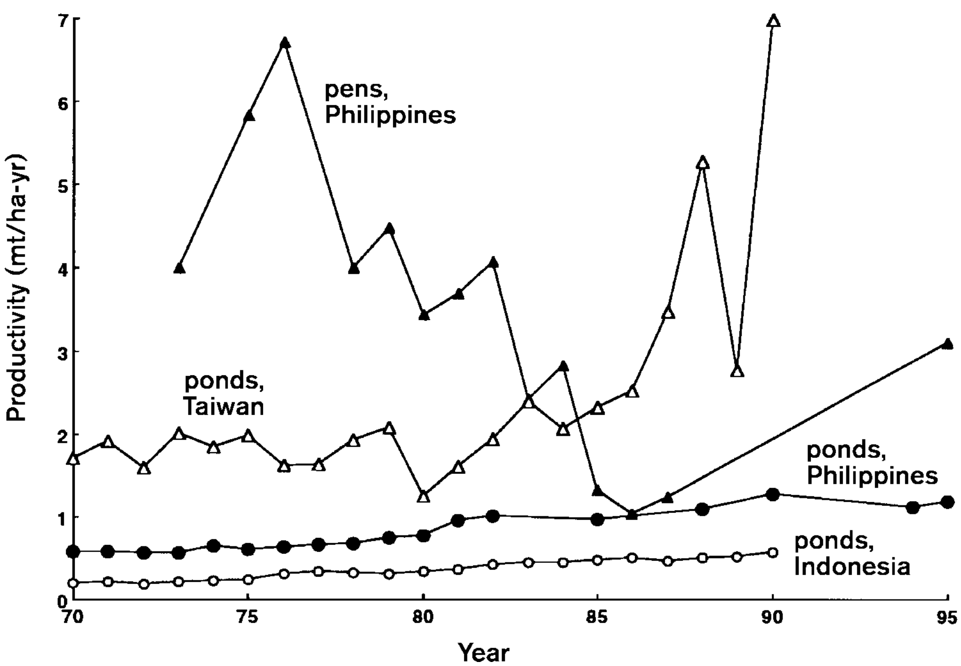
Problems of the industry

1. Low yields

Milkfish farming has been carried out mostly in extensive ponds with minimal management and yields increased very slowly from 250 kg/ha-yr in 1940 to 760 kg/ha-yr in 1978 and 1,000 kg/ha-yr 1982. The national average yield reached the 1,000 kg/ha-yr mark in 1982 when farmers adopted modified extensive farming techniques with increased stocking rates, fertilizer use, and supplemental feeding. Large ponds in Iloilo, Bulacan, Pangasinan, and Negros produce higher than the national average.

At present, the average yield per hectare per year from ponds in the Philippines (1-2 mt/ha-yr) is lower than in Taiwan (2-7 mt/ha-yr), but higher than in Indonesia (0.5 mt/ha-yr).

Low milkfish yields per hectare have been a long-time and glaring problem that



Productivity or yield per hectare of milkfish ponds increased slowly in the Philippines and Indonesia and fluctuated widely in Taiwan, 1950-1995. The productivity of the milkfish pens in Laguna de Bay decreased as fishpen area increased in 1975-1985. After many fishpens were dismantled, a recovery took place. From Bagarinao (1998) in part.

pond operators did not seem to want badly enough to change. A study in 1978 showed that milkfish ponds were not made to produce as much milkfish as they were physically and economically capable of supporting, and most farmers seemed indifferent and did not appear to face economic pressure to produce larger quantities. But many farmers now want higher milkfish yields.

Low production of natural food, particularly *lablab*, results in low yields. Despite long experience in pond preparation, *lablab* production is still a dicey and unpredictable proposition. When the organic matter content of the pond soil is too low, or there is not enough sun, *lablab* does not grow. When ponds have plenty of snails, *lablab* can not start to grow. Farmers turn to fertilizers, feeds, and pesticides, but these bring another set of problems: high costs and poor water quality.

Climate affects milkfish yields. Farmers can do little more than choose suitable sites and prepare for bad weather. The milkfish industry suffers from about 20 typhoons and about 145 rainy days each year, beginning in June and continuing through September. Not only are dikes destroyed or flooded and valuable stocks lost, but algal beds and other fish food do not thrive after a heavy rain. Damage to pond gates, dikes, and other structures mean additional costs for repairs.

How is the productivity in fresh water? An early study showed that the primary productivity of Laguna de Bay could support up to 20,000 ha of fishpens stocked with 30,000 fingerlings/ha. Before the lake became overcrowded with fishpens, milkfish yields approached 6-7 mt/ha-yr. But in 1983, when milkfish pens occupied as much as 34,000 ha, more than a third of the total lake surface area, the average yield was reduced to 2.43 mt/ha-yr. In 1986, the 19,903 ha of pens yielded only 1 mt/ha-yr. Ten years later and with only 4,189 ha of pens, the yield was back at 3 mt/ha-yr. These data show that the lake's carrying capacity for fish pens was overestimated.

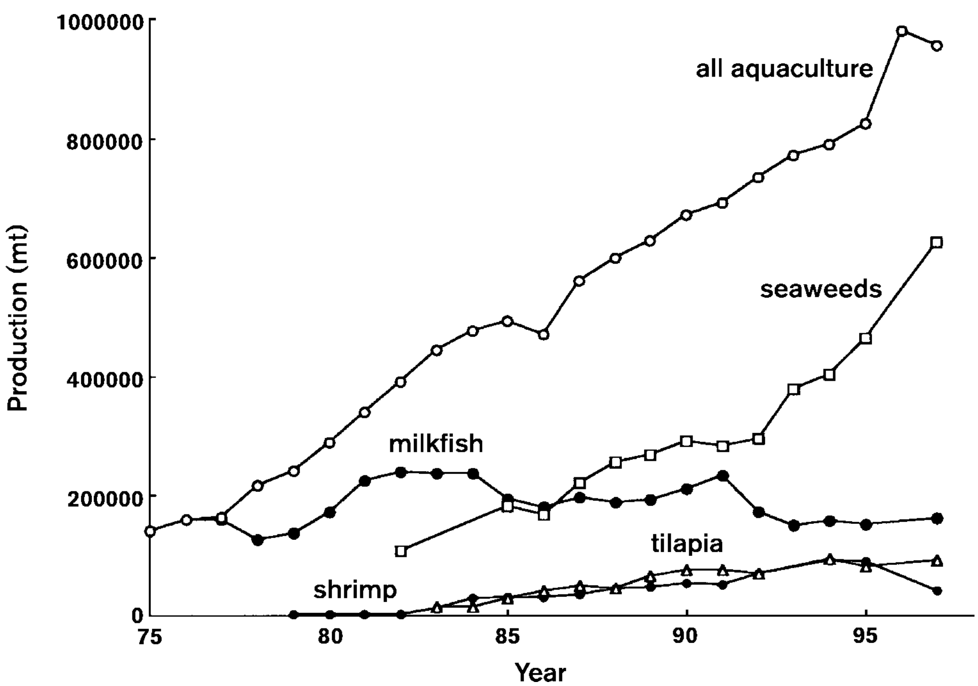
Given the present polluted multi-use condition of Laguna de Bay, there should be no more than perhaps 4,000 ha of fishpens if yields are to be kept reasonably high. In fact, the government plans to phase out fish pens from lakes and promote milkfish pens and cages in coastal waters.

2. Declines in production

Laguna de Bay seen from Mt. Makiling, April 1998. Fish pens for milkfish are just one of the many uses of the lake.

In 1975, some 141,461 mt of milkfish, the whole of aquaculture, made up 10.6% of total fish production. The contribution of milkfish reached a high of 12.6% in 1981-82. But after 1982, milkfish production fell, and the relative importance of milkfish declined with the expansion of the farming of tilapia, penaeid shrimps, and seaweeds. In 1997, the total milkfish harvest of 161,419 mt was only 5.8% of the total aquatic production and just 17% of the aquaculture production. The milkfish harvest was only one-fourth that of seaweeds, almost twice as much as tilapia, and almost 4x as much as shrimps. Production from brackishwater ponds used to be all milkfish in the early 1970s, but the share of milkfish came down to 78% in 1985, only 53% in 1993, and back at 74% in 1997.

Government statistics show declines in milkfish production from ponds in 1983



Production from all aquaculture, milkfish, seaweeds, shrimps, and tilapias, Philippines, 1975-1997. The relative contribution of milkfish to aquaculture has declined. From Bagarinao (1998).

and then again in 1992. Milkfish production from pens in Laguna de Bay also fell in 1978, 1985, and 1995. Similarly, milkfish production from marine pens and cages (not yet in fisheries statistics) was very high in 1996, and made many farmers in Pangasinan, Davao, and Quezon rich. But harvests fell drastically in 1997.

Declines in production in ponds, pens and cages were hardly due to fry shortage, contrary to claims in the mass media. Pond production of milkfish slowed down after 1982 when ponds were converted to shrimp farming, recovered as shrimp farming slowed down, but fell again after the ponds in central Luzon were buried under lahar, or converted to non-agricultural uses.

3. Environmental degradation

Milkfish pens in Laguna de Bay suffered production losses due to storms, fish kills, and the ordered dismantling of illegal fishpens. Water pollution due to discharges from various industries, petroleum depots, agriculture, and the unsewered urban population has badly affected milkfish farming in the lake.

Pen and cage operators in Pangasinan and Davao also suffered losses as water

B-20 MANILA BULLETIN, Thurs., Apr. 10, 1997

11 barangays affected

₱40 M lost in worst Pangasinan 'fish kill'

By MELANDREW T. VELASCO

BINMALEY, Pangasinan — In what was dubbed as the "worst fish kill" in the history of this town, a big volume of bangus (milkfish), siganid, shrimps, and other fish species worth some ₱40 million floated dead last week.

This ... million ... this ye...

the "fish kill" last week. These barangays are Pototan, Balagan, Balogo, Amancoro, Nagpalangan, Camaley, Naguilayan, Manat, Linoc and Gayaman.

Board Member Roberto Ferrer had earlier warned town officials saying "unless ...

land Domanlanta to clear the town's rivers of illegal fishpens.

Meanwhile, Anda Mayor Alice J. Pulido led a demolition crew that swooped down on some 300 illegal fishpens.

Some of the owners of the illegal structures were said to be government officials, ...

2 PHILIPPINE DAILY INQUIRER September 23, 1997

Ammonia, not oil spill, blamed for fish kills

BY DONA P. PAZZIBUGAN

"EXTENSIVE fish-culture," not a recent oil spill, is to blame for the series of fish kills in Binmaley River in Pangasinan early this year, the Department of Environment and Natural Resources said yesterday.

Rep. Jose Villarosa (Lakas, Occidental Mindoro), chair of the House special committee on fisheries and industry, said hundreds of tons of milkfish (*bangus*) worth P80 million to P200 million were wiped out in the disaster that took place from February to April.

He blamed the fish kills on the Coca-Cola plant in Calasiao town which was found to have discharged bunker oil into the Parongking River "way above" the limit set by the DENR.

excessive ammonia content of the river and the very low dissolved oxygen due to extensive fish pen culture in Binmaley River has caused the reported fish kill," Almogela said.

He said Parongking River, where the Coke plant releases its treated waste, "is not in any way connected to Binmaley River."

The oil spill sparked a congressional investigation on the operations of Coca-Cola Bottlers Phils. Inc. and other companies that pollute the country's fishing grounds and endanger the nation's food security.

Almogela said the oil discharge into the Parongking River on July 3 was "accidental."

Nevertheless, he said, the company has been fined P50,000 "for failing to notify the DENR regional office of the plant's accidental discharge of bunker ...

A fisherman and his daughter show dead fish that were among those that turned up by the hundreds of thousands in Laguna de Bay by the towns of Jalajala, Morong, Tanay and Pililla, 1998.

quality went bad, fish kills became more frequent and massive, pens and cages were ordered dismantled, and the costs of feeds and cages became too high to recover.

In the estuaries and shallow marine areas in Binmaley, Pangasinan and adjoining areas, there were about 1,445 fishpen and fish cage operations in 1997. These pens and cages were overstocked, and feeds were added in large amounts, about 45,000 bags of feeds (25 kg/bag) each month. These pens and cages exceeded the carrying capacity of the farm sites, particularly in terms of the oxygen supply. There were several large fish kills in Binmaley in 1995-97, the protracted one in April-May 1997 amounting to P70 million in losses.

4. Fry shortage?

In 1995, loud claims of "fry shortage" were made (again, as in the 1970s) by the private sector, as well as by government agencies. BFAR projected that 1.726 billion fry will be required yearly by the milkfish industry during the next several years to stock 114,795 ha of ponds in operation. The assumptions for the calculation were not explained, and in fact, there are no available data on how much farm area is stocked by how much *semilya* for how many times during the year.

Closer examination of the facts belie claims of fry shortage in 1995 as in the 1970s. Milkfish production increased between 1973 to 1991 with fry only from the wild and none from Philippine hatcheries. The recent intensification of milkfish farming in ponds, cages, and pens shows that the fry supply is not short (not yet, anyway) and that production technology is not a problem. Some Filipino farmers with Taiwanese connections have imported hatchery-reared fry from Taiwan for the past five years or so, but this was probably for convenience or low price rather than low catches at home. Given that there are only 114,795 ha of ponds now, in contrast to 176,000 ha in 1976, and that only a small part of this pond area plus a limited area of pens and cages are stocked at 30,000/ha, the fry shortage could not have been as large and critical as alleged.

Nevertheless, the fry requirement will certainly increase when the grow-out industry is intensified beyond the present levels. Given the lack of quantitative data on current industry practices, the fry requirement may be calculated under several scenarios one might imagine the milkfish industry to be in the future. One straightforward calculation may be made for a scenario where 300,000 mt of milkfish are produced by year 2010, double the average 1993-95 harvest of about 150,000 mt. Given a harvest size of 250 g and 50% mortality from fry to market size, the fry requirement would be 2.4 billion by 2010. In the better farms, in fact, much of the milkfish harvest now consists of 300-500 gram fish and the survival rates are higher. Thus, the fry requirement may be pegged at two billion.

About one billion fry may be supplied from the wild, provided the coastal ecosystems and milkfish habitats are protected. Thus, hatcheries in the Philippines need only set a production target of one billion fry by year 2010. This gives farmers about 5-10 years to develop milkfish broodstock from local sources and no reason to panic and import broodstocks from Taiwan, Indonesia, or Australia. Without proper quarantine, such importation might bring fish diseases from Taiwan to the Philippines, where milkfish are relatively disease-free.

