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# AQUA FARM NEWS

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## Hatchery Systems

The hatchery industry in the Philippines is almost all tiger shrimp. Milkfish hatchery is an offshoot of the national milkfish breeding program of the Philippine government and SEAFDEC/AQD. Sea bass hatchery is an initiative of a few private operators. There are also hatcheries for tilapia, bighead carp, and giant clams.

In a book published by Elsevier (Amsterdam, The Netherlands) in 1992, AQD Scientist Jurgenne Primavera wrote a chapter reviewing the status of the tiger shrimp industry in the Philippines. She noted that most commercial hatcheries were established in 1975, when AQD first operated its big-tank hatchery. The cost of a wild tiger shrimp spawner was only about P80 compared to at least P1,000 at present. Fry production was about 15 million in 1978, 40 million (from 50 hatcheries) in 1982, and about 3 billion (from more than 300 hatcheries) in 1988. Pond operators started buying hatchery-bred fry instead of wild fry because these are available, of more uniform sizes, and do not carry predators. There are several types of tiger shrimp hatcheries: backyard (total capacity, less than 50 tons), small-scale (51-100 tons), medium-scale (101-500 tons), and large-scale (more than 500 tons). The backyard hatchery is the most profitable. Majority of tiger shrimp hatcheries are found in west central Philippines where AQD is located. AQD provides information and trains aquaculturists in shrimp broodstock management and larval rearing.

Among the early problems that beset the tiger shrimp hatchery industry are massive export of spawners and broodstock to Taiwan, lack of well-trained technicians, improper siting, lack of reliable marketing information, and financing. Today, tiger shrimp hatcheries are plagued by diseases and marketing problems.



In this issue, we take a look at the hatchery technology for tiger shrimp, milkfish, and sea bass developed by AQD; some improvements in hatchery operations; the new trends in disease control; fry quality criteria; and the merits of wild vs. hatchery fry.



**SEAFDEC/AQD TECHNOLOGY**

# Larval rearing techniques

Much of the output of the SEAFDEC Aquaculture Department have been on hatchery technology, addressing three main areas of operation: broodstock management, larval rearing methods, and natural food production. Larval rearing techniques for tiger shrimp, milkfish, and sea bass have been successfully transferred to the private sector (see summary on pp. 3-5).

The concept of a multi-species hatchery is new and SEAFDEC/AQD has just started refining a workable and practical method. For instance, the milkfish hatchery techniques transferred to the private sector can be practiced in existing tiger shrimp hatcheries. Hence, diversification to other fish species may follow. AQD researcher Marietta Duray is working on multi-species hatchery; her paper on this topic will soon be published in the journal *Aquaculture Engineering*.

Since the publication of AQD's hatchery techniques in 1990-1991, several new studies to improve hatchery techniques have been completed. These are described below.

## Artificial diet for tiger shrimp

Artificial diets have been proven to be effective feeds for larval shrimp. Their use has helped solve problems currently limiting shrimp

hatchery production through assurance of a reliable supply of nutritionally balanced larval feed, reduction of the level of technical skill required to operate a hatchery, simplification of hatchery design, and reduction in capital investment.

AQD formulated in 1989 a kappa-carrageenan microbound diet made from locally available ingredients. It was tested in large scale hatchery production of tiger shrimp larvae. The diet has about 50% protein and 14% lipid, and is composed of:

Ingredients	% composition
Shrimp meal	35%
Squid meal	30
Bread flour	11
Cod liver oil	8
Soybean lecithin	2.5
Cholesterol	1.0
Vitamin mix, commercial	6.0
Mineral mix, commercial	4.0
Butylated hydroxytoluene	0.05
Carotenoid	0.25
Celufil	1.95

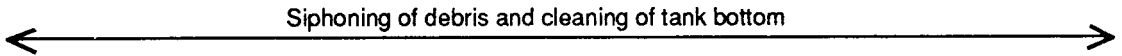
The results of the trials are very promising. The best feeding scheme so far is as follows:

☞ p. 6

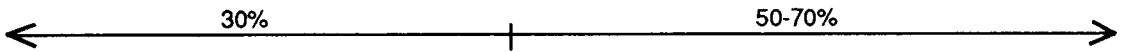
# Larval rearing of tiger shrimp, milkfish, and sea bass at SEAFDEC/AQD

(see pp. 4-5 for some notes on this scheme)