Only a few private hatchery operators have adopted the milkfish hatchery

THE PHILIPPINE STAR SUNDAY, JULY 6, 1997 PAGE 19

Milkfish growers turn to hatcheries for their fry requirements

By RUDY A. FERNANDEZ

Time was when bangus growers depend solely on fry caught from seashores.

Now, milkfish growers have another choice: fry produced in hatcheries.

"Pond production of milkfish produced from the

fishfarmers who have cultured hatchery-produced milkfish fry in brackishwater ponds on Guimaras, Negros, and Panay islands.

SEAFDEC-AQD pointed out that evaluation of pond production (growth, harvest size, and survival) is essential to determine whether hatchery-produced

Agriculture Organization (FAO) assistant aquaculturist, has been obtaining fry (about 100,000 annually) from SEAFDEC-AQD to stock her brackishwater ponds in Barotac Nuevo, Iloilo.

Although he has been using wild fry for pond culture since 1958, Padlan has now opted to rear hatchery-produced fry as he has observed no radical difference in the pond yield between hatchery-produced and wild-caught fry, SEAFDEC-AQD reported.

Another Iloilo City fishfarmer, Tomas Hautea Jr. started buying hatchery-produced fry from SEAFDEC-AQD in 1994.

Multi-species hatchery used for milkfish, Tigbauan, Iloilo, 1998.

Shrimp hatchery now used for milkfish, Batan, Aklan, 1997.

technology developed at SEAFDEC AQD. Most have been preoccupied with shrimp fry production. In contrast, private pond operators in Taiwan and Indonesia were quick to develop milkfish broodstock and hatchery operations and have already become important suppliers of hatchery-reared fry. Hatcheries contributed 30,000 fry to Taiwan's supply in 1979 and 130 million in 1990; seven large hatcheries produced over 100 million fry in 1991. Small hatcheries have proliferated in Indonesia because hatchery-reared fry command a high price; one hatchery produced almost nine million fry in 1994 from year-round spawning.

In 1995, hatcheries in the Philippines started producing milkfish fry. One large company has its own broodstock, produces large numbers of milkfish fry, stocks them in their own large intensive ponds, and processes various value-added products.

Hatcheries in the Philippines may be able to produce 100 million milkfish fry a year very soon, and double that production even sooner. However, this can only happen when the demand for fry really increases. Will milkfish farmers in the Philippines further expand and intensify operations, given the current economic and environmental situation in the country? It is important to get answers to this question from a broad sector of the industry, not just the farmers with intensive farm operations or short-term agenda.

5. Production costs and market constraints

A comparison of the economics of milkfish farming in the Philippines and Taiwan in 1972 showed that milkfish was relatively expensive to produce in the Philippines. Milkfish farming became less profitable in the 1980s as high inflation and declining per capita income reduced per capita fish consumption. The demand for milkfish, a traditional first-class fish, declined in favor of cheaper fish, pork, and chicken. Milkfish farmers were caught in a cost-price squeeze when input costs increased more rapidly than market prices of milkfish.

The profitability of milkfish farming in the Philippines has improved in recent years, but data on current production costs are hard to find. The table opposite compares production costs over the years for different milkfish farming systems. Recent estimates are given for an extensive farm, a modular farm, and a semi-intensive farm, based on experimental data. Fully 37% of the production cost in semi-intensive ponds go to good-quality feeds to support the high fish biomass.

Costs-and-returns analysis showed acceptable economic indicators for all three

Costs of inputs in milkfish pond and pen operations, Philippines, various years, n=number of farms. From Bagarinao (1998).

Inputs	Costs of inputs as % of total costs									
	1972 ponds (n=93)	1978 all ponds (n=324)	1978 large ponds (n=23)	1979 ponds (n=115)	1992 ponds (n=30)	1992 pens (n=10)	1992 nurseries (n=5)	1996 extensive pond	1996 modular pond	1996 semi-intensive pond
Fry & fingerlings	9	15.3	20.9	19.2	44.5	82.2	75.4	21.7	20.9	16.0
Organic fertilizers	11	11.9	14.4	37.4	15.8	2.6	0.6	9.9	15.3	6.3
Inorganic fertilizers		8.3	11.8					14.6	4.3	3.5
Supplemental feeds		4.9	6.4	5.3	6.1	4.1	0.8			37.1
Pesticides, tobacco dust		1.8	1.9	3.6	12.2		0.01	1.8	15.8	0.6
Lime					11.9			6.3	2.88	2.0
Electricity					1.0	1.2				4.8
Gasoline and oil					2.4	9.9	0.03			
Ice					6.2	0.8	1.4	1.1		
Hired labor	28	20.3	13.4	34.4	nc	nc	0.8	22.4	20.4	10.5
Unpaid family labor		7.0	2.7	nc	nc	nc				
Misc. operating costs*	40	30.4	28.5	nc	nc	nc	22.4	22.5	19.1	18.4
Marketing	12	nc	nc	nc	nc	nc	nc	nc	nc	nc
Total cost/hectare	US$255	P3,394	P3,415	P2,657	P4,590	293,264	P105,954	P16,606	P9,827	P52,660

* Includes repair and maintenance, rent and tax, interest, depreciation, opportunity cost
nc, not considered in the cost of production
Blanks indicate the input was not used at the time.

farming systems. But the modular farm had the highest return on investments (83%) and return on working capital (203%), and a payback period of only one year. A semi-intensive milkfish farm in existing shrimp ponds was about as cost-effective as an extensive farm, and a semi-intensive farm in newly deepened ponds was least attractive.

Milkfish farmers can and will produce large amounts of milkfish as long as the effort pays off. The low production of 150,858 mt and the corresponding high farm-gate prices in 1995-1996 encouraged many farmers to culture milkfish in intensive ponds, pens, and cages. Intensive pond operators in Negros and Sarangani found milkfish very easy to produce, at much profit in 1996 and early 1997. But the windfall was short-lived as the high production drove the farm-gate prices down. These pond operators are not much encouraged to continue with milkfish farming.

Indeed, there are market constraints and socioeconomic limits to the intensification of milkfish production. High-intensity farming involves not only higher stocking and feeding rates, but also higher levels of other farm inputs; it may result in higher yields but not necessarily in higher profits. Milkfish grow-out in intensive systems is not profitable when the farm-gate prices are low, and farmers will not persevere in milkfish farming when they find better uses for their money.

Some large companies, however, profit from economy of scale, efficiency of process, and innovative marketing.

No data are available for production costs in marine pens and cages, but infrastructure, fry, and feeds certainly comprise much of the costs, and together with water quality, determine how long the operations last.

Large amounts of feeds are now used for milkfish in brackishwater ponds, and increase the production cost.

The milkfish industry in the Philippines has recently cornered a greater share of the export (USA) market, but only among the expatriate Filipinos. Milkfish has yet to break into the international seafood trade fairs and markets.

Unlike shrimps, salmon, and lobsters, milkfish has not made it big in international seafood trade fairs.

Workers changing the net of a fish cage.

Pond owner personally attending to farm business.

Researchers monitoring conditions at a fish farm.

Chapter 7

The People in the Milkfish Industry

Milkfish is more than just food, pesos, and dollars. The industry also means employment and economic growth. But accurate employment figures for the milkfish industry are lacking. Philippine fisheries yearbooks always give the employment figure for aquaculture as about a quarter-million people, from the assumption that one person is hired for each of the quarter-million hectares of ponds. But this is no longer correct. The pond area has decreased to about half, and the labor requirement is no longer just for maintaining extensive grow-out ponds.

The milkfish industry now includes various grow-out and hatchery systems, many of which require skilled labor and technical personnel. Milkfish farming has important linkages with the various sectors that supply the inputs: fry gathering and trade, fertilizer and chemical supply, supply of construction materials and feed ingredients, and feed manufacture, transport and storage. Many people work in the allied sectors: post-harvest processing, transport and storage, marketing and trade, and financing. Add to these the highly trained manpower involved in research and development, and in training and extension in support of the milkfish industry.

Farm workers harvesting, chilling, and sorting bangus. Sarangani, 1997.

Contractual laborers excavating a pond.

Overall farm management is the responsibility of the owners or operators who may hire managers or caretakers to oversee the ponds in their absence. On a few corporate farms, technicians, secretaries, housekeepers, and security guards are also employed. Caretakers are assured of year-round employment, but casual and contractual laborers are hired for seasonal work, usually for dike and gate repair, pond preparation, and harvesting.

Family members are often involved in pond operations, and management is handed down to the children, who undergo training and attend conferences and workshops to prepare for the takeover. Some farms are run on rotation basis among family members.

Farm caretakers take care of stock sampling and day-to-day operations.

A survey of 447 milkfish farmers in seven provinces in 1981 showed an average age of 49 years, family size of seven, formal schooling of eight years, and 15 years experience in milkfish farming. Managerial ability and yields were higher among farmers in the 41-60 year age group. Farmers with more than five years experience and more family members used more inputs and had higher yields.

The average milkfish farmer in 1981 earned five times more than the municipal fisherman, seven times more than the rice farmer, and two times more than the urban Filipino. Some 42% of the milkfish farmers reported non-milkfish sources of income, but 71% claimed to be full-time operators. Still, most pond operators left to their caretakers routine but essential tasks such as regular checks for stress signs. Successful farmers understand that they must assume the active role in pond management; they put it very aptly: "The best input for a fishpond is the shadow of the milkfish farmer across the pond or the number of footsteps on the dikes."

Milkfish farmers in 1981 were generally willing to exchange technical and managerial information; 65% classified themselves as active information seekers. The farmers had secondary to tertiary level education and should have had little difficulty receiving and decoding technical information in extension materials. However, only 10% of the farmers had any written technical materials on milkfish farming and only 30% of the farmers had contact with extension agents (many thought that they were more knowledgeable than the extension workers anyway).

A 1992 survey of five nursery pond operators, 30 fishpond operators, and ten fishpen operators showed higher farm productivity, which was attributed to the adoption of modern farming techniques learned mainly from training courses, seminars, or consultation with experts.

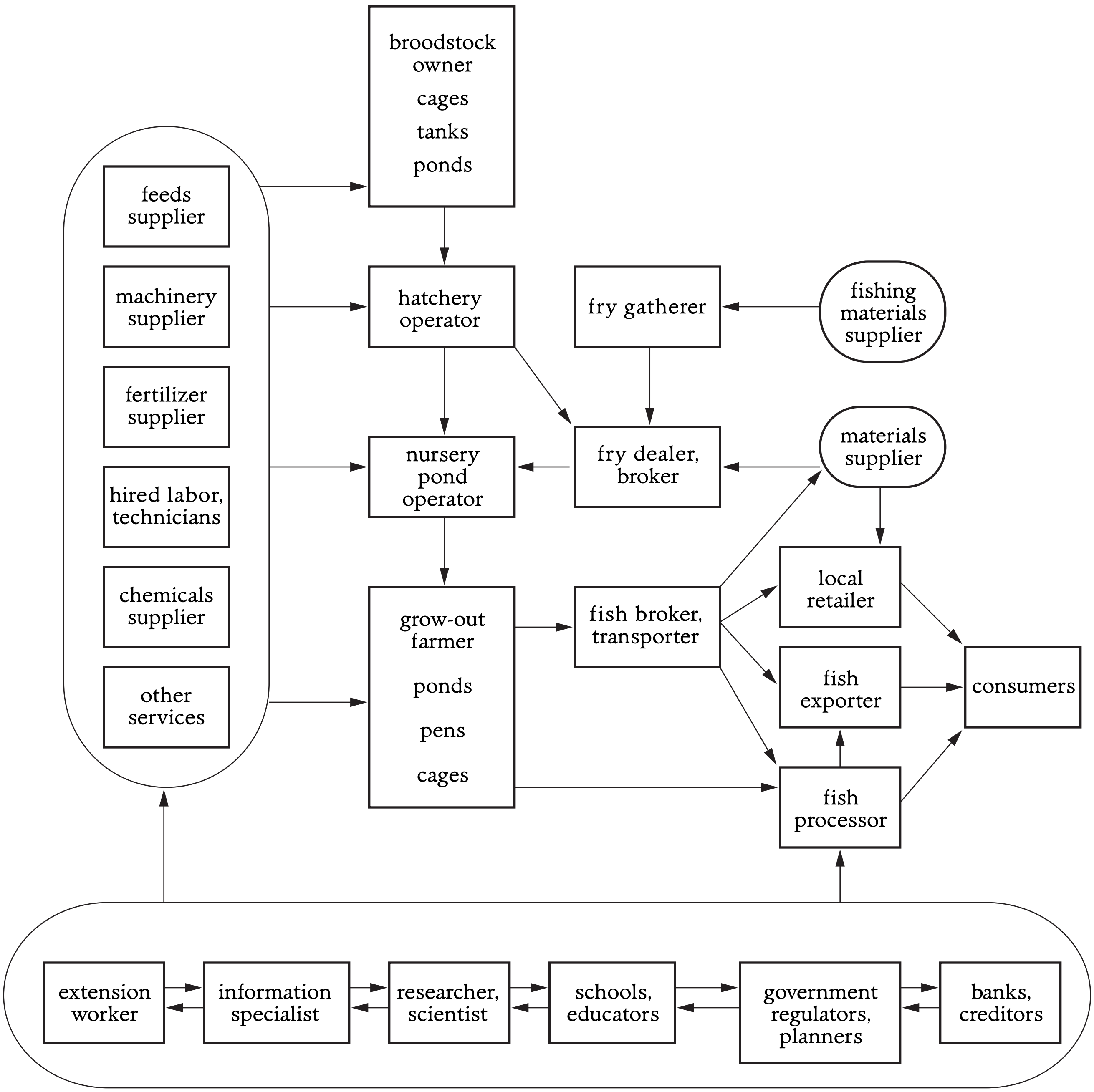
The development of the fishpen industry had multiplier effects on the economy and employment around Laguna de Bay and other lakes. But there have also been bitter conflicts arising from wealthy pen and cage owners using a public resource at the expense of the lake fishermen and other traditional users. About 83% of the 29,087 ha of fishpens in 1984 belonged to corporations, partnerships, or associations that made up 38% of 1,368 operators. Under pressure from the media and fishermen's groups, large areas of fishpens were dismantled in 1985.

Characteristics and productivity of milkfish farmers, Philippines, in 1978, 1981, and 1992. From Chong et al. (1982, 1984), Librero et al. (1992).

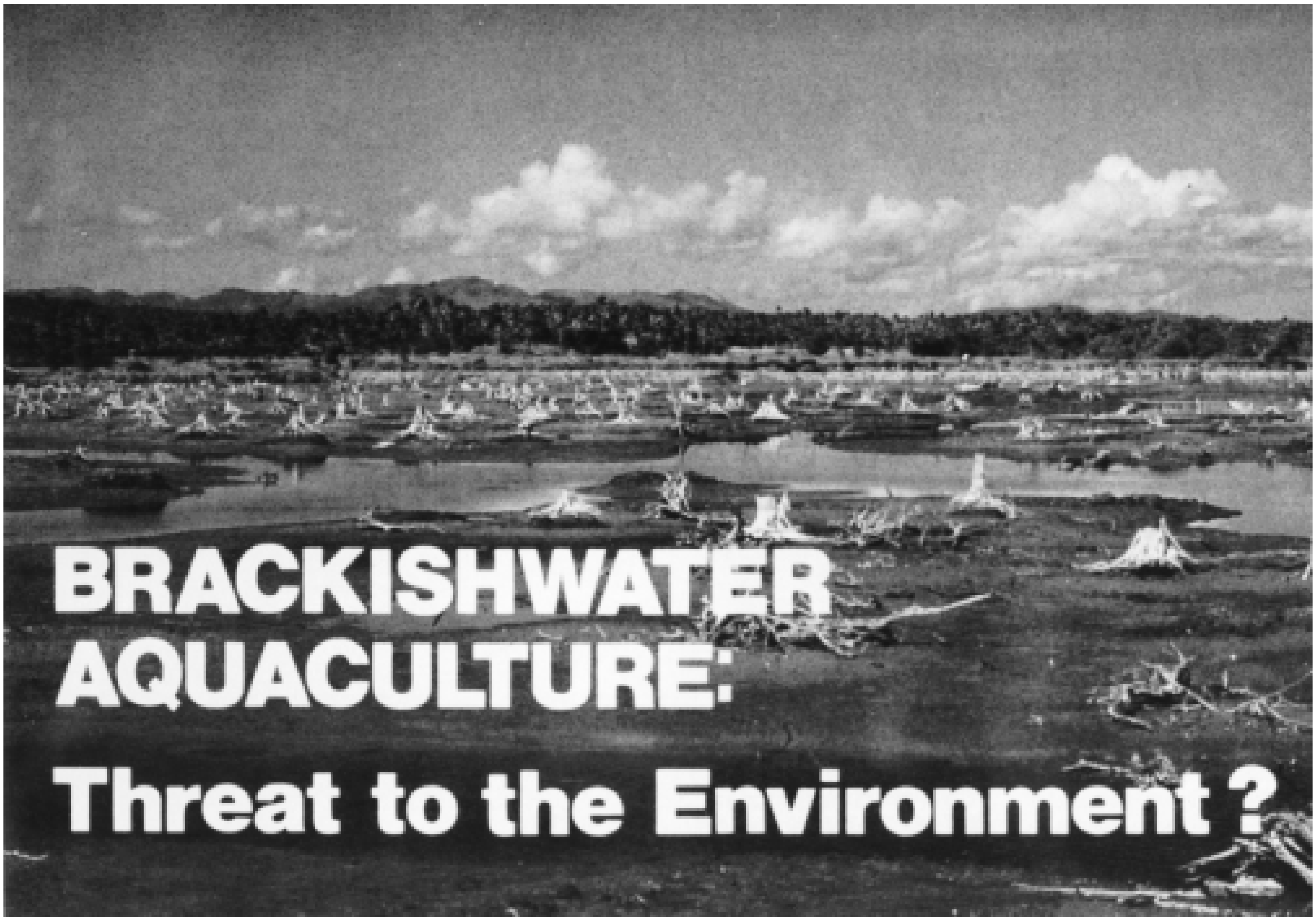
Milkfish farmers (n=no. in sample)	Farmer age (yr)	Family size	Formal school (yr)	Farmer experience (yr)	Annual income[a] (P)	Assoc members (%)	Farm size (ha)	Labor[c] (man-d/yr)	Survival harvest (%)	Yield (kg/ha-yr)
1978										
Fishpond operators (n=324)				16 ±14			16 ±26	458[d] ±476	49[e] 63[f]	761
1981										
Fishpond operators (n=447)	49 ±14	7 ±4	8 ±5	15 ±12	30,000[b]	25	20 ±76			831
1992										
Fishpond operators (n=30)	49	5	11	10	906,619	30	15	907	85[e+f]	1,813
Fishpen operators (n=10)	56	7	11	17	647,799	90	18	2,220	81[f]	4,552
Nursery pond operators (n=5)	52	8	7	20	341,600	40	12	171	88[g]	4 million fingerlings

[a] Annual income (in 1992 pesos) from the given milkfish operation only; almost all operators had other income;
[b] In 1980 pesos
[c] Labor of owner, family, caretaker, and casual workers
[d] Hired labor only, excluding work of owner and caretaker.
[e] Fry to market-size
[f] Fingerling to market size
[g] Fry to fingerling

Milkfish farmers, industry leaders, and scientists meet to discuss problems.



The major stakeholders in the milkfish industry, including the input suppliers, human resources, and support services.



Many people have become concerned about the environmental impact of aquaculture in cleared mangrove forests. From Saclauso (1989).

Large old pond still with mangrove stumps, and with Brestan used against snails. Iloilo, 1996.

Chapter 8

Sustainable Milkfish Farming

Around the world today, one billion people do not have sufficient food for a healthy, full, and active life. A majority of the food-insecure live in Asia. Aside from food shortages and low productivity, poverty and non-food factors such as sanitation and lack of safe drinking water contribute to food insecurity.

The earth's capacity to produce enough food for a growing human population is emerging as the overriding environmental issue in the 21st century. The ecological foundations essential for plant and animal productivity are getting eroded, and the Earth's carrying capacity for humans is approaching the limit.

As the new millennium approaches, all nations must accept the challenge of securing food for all, and the responsibility of conserving the Earth's natural resources. Governments need to promote sustainable food production and rural development, improve access to food particularly among the disadvantaged groups, and invest in infrastructure, research, and training.

In developing countries, agriculture, crop and animal husbandry, aquaculture, forestry, fisheries, and agro-processing, provide most of the jobs and income in the rural areas. Intensification, diversification, and value addition in these production sectors is necessary to meet the challenge of producing more food, income, and jobs from diminishing per capita land, water, and non-renewable energy resources.

The Philippines now has about 73 million people, up from 37 million in 1970. More Filipinos need more food, more goods, more housing, more services, more jobs, and more income. The fish requirement alone is now more than three million metric tons. Fisheries and aquaculture provide only two million metric tons for direct human consumption. The deficit of about one million metric tons of fish must be met, partly from milkfish.

Milkfish has been and will continue to be an important part of the fish supply in the Philippines. In terms of available resources and technology, milkfish farming can easily be intensified to a national minimum yield of about 3 mt/ha-yr, or a total production of about 300,000 mt a year, double the current rates. Such intensified production can and must be done in the existing 100,000 ha of ponds, not in new ponds, and in pens and cages at locations not used by other sectors; these milkfish farms must use inputs not directly needed by people or other sectors.

Intensive milkfish ponds in Negros, Iloilo, Sarangani, and Davao, like those in Taiwan, already produce 4-12 mt/ha-yr. But given the environmental and economic conditions in the Philippines, intensive milkfish farming is not likely to be profitable nor sustainable if adopted by the majority of farmers. Aquaculture can be intensified only up to a limit and adverse ecological and socioeconomic effects have been documented for uncontrolled development.

Brundtland Commission and 'sustainable development'

Sustainable development is one that "meets the needs of the present without compromising the ability of the future generations to meet their own needs." To ensure sustainability, "the environment should be protected in such a condition and to such a degree that environmental capacities (the ability of environment to perform its various functions) are maintained over time, at least at levels sufficient to avoid future catastrophe, and at most at levels which give future generations the opportunity to enjoy an equal measure of environmental consumption."

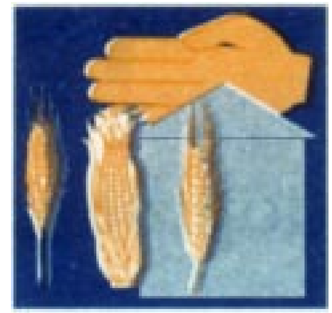
Earth Summit, Rio Declaration, Agenda 21

Recognizing the integral and interdependent nature of the Earth, our home, the Earth Summit or the United Nations Commission for Environment and Development in Rio de Janeiro in 1992 adopted a set of principles to guide future development, and a global plan of action called Agenda 21 to address the most critical issues facing the global community.

The Rio Declaration is the most important global document covering sustainable development and human survival; it defines the rights of people to development and their responsibilities to safeguard the common environment. The Rio Declaration includes the following principles:

- People are entitled to a healthy and productive life in harmony with nature.
- Development, environmental protection, and peace are interdependent and indivisible. Development today must not undermine the development and environment needs of present and future generations. Environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.
- Nations should reduce and eliminate unsustainable patterns of production and consumption, and promote appropriate demographic policies.
- Nations shall cooperate to conserve, protect, and restore the health and integrity of the Earth's ecosystems.
- Nations shall enact effective environmental laws and develop national law regarding liability for the victims of pollution and other environmental damage. Nations shall assess the environmental impact of proposed activities likely to have significant adverse impact. The polluter, in principle, shall bear the cost of pollution.
- Nations shall use the precautionary approach to protect the environment. Where there are threats of serious or irreversible damage, scientific uncertainly shall not be used to postpone cost-effective measures to prevent environmental degradation.
- Environmental issues are best handled with the participation of all concerned citizens or stakeholders. Nations shall facilitate and encourage public awareness and participation by making environmental information widely available.
- Sustainable development requires better scientific understanding of the problems. Nations shall share knowledge and innovative technologies to achieve sustainability.

From Keating (1994).



- Sustainable agriculture, fisheries, aquaculture, and rural development require major adjustments in agricultural, environmental, and economic policies in all countries and at the international level. Nations should have sound food policies based on an awareness of the environmental costs and the benefits of various policy choices.
- Agriculture, aquaculture, and fisheries have to meet the rising need for food mainly by increasing productivity because most of the best food lands are already in use. Available techniques to increase productivity, reduce food spoilage and loss to pests, and conserve soil and water resources must be widely and systematically applied.
- Land use policies should encourage planning on a scale large enough to maintain the health of regional ecosystems, such as watersheds. People should be encouraged to invest in the future of the land by giving them ownership and providing access to resources.

- Better use of the world's biodiversity is essential to diversify and increase food production. Nations should encourage traditional methods of agriculture, agroforestry, forestry, livestock-raising that use, maintain, or increase biodiversity.
- Marine environmental protection must be an integral part of national and international policies. Solid waste management, control of pesticides and fertilizers, and treatment of sewage and industrial wastes are imperative. Coral reefs, estuaries, mangroves, wetlands, seagrass and seaweed beds must be protected, and damaged ecosystems must be rehabilitated.

- Policies for sustainable use of the seas and fresh waters must account for the needs of local communities, include more aquaculture development, and prevent or mitigate adverse effects.

Sustainable development: FAO definition

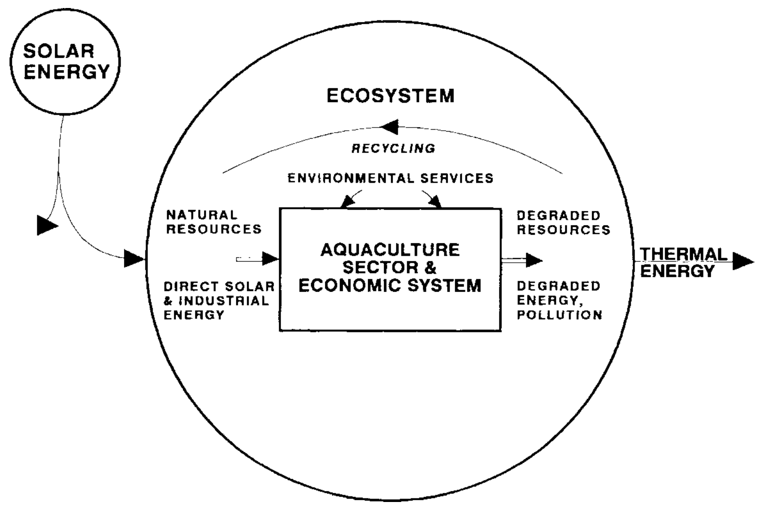
"Sustainable development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development conserves land, water, and plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable, and socially acceptable."

Code of Conduct for Responsible Fisheries and Aquaculture

Responsible fisheries encompasses sustainability of production, proper transformation processes to add value to fishery products, and appropriate commercial practices, including postharvest handling, processing, and marketing to provide consumers quality products. "States should consider aquaculture, including culture-based fisheries, as a means to promote diversification of income and diet. In so doing, States should ensure that resources are used responsibly and adverse impacts on the environment and on local communities are minimized."

Aquaculture and the environment: general principles

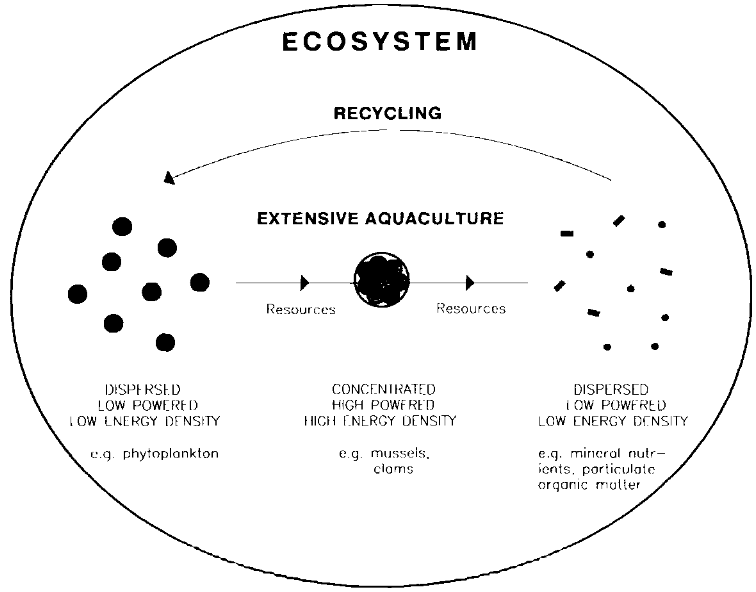
Aquaculture is part of the natural environment and farming systems operate inside larger ecosystems. Aquaculture takes natural resources and energy from the ecosystem and puts out a crop, but also degraded resources, degraded energy, and pollution. The ecosystem also performs services such as water supply, waste treatment, food supply, oxygen supply, nutrient cycling, and protection from winds and waves. Growth of aquaculture is only possible where ecosystem integrity and life-support functions are maintained.