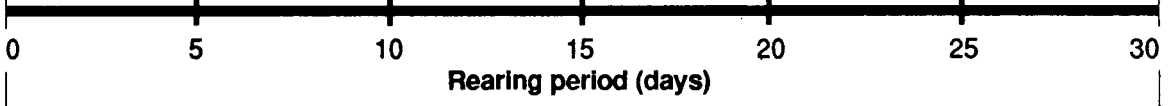
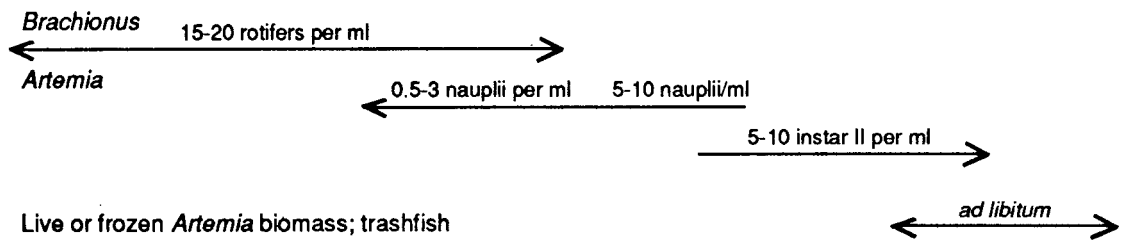
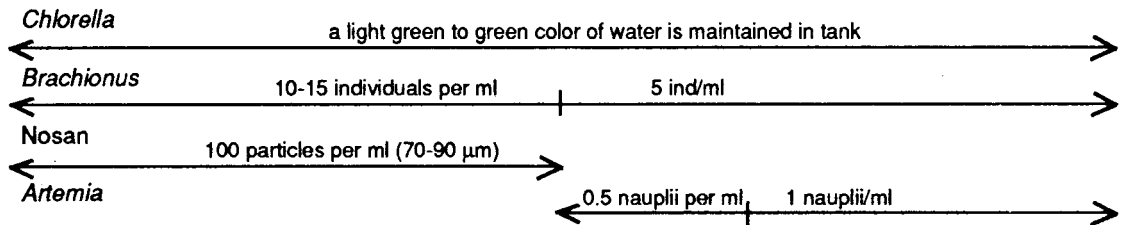
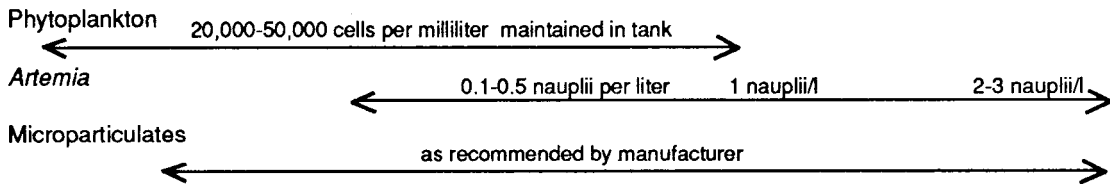
## WATER MANAGEMENT:



## WATER VOLUME CHANGED:



## FEEDING SCHEME:



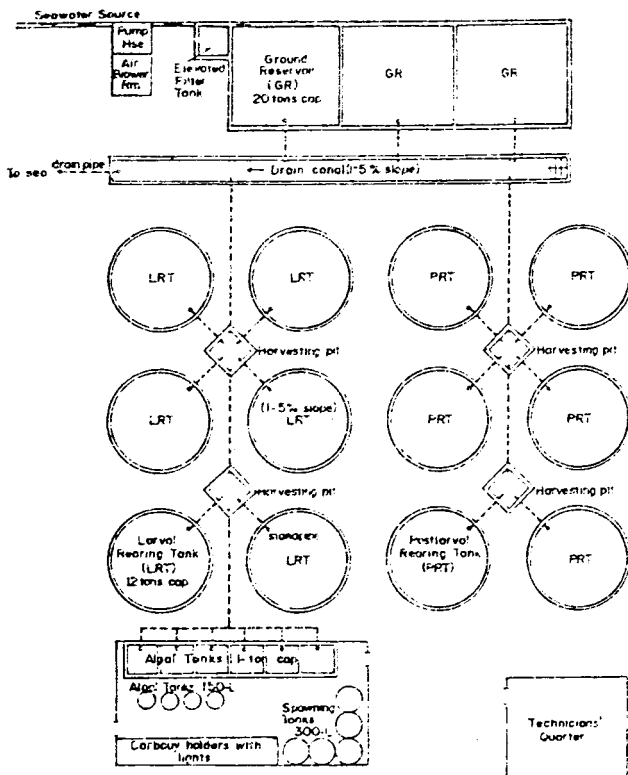
## Notes on the larval rearing scheme at SEAFDEC/AQD

For tiger shrimp, milkfish, and sea bass, larval rearing starts with the hatching of artificially spawned eggs. The eggs are stocked in larval rearing tanks, hatched, and metamorphosed larvae are fed and reared with good water management. Fry are harvested after about 30 days.

### Stocking

Tiger shrimp are stocked at about 50-100 larvae per liter. Milkfish are stocked at 30/l. Sea bass are initially stocked at 30/l.

**A sample layout of a tiger shrimp hatchery. Milkfish may also be raised in this hatchery.**



but as they grow, this is thinned out to 15/l on the 10th day, then to 6/l on the 20th day. To minimize cannibalism, sea bass larvae are size-graded when the difference in length is about 30%.

### Feeding management

A combination of live natural foods and artificial feeds are given to larvae. It is important to synchronize natural food production and larval rearing to ensure availability of food for larvae. A production schedule can be of help.

Of the live natural foods, the phytoplankters *Chaetoceros*, *Skeletonema* and *Tetraselmis*, and the brine shrimp *Artemia* are fed to tiger shrimp. Milkfish and sea bass are fed the rotifer *Brachionus* and *Artemia*. The algae *Chlorella* "conditions" the water in the tank.

**Algal cultures.** Since it is expensive for hatchery operators to maintain pure algal cultures, starter cultures may be bought from R & D institutions like SEAFDEC/AQD. *Artemia* is commercially available; its preparation is explained by the manufacturer on the can label.

To mass propagate *Chaetoceros*, *Skeletonema*, and *Tetraselmis*, 1-liter starter cultures are needed. A portion is diluted (with water) and the rest used as starter for the next batch. The phytoplankters are cultured in successively bigger containers until they reach their peak density (in about 4-5 days). Cultures of *Chaetoceros* and *Skeletonema* are fertilized with urea (100 grams per ton), sodium phosphate (10 g/t), ferric

chloride (3 g/t), and sodium metasilicate (2g/t). *Tetraselmis* culture is fertilized with urea (150 g/t), 21-0-0 (100 g/t), and 16-20-0 (15 g/t).

Cultures of *Chlorella* and *Brachionus* are started at least a month before larval rearing. To propagate *Chlorella* outdoors, a 10-liter starter culture is needed to seed a 100-liter tank. Ammonium phosphate (or 16-20-0) and urea (or 46-0-0) at 16 mg per liter and ammonium sulfate (or 21-0-0) at 100 mg/l are used as fertilizers. The culture reaches peak density in 3-4 days. At this stage, *Chlorella* can be cultured in progressively large containers until it reaches 10 tons. Sodium hypochlorite (100 ml per ton) can prevent growth of diatoms. *Brachionus* may be introduced at 5-10 individuals per ml to the *Chlorella* tanks. When the algal culture changes from dark to pale green, *Brachionus* may be harvested.

### Water management

The quality of the water in the tank deteriorates after some time due to the accumulation of feces, decomposition of uneaten food and dead larvae. Regular water change dilutes the concentration of toxic metabolites. Rearing water is disinfected with hypochlorite, an oxidizing agent that kills or retards the growth of pathogens, and neutralized with thiosulfate.

### Harvest

Harvest the fry by partially draining the water in the tank. Using a fine-mesh net or a small basin, scoop the fry and transfer to containers, preferably big white basins. The total number of fry may be visually estimated if they are all placed in uniform containers.

If to be transported for 8 hours or less, fry are packed in double-layered oxygenated plastic bags containing 8-15 liters of water. For tiger shrimp, about 2,000-2,500 PL<sub>25-30</sub> may be packed in a bag.

Older fry (PL<sub>40-50</sub>) are packed at 500/bag. For 21-day old milkfish, density is 300 per liter of water. For 1-cm sea bass fry, density is 500 /l.

### References:

(1) F Parado-Estepa. 1993. *Shrimp production at SEAFDEC/AQD*. In: CT Villegas, MT Castaños, RB Lacierda (eds). *Proceedings of the Aquaculture Workshop for SEAFDEC/AQD Training Alumni*; 8-11 Sep 1992; Iloilo, Philippines. SEAFDEC Aquaculture Department.