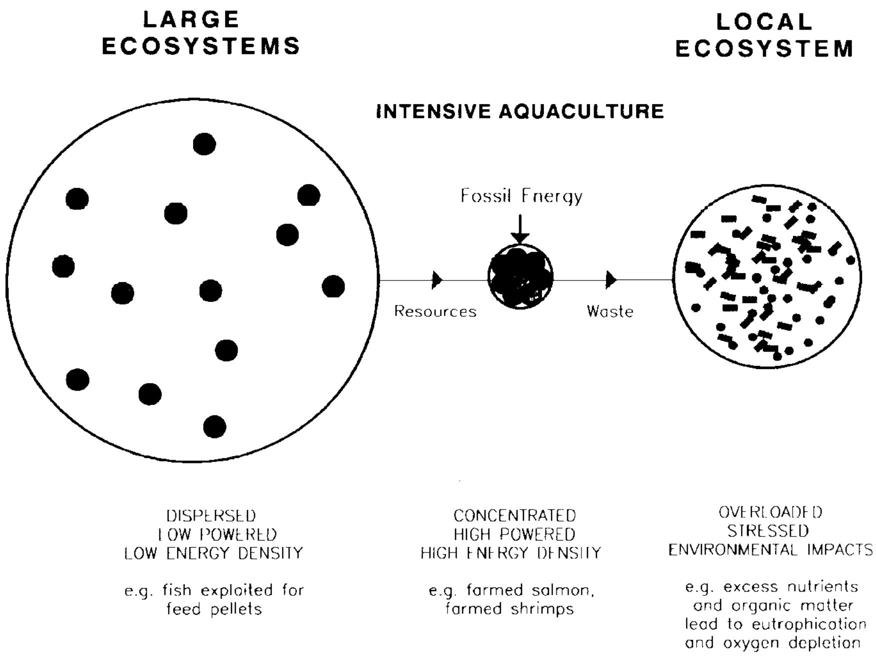
Aquaculture is an economic subsystem of the overall ecosystem. To make aquaculture possible, ecosystems are used as sources of energy and farm inputs and as sinks for waste outputs. From Folke and Kautsky (1992).

The challenge for aquaculture is to match the culture techniques with the processes and functions of the ecosystems, for example by recycling some degraded resources.

Extensive farming may keep the ecosystem in balance. For example, in a pond or lake, *lablab* or plankton are eaten by milkfish, which then produce urine and fecal wastes that are reused by *lablab* or plankton in the same pond or lake. Low-energy resources are transformed into a high-energy fish crop that produces mineral nutrients and low-energy organic matter that are reused in the same local ecosystem.



In extensive aquaculture such as oyster farming, resources such as dispersed phytoplankton are collected by filter-feeding, and the mineral wastes from oysters go back into the ecosystem, to be used as resources all over again. From Folke and Kautsky (1992).



In intensive aquaculture such as milkfish farming in cages, dispersed resources collected from non-local ecosystems are concentrated in the farm. Large sea areas are exploited for small fish that are turned into fish meal for feeds. Farm wastes overload the local ecosystem and cause various problems. From Folke and Kautsky (1992).

Intensive farms use inputs from non-local ecosystems and generate wastes that overload the local ecosystem. Feeds for fish are made with fish meal from capture fisheries operating oceans away from the farm. Fuel to operate paddlewheels and pumps comes from Saudi Arabia or elsewhere abroad. Intensive farms often do not include feedbacks or recycling mechanisms between the farm and the environment.

Sustainable farming systems make environmentally sound use of resources. Such systems do not divert or replace resources that may be used in a more productive way for other purposes and do not degrade the environment that the livelihood of future generations is jeopardized. Ecological integrity is maintained and biodiversity is conserved at the gene, species, and ecosystem levels.

Sustainable farming systems are acceptable to the local communities, the net benefits accrue to more people, and user conflicts are avoided. These systems ensure sufficient income over the long term to enable continued inputs, necessary developments, and profitability. Environment-friendly and socially acceptable aquaculture is likely to be economically successful over the long term.

To be sustainable, aquaculture must be part of a well-balanced, integrated coastal or watershed resources management plan that considers all other existing developments, activities, and users. Effective and balanced planning, based on a clearer understanding of the interactions between the farm and the environment, is the key to sustainable aquaculture. The carrying capacity of the local ecosystem must be estimated during the planning stage in order to decide both the density of the farms and the intensity of farm operations.

Policy-and decision-makers need to develop the expertise, tools, and guidelines for the planning and execution of aquaculture development, and for the formulation and enforcement of environmental laws.

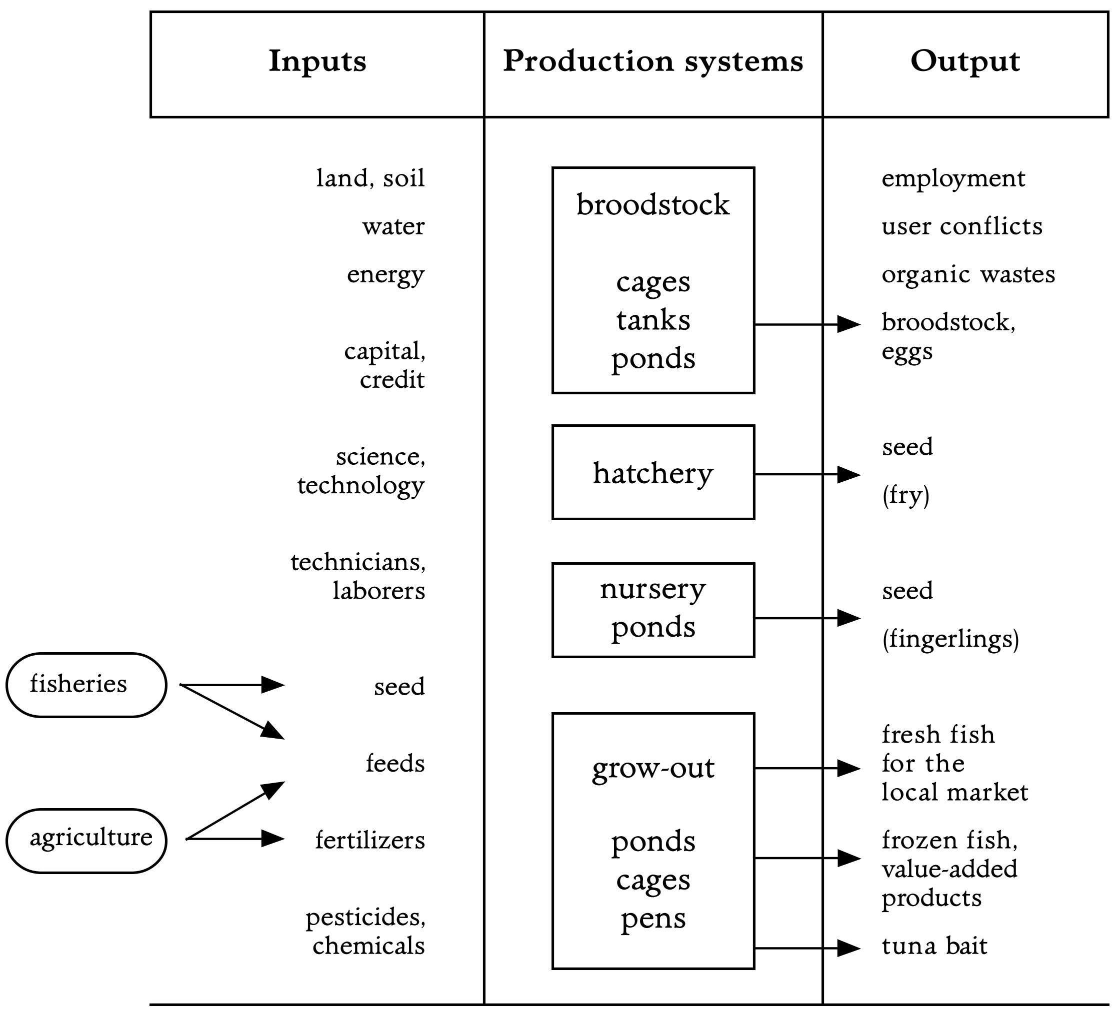
Aquaculture in developing countries can best be maintained and expanded if sustainable, environmentally compatible aquatic farming systems are developed through long-term adequately funded research.

The milkfish resource system

Aquaculture is essentially livestock rearing that uses common resources with agriculture and also draws inputs from, and impacts upon, capture fisheries, with which it shares processing and marketing. Milkfish farming must be seen in its proper context, not only as a producer of food and revenue, but as a consumer competing for finite resources, and which must live in harmony with other sectors.

A large variety and amount of inputs go into milkfish production systems – broodstock facilities, hatcheries, and grow-out ponds, pens, and cages – ultimately to produce large volumes of milkfish for the domestic and export markets. Among the many resource inputs, also needed are machinery, capital and operating funds, technical manpower, and appropriate science and technology. In addition to the fish harvest, income to farmers, and employment for other workers, the farm operations also produce wastes and use conflicts with other sectors.

Milkfish resource system



Understanding the limits

Various factors and processes outside and inside the milkfish farm may limit the extent, scale, profitability, and sustainability of the operation. Growth and yields of milkfish depend on the inputs, but may be limited by soil and water quality in the farm.

Intensive milkfish farming will be limited by environmental, resource, and market constraints. Demand will increase for machinery, fuel oil, fish meal for feeds, fertilizers, and other inputs, but the supply is short. The resulting high production cost may not leave any profit for the farmers, and the high volume of production may bring down milkfish prices and farmer incomes.

Land and water. The supply of enough clean fresh, brackish, or sea water is a critical factor that determines the sustainability of intensive milkfish culture. But suitable farm sites with unpolluted water are now very difficult to find in many coastal areas subject to urbanization, industrialization, and pollution from agricultural chemicals. Total water demand increases with intensification as more water is required to flush away ammonia, feces, and other wastes. Building intensive farms on old extensive farms is probably a good use of available resources, but old pond sites may not have the water supply to cope with the higher water demand of more intensive operations.

The acquisition and maintenance of good soil and water quality are costly. But the environmental services of the water and soil in and around the farm have often been undervalued and are not accounted for in the cost of milkfish production.

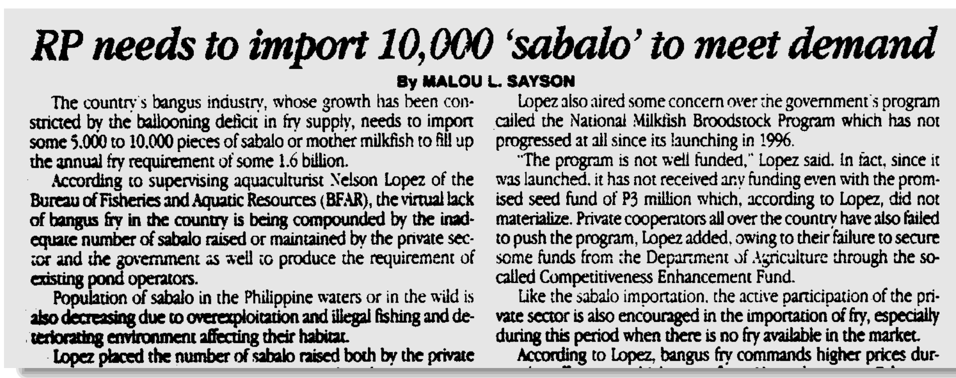
Large ponds are built on extensive tracts of coastal land and require enormous amounts of clean water.

Sea cages have unlimited water but are subject to storm damage.

Fertilizers and manures. Existing methods for *lablab* production can not support high stocking rates. Semi-intensive farms require greater inputs of imported NPK fertilizers, increasing both the production cost and the dollar drain. Even the increased use of chicken manure adds to the cost of production. More nutrients will be released into the surrounding waterways and cause problems.

Seed. The natural sources of milkfish fry are increasingly under threat from illegal fishing of *sabalo*, degradation of milkfish habitats, pollution of coastal waters, and disturbance from human settlements and activities. On the other hand, the milkfish fry fishery kills a large number of larvae of many different species of fish and crustaceans, and thus adversely affects many fishery stocks aside from milkfish.

Hatchery-reared fry may fill the requirement of intensive farms, but hatcheries also require land, water, feeds, and fuel. Broodstock development requires huge capital outlay and operating expenses. Another potential problem is that the import and export of milkfish fry could move potential pathogens to places where they did not occur previously.



RP needs to import 10,000 'sabalo' to meet demand

By MALOU L. SAYSON

The country's bangus industry, whose growth has been constricted by the ballooning deficit in fry supply, needs to import some 5,000 to 10,000 pieces of sabalo or mother milkfish to fill up the annual fry requirement of some 1.6 billion.

According to supervising aquaculturist Nelson Lopez of the Bureau of Fisheries and Aquatic Resources (BFAR), the virtual lack of bangus fry in the country is being compounded by the inadequate number of sabalo raised or maintained by the private sector and the government as well to produce the requirement of existing pond operators.

Population of sabalo in the Philippine waters or in the wild is also decreasing due to overexploitation and illegal fishing and deteriorating environment affecting their habitat.

Lopez placed the number of sabalo raised both by the private

Lopez also aired some concern over the government's program called the National Milkfish Broodstock Program which has not progressed at all since its launching in 1996.

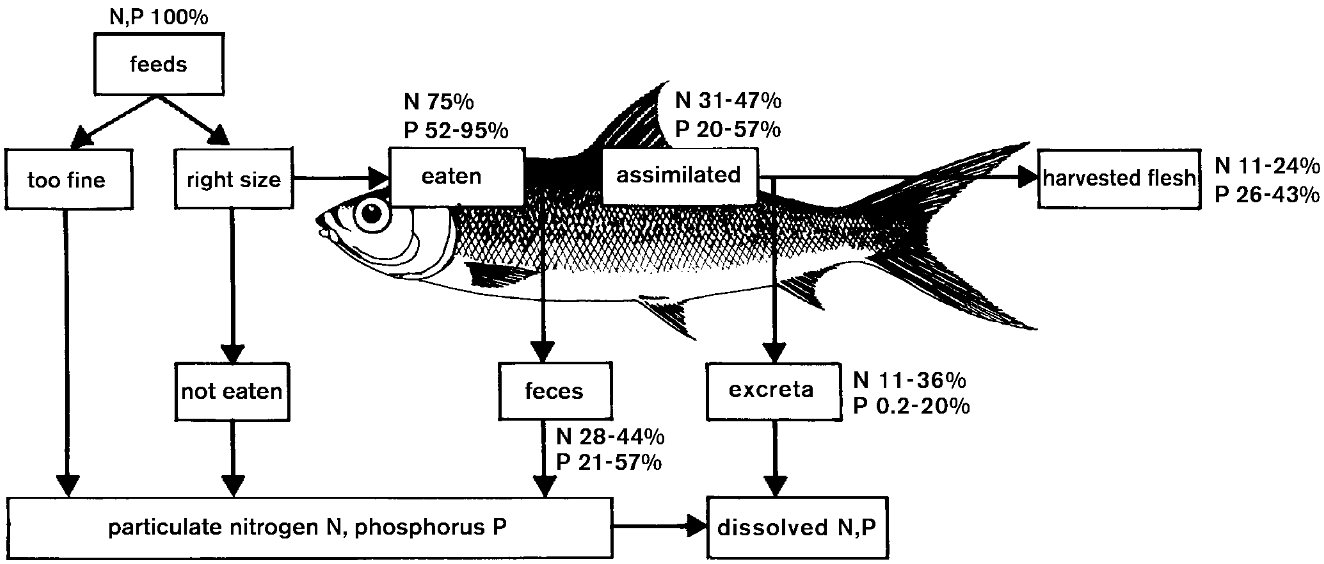
"The program is not well funded," Lopez said. In fact, since it was launched, it has not received any funding even with the promised seed fund of P3 million which, according to Lopez, did not materialize. Private cooperators all over the country have also failed to push the program, Lopez added, owing to their failure to secure some funds from the Department of Agriculture through the so-called Competitiveness Enhancement Fund.

Like the sabalo importation, the active participation of the private sector is also encouraged in the importation of fry, especially during this period when there is no fry available in the market.

According to Lopez, bangus fry commands higher prices dur-

Broodstock facilities require huge capital outlay and operating expenses.

Feeds and feed ingredients. Inadequate supply and high costs of feeds are no longer serious constraints to intensive milkfish farming. Many feed companies now make milkfish feeds, which farmers buy as long as they can make a profit. But, increasing the stocking and feeding rates increases the waste loads and affects the water quality within and outside the farms. A large fraction of the feeds (with carbon, nitrogen and phosphorus) added to a fish pond is wasted, more in intensive than in semi-intensive ponds.



A large part of the feeds (containing nitrogen N and phosphorus P) given to fish in farms are wasted and only a small part is harvested as fish biomass. Feeds may be uneaten (too fine, sink too fast), or undigested (come out as feces). Nutrients are excreted mostly in urine but also across the gills, or shed off as mucus or slime. Values from Neila Sumagaysay, SEAFDEC AQD.

The problem with feeds and feeding of milkfish are serious but not too obvious. Feed mills and the making of fish feeds constitute still another drain on limited land, water, fuel, feedstuffs, and other resources. Use of fish meal in making feeds for omnivorous fish like milkfish is ecologically inefficient (an extra trophic level is inserted in the food chain), and worsens the 'fish meal trap' (the use of 3 kg of fish from capture fisheries to produce 1 kg of farmed fish or shrimp). Formulated feeds compete with human requirements for fish (that goes into fish meal), vitamins, bread flour, soy beans, and other agricultural products.

Large amounts of feeds are used for milkfish in marine cages and pens, another "fish meal trap."

Pesticides and other hazardous chemicals. A large number of pesticides and other chemicals are now used in milkfish ponds. More chemicals including antibiotics and chemotherapeutants and water conditioners will become necessary in intensive farming. Indiscriminate use of antibiotics and other leads to the development of resistant strains of pathogens and the increased incidence of diseases.

Pesticides are harmful not only to the target pests but also to non-target organisms, farm workers, and fish consumers. Many pesticides are persistent in the environment, accumulate in organisms, and trigger various diseases like cancers. Non-persistent pesticides are similarly toxic and frequent applications can be expensive.

Capital and operating funds. Construction, repair, or renovation of farms according to a suitable design is costly. All the various inputs, including equipment and technical manpower add to the investment costs. Farmers need funds or access to credit for all these expenses. But, the high production cost and the price fluctuations of milkfish in the market affect the willingness of farmers to invest and produce more milkfish. Banks usually give loans for farm construction but not operation and maintenance.

Infrastructure. Absence of farm-to-market roads can limit the provision of inputs at the farm and the transport of the milkfish harvest to the markets. The Philippines does not have adequate farm-to-market roads and post-harvest facilities for all its agricultural products including captured fish and farmed fish like *bangus.*

Many ponds are in remote rural areas with poor roads and few transport vehicles.

Trainees at the SEAFDEC AQD broodstock cages.

Technical manpower, farmer skills, knowledge, and attitudes. Intensive farms require more attention, time, and expertise from the farmers. Farmers need to understand the interplay of the various factors and processes that affect milkfish production. They need to have more technical training, or hire good technicians, or avail of extension services. They need to invest in new information, training courses, and instruments to monitor soil and water quality.

Milkfish farmers also need to adjust mindsets and find a balance between the farm and its environment. They need to develop a long-term perspective of optimized use of land, water, and all resources. The quick-profit mindset either inhibits investments in milkfish farms, or encourages unsustainable farming systems.

Information materials are available from the SEAFDEC Aquaculture Department.

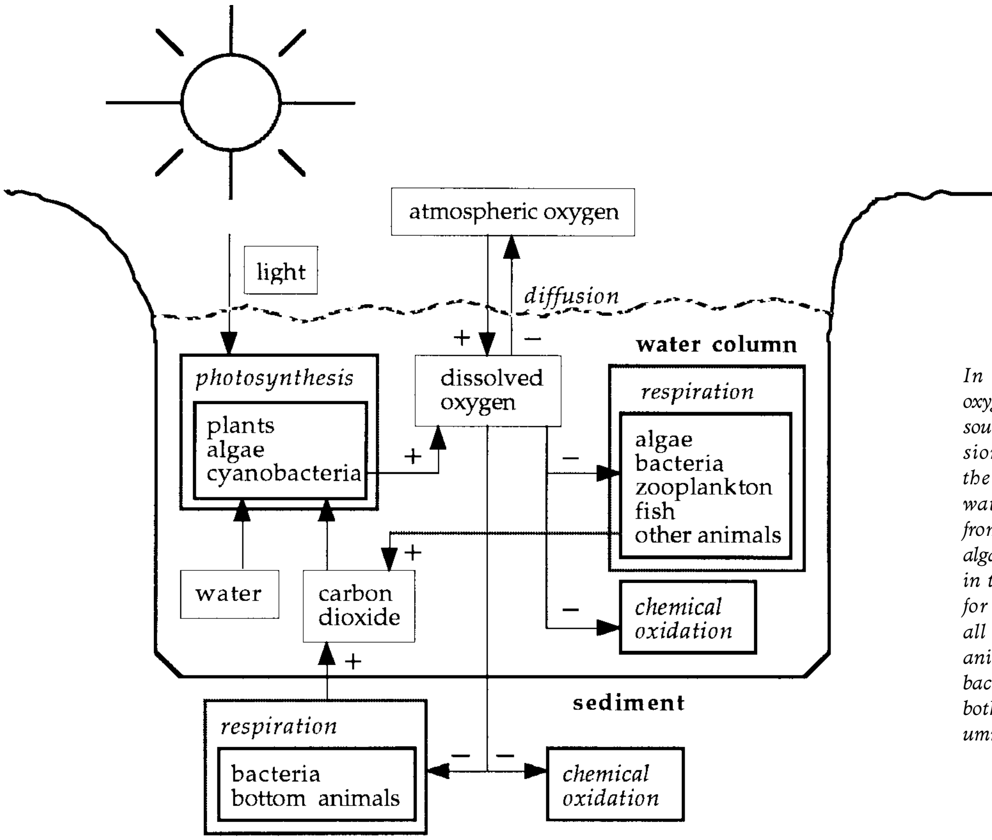
Fuel oil and energy-demanding machines. Free solar energy runs the algal pantry and oxygen-producing machinery in extensive farms, but electricity is needed to run the paddlewheels, pumps, demand feeders, work machines, vehicles, and other equipment in the intensive farm. Farms can not operate at high stocking and feeding rates without aeration and water exchange. To provide electricity for fish farms, more oil will be imported and more power lines connected.

Paddlewheels aerate and circulate the pond water.

Intensive ponds have large power requirements and capital outlay.

Oxygen. Oxygen demand increases with temperature, stocking rate, feeding rate, total feed input, and the density of algae, benthic animals, and sediment bacteria. Farm wastes (dissolved nutrients and organic solids) stimulate the rapid growth of bacteria and plankton, leading to oxygen depletion.

The oxygen supply and oxygen saturation levels are major factors in the carrying capacity of ecosystems for aquaculture. These saturation levels decrease at high temperatures and high salinities. The tropical temperatures of the Philippines limit the amount of dissolved oxygen in fresh, brackish, and sea water to about 5-8 mg/l. Examples of successful high-density fish farming are mostly temperate freshwater systems with higher oxygen saturation levels able to accommodate higher stocking rates and feed loads for high yields, that is, carps in China, carps and tilapias in Israel, and channel catfish in the southern USA.



In ponds, dissolved oxygen comes from two sources: through diffusion of oxygen from the air through the water surface, and from photosynthesis of algae and other plants in the pond. Demand for oxygen comes from all the milkfish, other animals, plants, and bacteria in the pond, both in the water column and the sediment.

Oxygen: what do we need to know?

Milkfish farmers must understand the following facts about the supply and demand of dissolved oxygen or DO in fish farms (pens, cages, or ponds):

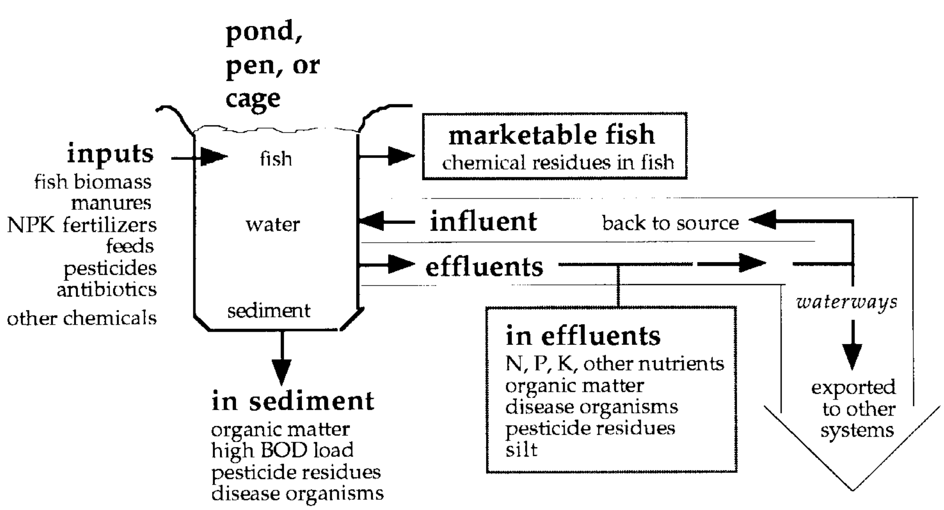
- Fishes and other aquatic animals with gills take DO from the water where they swim, eat, and put out wastes.
- DO comes from the air by diffusion across the water surface, and from the photosynthesis of aquatic plants. Shallower, more turbulent waters with plants contain more DO than deep static waters without plants.
- Tropical and salty waters contain less DO than cold and fresh waters.
- DO consumption of fish is faster in warmer waters and increases with fish size and numbers.
- Organic wastes like feeds and feces and substances like ammonia and sulfide consume DO during decomposition and oxidation. Thus, polluted waters contain less DO than clean waters.
- When the DO is used up, toxic substances like sulfide come out of the sediments and may poison the fish.
- When DO is always low, the fish are stressed, grow slowly, and are more likely to get sick and die.
- As stocking rates per cage and the number of cages per unit water volume both increase, the greater the oxygen demand and the likelihood of fish kills.

Metabolic wastes. Ammonia, sulfide, carbon dioxide, methane, and high acidity are toxic to fish, and also reduce the dissolved oxygen. Hydrogen sulfide from sediments is responsible for the deterioration in the health of farmed fish (increased stress, reduced growth, gill damage), mortality, and loss of production. Large amounts of feeds, feces, and other particulate matter settle on the pond bottom and increase the oxygen consumption and the production of toxic metabolites.

Milkfish kill in ponds, Iloilo, 1996.

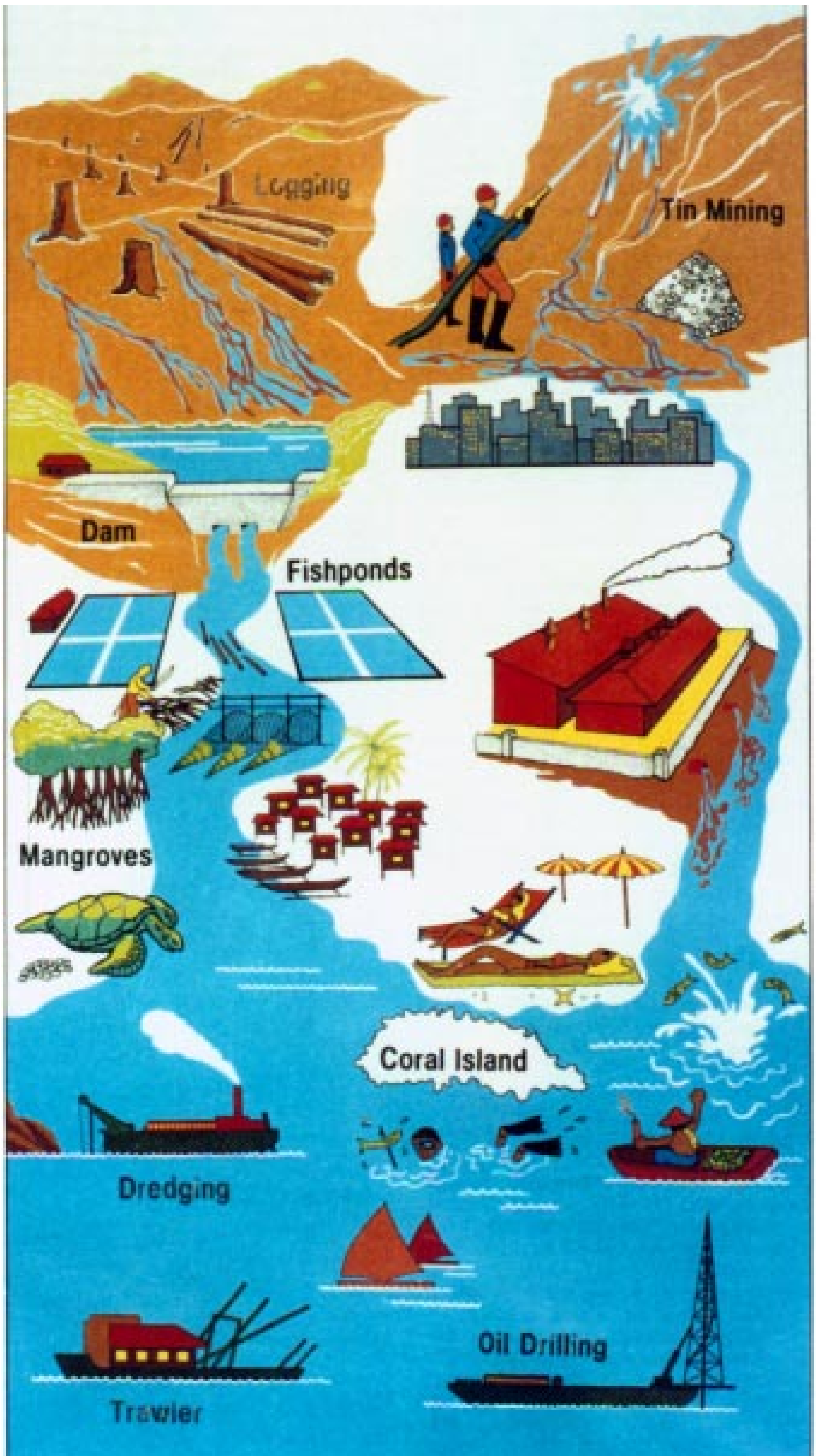
Pond sediments have high levels of sulfide that may be released when the pond is oxygen-depleted.

Effluents, self-pollution, and diseases. Farm wastes and chemicals add to freshwater and marine pollution. Discharge of effluents from intensive farms reduces the dissolved oxygen in the receiving waters, results in siltation, and changes the productivity and community structure of benthic organisms. Intensive milkfish farms are adversely affected by the wastes and effluents from nearby fish farms or even from themselves. Such self-pollution often leads to disease and is more serious in enclosed coastal waters or rivers subject to heavy farming and poor water exchange. Where waste production exceeds the capacity of the receiving environment to dilute or assimilate wastes, large areas of farms could collapse.



Fish ponds, like other agricultural farms, pollute the surrounding waterways and themselves, and may suffer from disease outbreaks and serious losses.

User conflicts. The operation of milkfish pens and cages in lakes, rivers, and coastal waters conflicts with open-water fisheries, navigation, tourism, and other uses. Use of various inputs in milkfish farms reduces the resources available to people and other sectors. When other users file legal complaints against fish farmers, there could be additional costs for mitigating measures or lawyers. But even when no complaints are formally filed, milkfish farmers as citizens must be sensitive to the needs of other users and fellow citizens.



The various economic activities in the coastal zone, including aquaculture and land-based industries, all use ecosystem goods and services, generate wastes, and affect each other. From Pauly & Chua (1988).

Recommendations for sustainable and responsible milkfish farming

These recommendations derive from lessons learned from current industry practices and realities, the extensive biological information on milkfish, and from desiderata defined by international and national agencies, policies, and laws in the pursuit of sustainable development (pp. 126-127).

1. **Protect milkfish stocks and habitats by enforcement of appropriate policies and laws, research and use of accurate data, and environment education of the general public.**

   The future sustainability of the milkfish industry depends, above all, on the maintenance of ecosystem integrity. There must be a conscious and concerted effort to protect the coastal habitats required by milkfish during the life cycle: coral reefs for milkfish spawning, shore waters for the transit of postlarvae into backwaters, mangrove swamps and estuaries for shelter and growth of juveniles, and rivers and lakes for migration and growth of sub-adults.

   The ban on *sabalo* fishing must be enforced, but ways to monitor the milkfish stocks must be developed. Government should accurately monitor milkfish fry catches and trade so that appropriate action can be taken about fry shortages.

   The Philippine Fisheries Code of 1998 must be enforced to maintain the supporting ecosystems. Mangrove conversion into ponds or other uses must no longer be allowed now that only 20% of the mangrove area nationwide remains. Mangrove reforestation must be intensified in degraded government-owned forests and privately owned mangrove areas and ponds. Non-productive brackishwater ponds must be allowed to revert back to mangrove forest. Fish corrals must not block rivers and entrances into bays and mangrove lagoons. Destructive fishing and other disturbances on the coral reefs, surf zones, rivers, and lakes, must not be tolerated. Marine debris and pollution must be curbed through proper waste management and appropriate laws, incentives, or disincentives against waste-generating consumers and manufacturers.

International Coastal Cleanup can be part of environment education for the protection of coastal ecosystems.

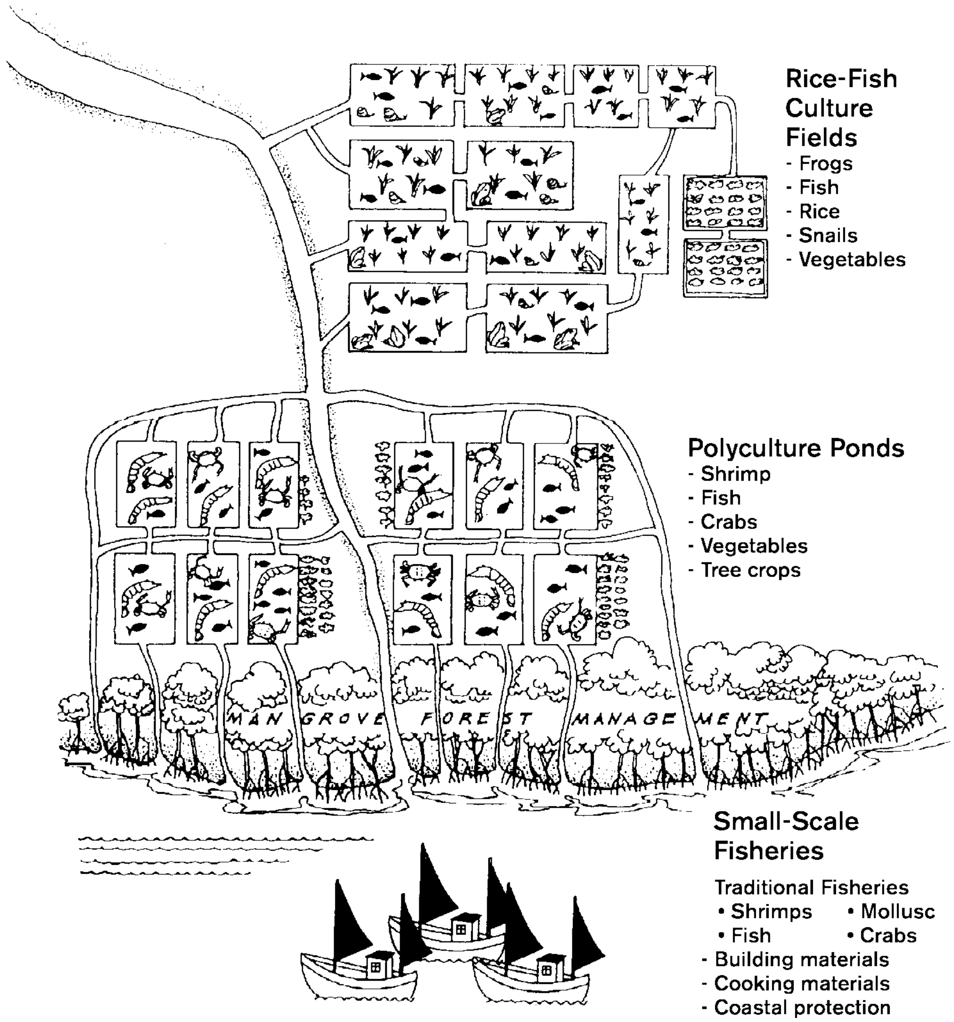
2. **Critically assess milkfish production systems (broodstocks, hatcheries, and grow-out ponds, pens, cages) in relation to other uses and users of the coastal zone, rivers, and lakes. Include milkfish farming in an integrated ecosystem and resources management plan.**

   Milkfish farmers and local governments must produce maps of the farms, human communities, as well as agriculture, industries, commerce, and other economic activities in a given watershed or coastal ecosystem. These maps become the basis for further developments in a given area and must be updated regularly. The maps must identify all resources, products, and users and stakeholders. All sectors of the local community must be involved in the development planning and the management of resources.

An output of a training exercise in coastal resources management, showing integration of fish-shrimp pond with plant crops and livestock, post-harvest processing, industries with waste water treatment, and environmental protection.

An idealized rural coastal zone integrating fisheries, aquaculture and other uses. Drawn by I. Tendencia and E. Ledesma.

An example of integrated coastal zone management, practised traditionally in Indonesia. Sustainable integration has developed between land and water systems including mangrove forests, rice-fish farms, extensive polyculture ponds, and small-scale local fisheries. From Folke and Kautsky (1992).

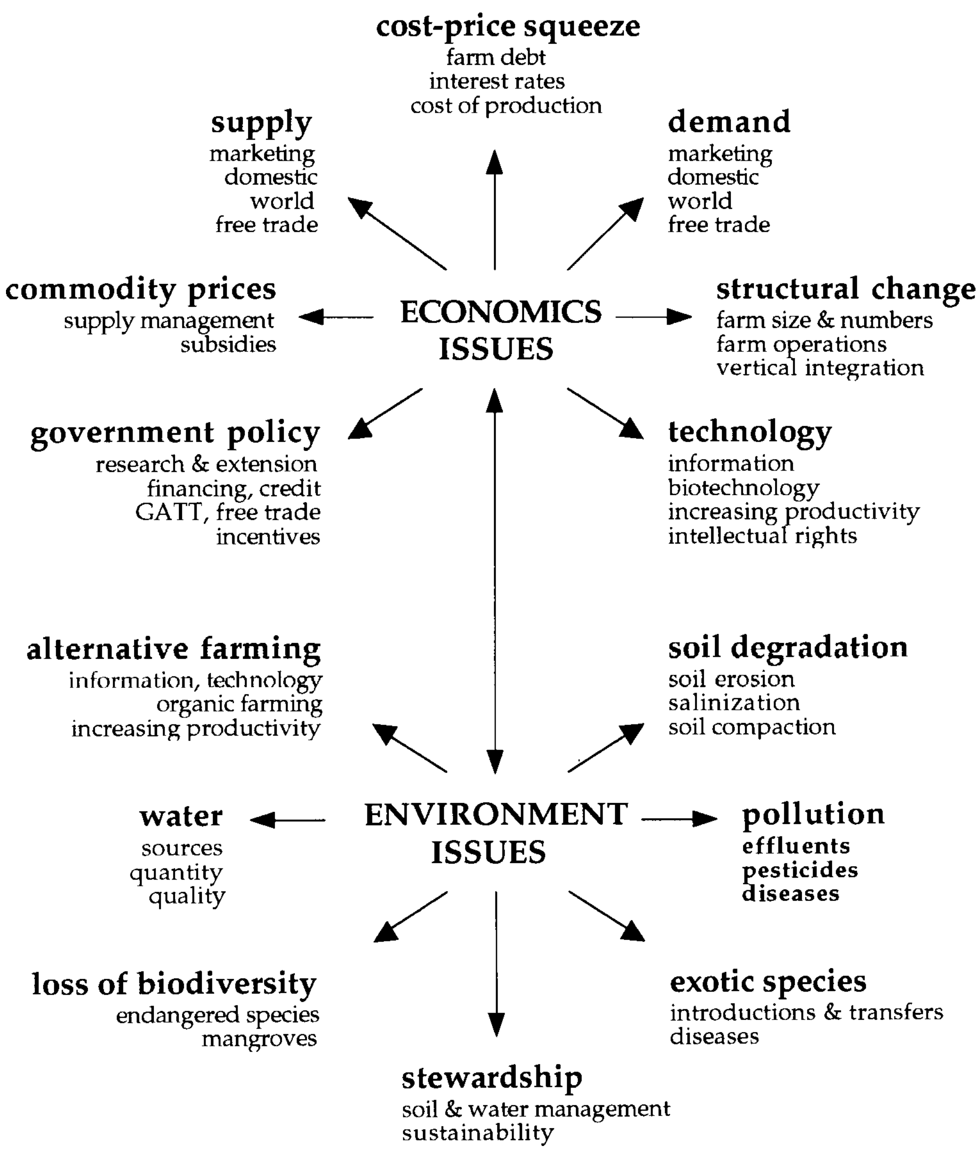


Many ecological problems may be avoided if fish farms are properly planned and integrated with other uses by other sectors in a given area. Productive agricultural farms, wetlands, and mangroves must not be converted into milkfish ponds. Only the (deeper) open waters of large lakes, rivers, and marine bays may be used for milkfish cages and pens.

Ideally, government must invest in remote sensing and geographic information systems (GIS) to aid in integrated ecosystem and resources management, including aquaculture planning and development, particularly site selection.

A GIS is an integrated assembly of computer hardware, software, geographic data, and personnel designed to efficiently acquire, store, manipulate, analyze, display, and report all forms of geographically referenced information. GIS combines the capabilities of a large database, the algebraic and logical analytical functions of a spreadsheet, and the hardware and software to make maps. When incorporated in a GIS, remotely sensed data can be mapped with other variables to answer various questions. GIS spatially links and conceptually integrates the complex data needed to develop and manage fisheries and aquaculture and other water uses to ensure a productive aquatic environment.

An important requirement for integrated resource management is for the many stakeholders in the milkfish industry to address and resolve the current economic and environmental issues facing aquaculture (and all other sectors of food production). The issues are numerous and complicated, but they can not be ignored if the industry is to persist. Government and the research and academic community have to lead the necessary information dissemination, discussions, and consultation with the milkfish farmers and business people.



Various economic and environmental issues have to be addressed in aquaculture and all other sectors of food production. From Caldwell (1994).

3. Determine the carrying capacities of lakes, rivers, and coastal areas and monitor the environmental impact of aquafarms.

Congregation of too many fish farms in an area with the same water source must be avoided, even in areas not used for other economic activities. Productivity depends a great deal on soil and water quality, which deteriorates with the density of farms in a given area.

Suitable rules and regulations must be developed to restrict the establishment of farms that exceed the carrying capacity of the environment. Farm licenses must regulate the size of the farm, production volume, techniques, water intake, and the volume and quality of wastewater discharge. The regulations, guidelines, and standards must be adapted to the climatic and social conditions of the Philippines, and they must be enforced.

Before fish farms are set up in new locations, an environmental impact assessment must be made. During the operation of the farm, the effluents and other effects of the farm must also be monitored.

When data on ecosystem carrying capacity are not available, the congregation and intensity of operation of farms must be regulated according to the precautionary principle (when uncertain of impact, do not proceed with the project).

Before a shift to intensive farming, there must be adequate site surveys to determine the potential risks (such as soil and water quality) inherent at the site, the effects of effluents on the external environment, and the impacts on the farm of pollution from agricultural and industrial sources. The macroeconomic and social feasibility of intensive monoculture systems must also be studied.

Enclosed bays like this have limited carrying capacities very quickly exceeded by aquafarming and fishing. Balete Bay, Davao Oriental, 1997.

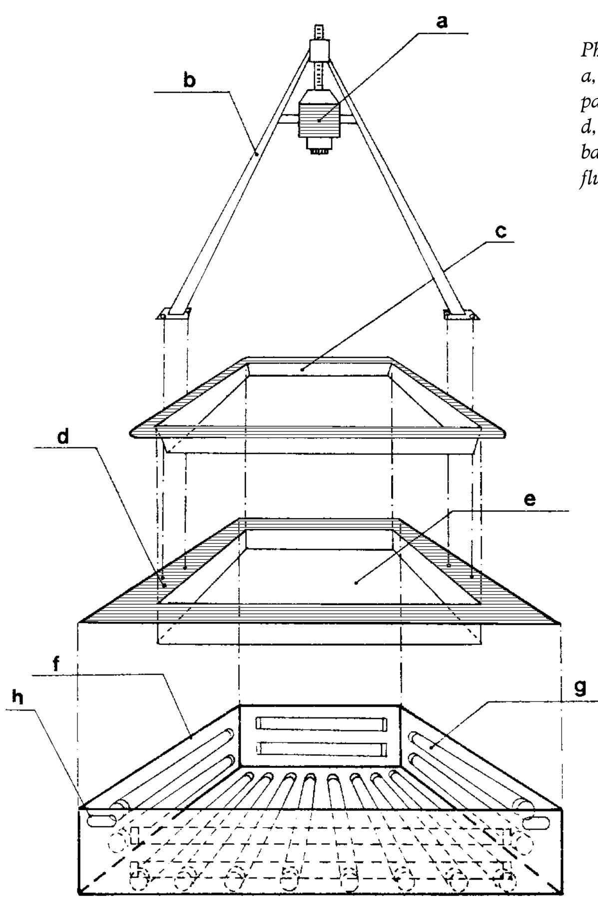
4. Improve milkfish fry gathering, handling, and counting to reduce losses.

Milkfish production is not strictly dependent on the supply of fry available for stocking. A simpler and more resource-efficient way to reduce the alleged fry shortage is to reduce the mortality during storage, transport, nursery, and grow-out. Fry and fingerlings constitute a large fraction of the cost of milkfish production; lower mortality means savings to farmers and less pressure on milkfish fry stocks and wild fish stocks in general.

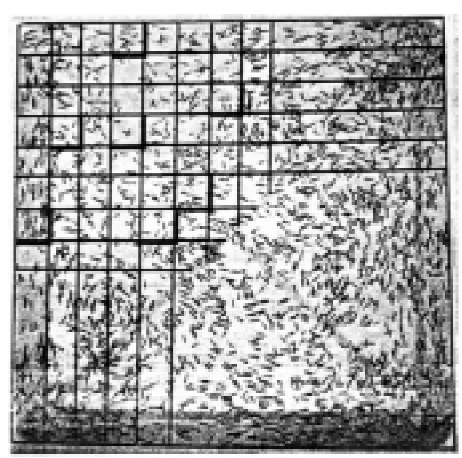
Fry gathering and handling techniques are in fact quite rough and it is a great wonder that milkfish fry survive capture, sorting and counting, transport, storage, further counting and transport, and stocking, all under very basic conditions. Fry mortality may be reduced by the use of passive fry gears and techniques that take advantage of fry behavior such as strong rheotaxis, phototaxis, optomotor response, and color vision. Fry gears need be moved at speeds only a little faster than 9-11 cm/s, the swimming speed of milkfish fry.

A method should be developed to count milkfish fry reasonably accurately so that the practice of *pasobra* would be eliminated and the fry would be properly valued and priced as a resource. Milkfish farmers are lax about improving their handling and farming methods when—or because—the fry are abundant and inexpensive, and *pasobra* is given by fry dealers for expected mortalities.

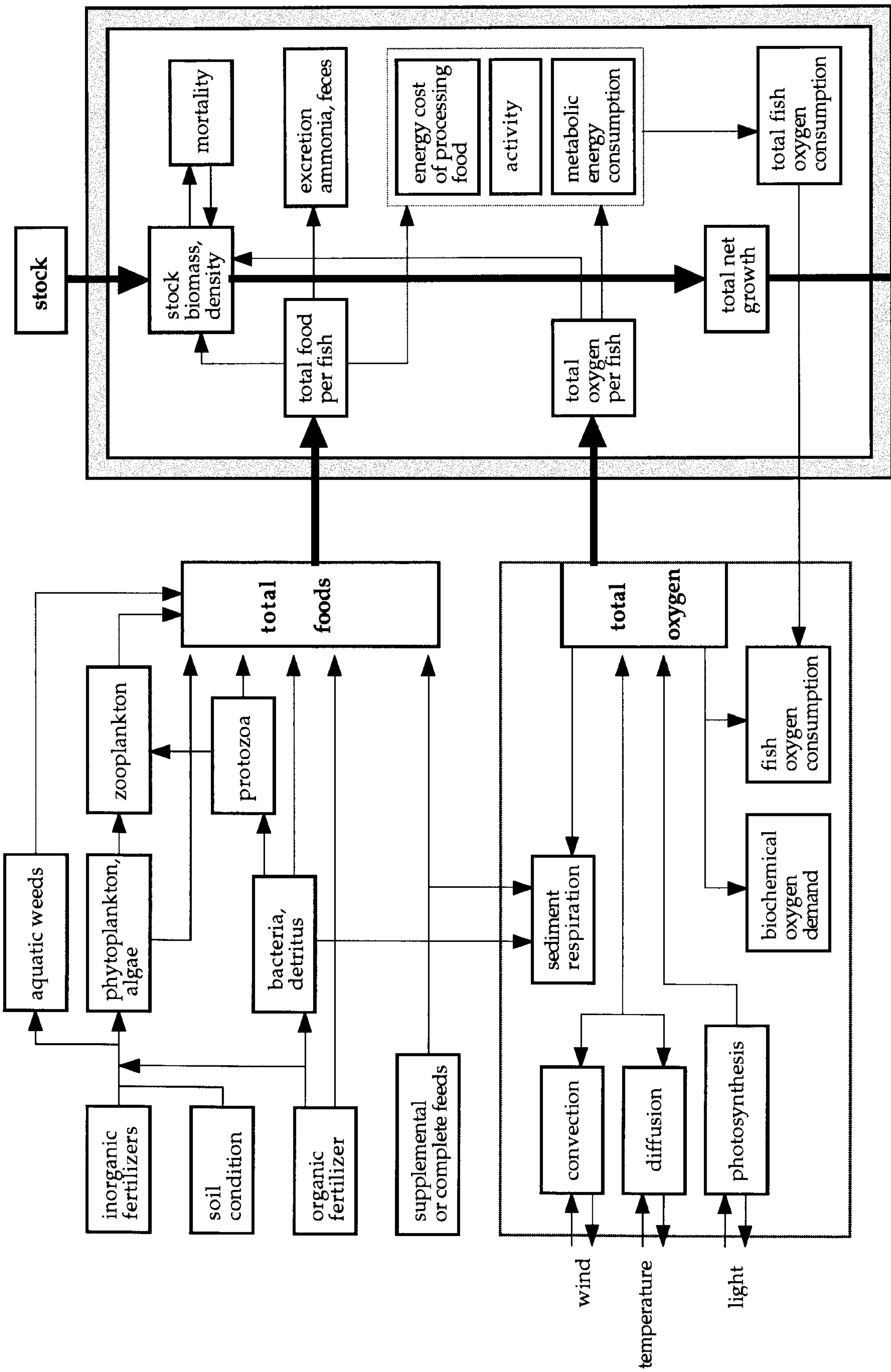
To increase survival and lower the price, channels in fry marketing must be shortened by better networking and communication of fry gatherers, dealers, and farmers, and by immediate sale, shorter storage, and faster transport.



Photographic larval fish counting apparatus: a, polaroid camera; b, adjustable bracket; c, partially translucent white polyethylene tray; d, marine plywood cover; e, Plexiglass sub-base; f, marine plywood base; g, cool-white fluorescent lamps 60-85 W; h, vents.



On the polaroid photograph, subsampling and counting squares are partially drawn. Larvae whose heads are in the highlighted squares are counted. From Chatain et al. (1996).



An example of a production model for a pond fish like milkfish. Aquaculture scientists work with models like this to understand how the pond ecosystem works and to try to make the system more productive through manipulation of one or more factors. From Chang et al. (1985).

5. Improve milkfish farming methods in ponds, pens, and cages.

The challenge to the milkfish farming industry in the next decade is to improve pond management so that higher per hectare yields can be achieved from even just one billion fry. Greater production and profits can come from improving culture methods to reduce the mortality during the nursery and grow-out phases, and particularly, to prevent mass fish kills. Growing milkfish to larger sizes increases production without increasing the fry requirement. Larger milkfish are more meaty, fetch higher prices, and are easier to process for value-added products.

The target minimum yield of 3 mt/ha-yr can be achieved by optimizing the farm design and preparation, stocking rate, fertilizer application, supplemental feeding, water management, oxygen supply, and the transfer of technical skills and information. Extension workers have to reach the farms still producing less than 1 mt/ha-yr, determine their capabilities, and recommend appropriate technologies.

Milkfish farmers generally have adequate knowledge of the basic methods of pond management. Farmer knowledge and skills should be packaged with research-based information, disseminated widely, and transferred widely to the less productive farmers. More demonstration farms should be set up by government, or model private farms identified and cross-farm visits arranged.

Refinements in farming methods require continuing research. Fish production depends on many variable factors and processes. Still poorly understood are interrelations among such factors as stocking rates, oxygen supply and demand, natural food production, water and soil quality, the carrying capacity of the farm, the costs of inputs, and their added value in use. The optimum stocking and feeding rates by size, site, and season in ponds, pens, and cages have yet to be determined by systematic studies. The oxygen and nutrient dynamics and the effects of sediments and effluents in milkfish farms have to be understood. The government policy to use the open sea for aquaculture requires research and technology refinements in fish farming in sea cages.

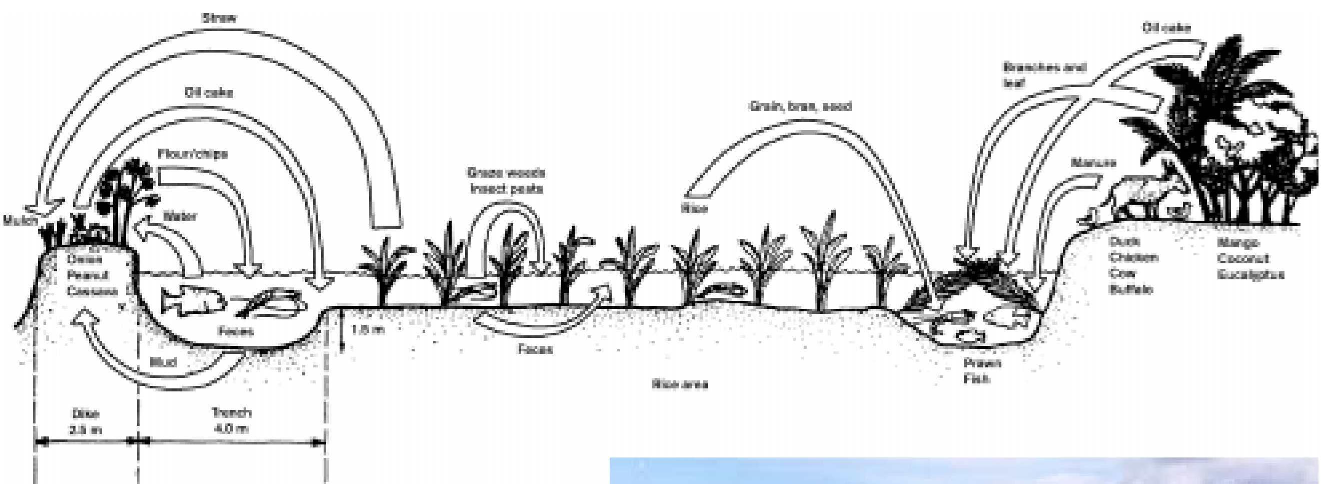
Farmers, researchers, and extension workers need to work together in a feedback system to find answers to farm and industry problems. Many farmers think they can learn nothing from researchers and extension workers, and the latter are often frustrated at the farmers' refusal to listen. Researchers are often unable to translate experimental results into farming techniques, and extension workers and farmers often can not understand the language of science. All three groups have much to learn from each other, and teach each other, but this can only happen in an atmosphere of trust, humility, tolerance, and common effort for common good. In the Philippines, extension workers in aquaculture are a rare breed, and more of them must be trained and fielded.

6. Develop and promote integrated intensive polyculture farming systems with milkfish.

In brackishwater ponds, milkfish may be raised, simultaneously or in rotation, with other fishes, shrimps, mud crabs, seaweeds, mollusks, and mangroves. Stocking milkfish during the peak fry season and other species like mullets and rabbitfishes during slack periods may also be feasible. Milkfish may also be grown in freshwater ponds, which could drain into vegetable plots, orchards, rice fields, drinking troughs for livestock or poultry.

Integrated intensive farming systems (IIFS) are the appropriate long-term response to the triple needs of the next century: more food, more income, and more jobs for more people, all from from less land, less resources, and less non-renewable energy.

IIFS that include semi-intensive aquaculture benefit from their environmental soundness, the positive interactions among enterprises, and the diversity in products. IIFS recycle biological resources, wastes, and farm byproducts, conserve natural resources, and increase total productivity and incomes. Unlike stand alone fish farms, IIFS are less risky and more suited to resource-poor farmers in developing countries.



Bioresource flows among components of an integrated agri-aquaculture farm. From Lightfoot et al. (1994).

Pineapple can be grown along pond dikes.

Chickens may be raised in coop built in the middle of a milkfish pond.

An integrated piggery and milkfish pond system, Negros, 1997.

Where the snails suso are abundant, they can be harvested and used in various ways for additional income.

Some milkfish farms my be integrated with ecotourism or restaurant service.

Milkfish may be included in an aquasilviculture farm.

7. Improve post-harvest handling, processing, and marketing.

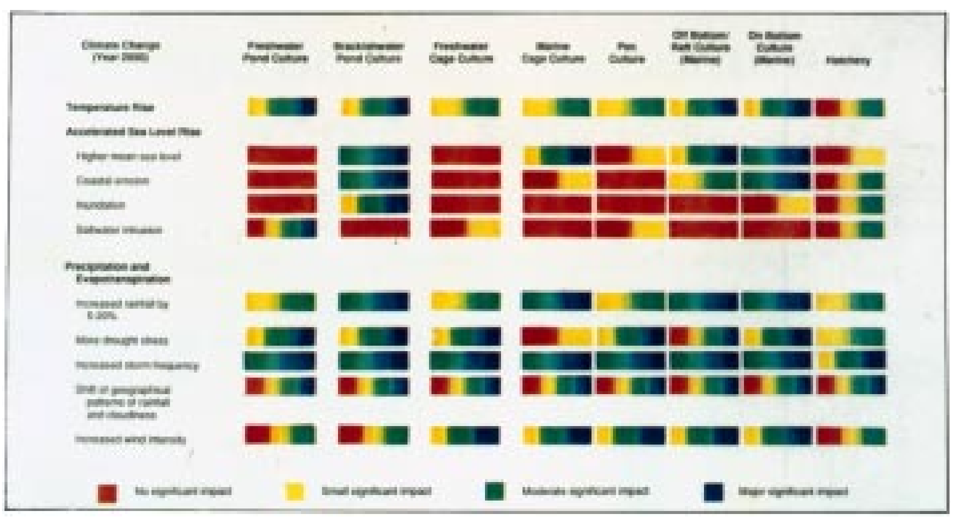
The increased milkfish demand may be met partly by minimizing post-harvest losses through better methods and facilities for processing, handling, storage, and transport, including farm-to-market roads.

Farmers and processors should develop value-added products from milkfish to absorb an increased production and keep prices high. Milkfish is a very good-tasting fish, and if convenient and attractive forms of it can prepared, even the non-Filipino markets may be captured. The better organized farmers should corner a larger share of the export market, that is, the large Filipino communities in the USA and elsewhere in the world.

Farmers have learned the hard way that in the mature phase of the industry, supply and demand become balanced and further growth depends on processing and marketing rather than on additional investments in farm facilities. To increase demand is the only way to maintain growth once markets are saturated with a commodity. The predicaments of the periodically oversupplied markets are now all too familiar to farmers.

8. Prepare for the effects of climate change on milkfish farming.

Profound global climate changes due to greenhouse gases are expected to occur by the turn of the century. There will be major significant impacts on fish farming in brackishwater ponds and freshwater and marine pens and cages.



Implications of climate change on tropical aquafarming systems. From Chua and Paw (1989).

The impacts on milkfish farming must be assessed further, along with the socioeconomic implications. Government programs, plans, and policies for the milkfish industry and other food production sectors must incorporate risk factors due to climate change, and implement strategies to cushion the impacts.

9. Know the Philippine Fisheries Code of 1998 and work for its proper and just enforcement.

Philippines Fisheries Code of 1998

The Philippine Congress of 1998 passed Republic Act 8550 (signed by President Fidel Ramos), "An act providing for the development, management and conservation of the fisheries and aquatic resources, integrating all laws pertinent thereto, and for other purposes." In May 1998, the Department of Agriculture issued the Implementing Rules and Regulations of RA 8550. All workers in the fishery sector, including students, teachers, and researchers should have a copy and be familiar with the Code and its implementing rules and regulations.

The policies and provisions under the Philippine Fisheries Code of 1998 are consistent with Agenda 21 and the FAO Code of Conduct for Responsible Fisheries.

DECLARATION OF POLICY

- Food security for all Filipinos is the overriding consideration in the utilization, development, conservation, and protection of fishery resources.
- Access to the fishery and aquatic resources of the Philippines is limited to Filipino citizens.
- Management and conservation of the fishery and aquatic resources of the Philippines, including the exclusive economic zone and the adjacent high seas, shall be consistent with the maintenance of sound ecological balance, and the protection and enhancement of the quality of the environment.
- Municipal fisherfolk have the right to the preferential use of municipal waters based on estimates of sustainable yields and total allowable catches.
- Support shall be provided to the fishery sector, primarily to the municipal fisherfolk, including women and the youth sectors, through appropriate technology and research, adequate credit, post-harvest facilities, marketing assistance, and other services including job opportunities and commensurate wages.
- Management of fishery and aquatic resources shall be according to the concept of integrated ecosystem management supported by research and technical services.
- The private sector shall be granted the privilege to use fishery resources under the concept that the grantee, licensee, or permittee is also an active partner of the government in the sustainable use, management, conservation and protection of these resources.

OBJECTIVES OF THE FISHERY SECTOR

- Conservation, protection, and sustained management of the country's fishery and aquatic resources
- Poverty alleviation and provision of supplementary livelihood among municipal fisherfolk
- Improvement of the productivity of aquaculture within ecological limits
- Optimal utilization of offshore and deep-sea resources
- Upgrading of post-harvest technology

RA 8550 contains articles on municipal and commercial fisheries, aquaculture, post-harvest facilities, activities, and trades, and prohibitions and penalties.

AQUACULTURE-RELATED PROVISIONS

Below are the salient sections of the Code and the implementing rules and regulations with respect to aquaculture, particularly milkfish.

- A Code of Practice for Aquaculture shall be established by the Department of Agriculture's Bureau of Fisheries and Aquatic Resources (DA-BFAR) after consultation with the Department of Environment and Natural Resources (DENR), fish farmers, research institutions, and other stakeholders – to outline general principles and guidelines for environmentally sound design and operation to promote the sustainable development of the industry.
- The local government units (LGU, town or city) have jurisdiction over municipal waters (streams, lakes, inland waters, and tidal waters within the town or city boundaries, and marine waters within 15 km of the coast, except parts of protected areas, public forests, timber lands, forest reserves, or fishery reserves). The LGUs in consultation with the Fisheries and Aquatic Resources Management Councils (FARMCs), are responsible for the management, conservation, development, protection, and use of all fish and fishery/aquatic resources within their respective municipal waters, and shall enact appropriate local ordinances, and enforce these and all national fishery laws, rules, and regulations.
- To promote sustainable aquaculture practices, DA-BFAR shall establish appropriate incentives and disincentives including effluent charges, user fees, negotiable permits, and fines.
- Public lands such as tidal swamps, mangroves, marshes, foreshore lands, and ponds suitable for aquaculture shall not be privatized. DA-BFAR and DENR shall determine areas or portions of available public lands suitable for fish pond purposes, or to be declared as fish reserve or sanctuary for conservation and ecological purposes.
- Lease of public lands for fish ponds shall be according to Fishpond Lease Agreements (FLAs) subject to the following conditions:

  FLA holders: only Filipino citizens may be granted and may keep FLAs

  Preferred FLA grantees: fisherfolk cooperatives/associations or small and medium enterprises

  FLA area: up to 50 ha for individuals and 250 ha for fisherfolk organizations

  Lease period: 25 years, renewable for another 25 years

  Lease rates: shall be set at levels that reflect resource rent accruing from the use of the ponds resources and shall be determined by DA-BFAR

  Pond development: pond must be commercially productive within 3 years; ponds not producing within 5 years shall revert to the public domain for reforestation

  Subleasing: not allowed in whole or in part, otherwise FLA will be cancelled

  Transfer of FLA rights: allowed only with prior written approval of DA-BFAR

  Reforestation: must be done by FLA grantee along the river banks, bays, streams, and seashore fronting the fish pond

  Waste treatment: lessee must provide facilities to minimize pollution from ponds

  Use of FLA fees: fees to be remitted to the National Fisheries Research and Development Institute and other qualified research institutions to be used for aquaculture research and development

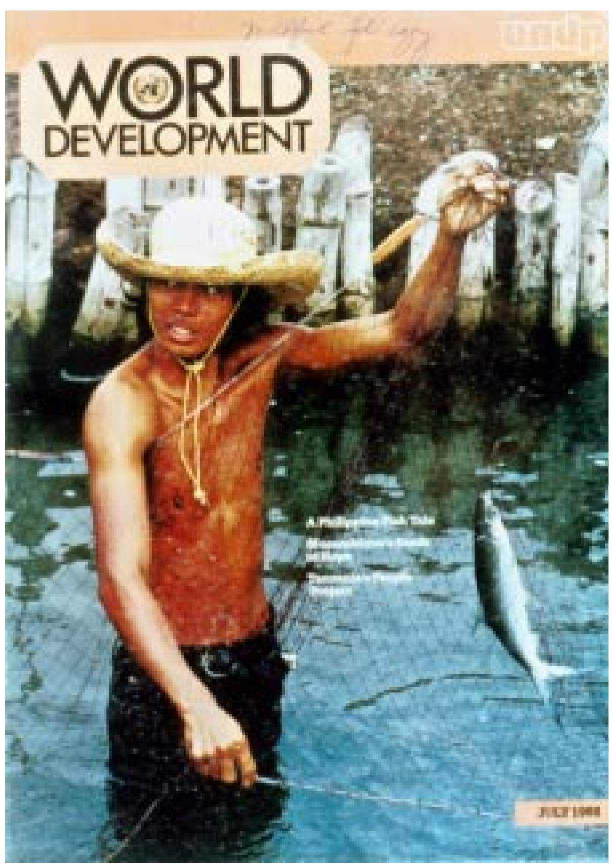
  Report of production: must be submitted yearly to DA, otherwise the FLA is cancelled, and the owner fined P500 (first offense) or 1,000 (next offenses) per unreported hectare

- Operation of fish pens, fish cages, and other structures for the culture of fish and other fishery resources shall be according to the following conditions:

  Privilege to operate: granted only to municipal fisherfolk and their organizations
  Location of operation: only within established zones duly designated by the LGU and FARMC, or by DA-BFAR, according to national policies
  Area for operation: up to 10% of the surface area, but to be determined based on the carrying capacity of the water body
  License, permit, lease, or concession from LGU: required before start of operation
  Operation without a permit is punishable by a fine of P2,000-10,000 and/or imprisonment of 1-6 months
  Report of production: must be submitted yearly to DA-BFAR, otherwise the owner is fined P500 (first offense) or 1,000 (next offenses) per unreported hectare

- Fish hatcheries, fish breeding facilities, and private fish ponds must register with the LGUs, which shall prescribe with DA-BFAR the minimum standards for such facilities.
- DA-BFAR shall conduct a yearly inventory of all fish ponds, pens, and cages, in public and private lands. Aquafarm operators shall annually report to the DA-BFAR the type of species and volume of production in given farm areas.
- Aquafarm structures and operations must not block free navigation for transport and fishing, or impede tidal flow, in any stream, river, lake, or bay flowing through or from the farm. Illegal structures shall be removed, the license or permit cancelled, and the violators punished by imprisonment for 1-6 months, and/or a fine of P2,000-10,000
- Aquafarm structures and operations must not block defined migration paths of fish and other species in lakes, rivers, and estuaries. Illegal structures shall be removed, the license or permit cancelled, and the violators punished by imprisonment for 7-12 years, and/or a fine of P50,000-100,000.
- Fish ponds, cages, pens, seaweed farms, other aquaculture projects, and post-harvest facilities such as ice plants and cold storage shall be covered under the insurance program of the Philippine Crop Insurance Corporation for losses caused by major natural forces.
- DA-BFAR shall formulate a Comprehensive Post-Harvest and Ancillary Industries Plan which includes clear and detailed guidelines for the distribution, construction, use, and maintenance of post-harvest infrastructure, and credit and incentives for post-harvest operations.
- Export of fishery products shall be regulated to ensure domestic food security.
- Fishery products may be imported only when certified necessary by DA-BFAR and the FARMC.
- A DA-BFAR permit is required for the import and export of fishery products. Violation is punishable by imprisonment for 8 years, a fine of P80,000, destruction of live goods or forfeiture of non-live goods, and a ban on becoming members or stockholders of companies engaged in fisheries at present or in the future.
- To protect and maintain the local biodiversity and ensure the sufficiency of domestic supply, spawners, breeders, eggs, and fry of milkfish, tiger shrimp and other local species may not be exported in any way. Violation is punishable by imprisonment for 8 years, confiscation of the goods or a fine double the value of the same, and revocation of the fishing and/or export license.

- It is illegal for any person to convert mangroves into fish ponds or for any other purposes. Violation of this provision is punishable by imprisonment for 6-12 years, and/or a fine of P80,000, and/or charges for the cost of rehabilitation of damaged areas.
- Abandoned, underdeveloped, or underutilized fishponds covered by FLAs shall be identified by DA-BFAR and DENR, then restored to the original mangrove state.
- It is illegal to gather, capture, or possess mature milkfish or *sabalo* and breeders of other species, except for scientific and research purposes and subject to DA-BFAR guidelines. Violations are punishable by imprisonment of 6 months to 8 years, and/or a fine of P80,000, forfeiture of the catch and the fishing equipment, and revocation of the fishing license.
- Aquatic pollution in all forms is illegal and punishable by imprisonment for 6-12 years, and/or a fine of P80,000, plus an additional fine of P8,000 per day until the violation ceases and the fines are paid.
- An Aquaculture Investment Fund of P50 million shall be established for soft loans for municipal fisherfolk who will engage in aquaculture, and for the development of undeveloped or underutilized inland fish ponds.
- Fishery and aquaculture schools and research and development agencies shall be strengthened.
- Fisheries conservation subjects shall be included in the curriculum of elementary and secondary schools, both public and private. A nationwide information campaign about sustainable development and aquaculture shall be launched by DA-BFAR and Department of Education.



Milkfish is recognized as important to socioeconomic development by various international agencies such as FAO-UNDP.

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