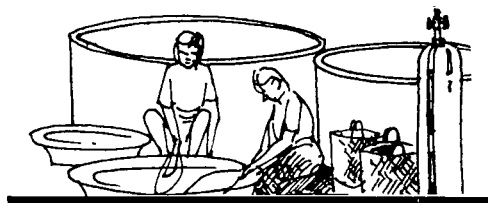
(2) FD Parado-Estepa, ET Qunitio, EL Borlongan. 1991. *Prawn Hatchery Operations*. Aquaculture Extension Manual (AEM) No. 19. SEAFDEC/AQD. 43 pp.

(3) M Duray. 1993. *Larviculture of marine fishes at SEAFDEC/AQD*. In: CT Villegas et al.

(4) RSJ Gapasin and CL Marte. 1990. *Milkfish Hatchery Operations*. AEM No. 17. SEAFDEC/AQD. 24 pp.

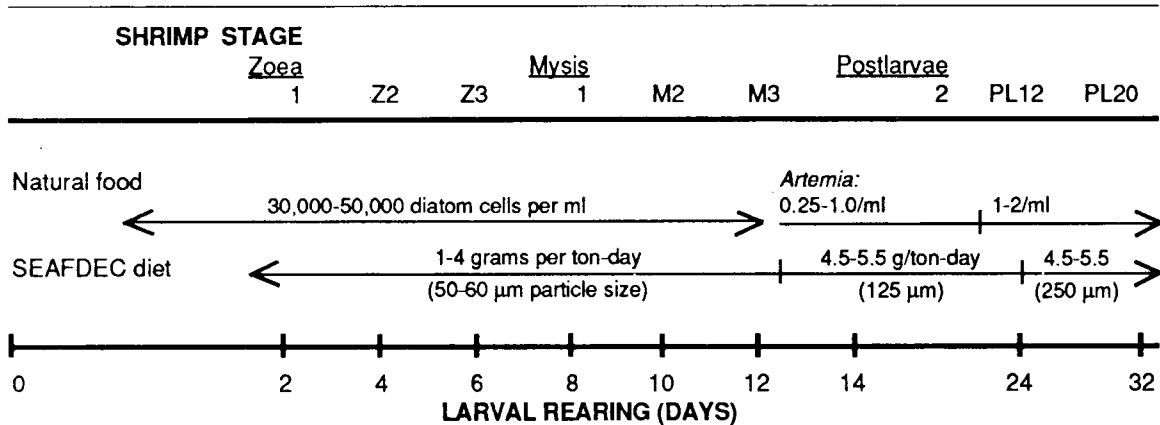
(5) MM Parazo, DM Reyes Jr, EM Avila. 1991. *Hatchery rearing of sea bass *Lates calcarifer* Bloch*. *The Philippine Scientist* 28: 65-76.

(6) MM Parazo, LMB Garcia, FG Ayson, AC Fermin, JME Almendras, DM Reyes Jr, and EM Avila. 1990. *Sea Bass Hatchery Operations*. AEM No. 18. SEAFDEC/AQD. 38 pp.



### Video programs available at AQD

- Hatchery and nursery production of prawn fry. 10 min.
- Caring for milkfish larvae. 14 min.
- Milkfish fry acclimation and fingerling production in freshwater. 10 min.
- Milkfish fry collection, handling, and storage. 16 min.
- Culturing microorganisms for larval rearing. 12 min.



Feeding scheme for the tiger shrimp using a SEAFDEC/AQD formulated diet.

The feeding scheme has resulted to 85% survival during the zoea-mysis metamorphosis, 42% survival for mysis-postlarvae metamorphosis, and about 37% survival for PL18.

Reference: MN Bautista, F Parado-Estapa, OM Millamena, and EL Borlongan. 1991. *Large scale hatchery production of Penaeus monodon using natural food and artificial diets. The Israeli Journal of Aquaculture - Bamidgeh* 43 (4): 137-144.

### Alternative live food for sea bass

The freshwater cladoceran *Moina macrocopa* (Strauss) can be used as partial or complete substitute for the more expensive *Artemia* in rearing the sea bass *Lates calcarifer* (Bloch) fry. *Artemia* is imported in the Philippines.

The current practice in hatcheries is to feed sea bass the marine rotifer *Brachionus* during the first 15 or 20 days, followed by brine shrimp *Artemia* until harvest. Other schemes include feeding *Moina* immediately after weaning from *Artemia* diets but prior to feeding minced fish. During this period, sea bass may be reared at lower salinities -- about 10 ppt -- to allow feeding of freshwater zooplankton. This will not be a problem because sea bass is catadromous; its postlarvae move upstream into freshwater lagoons for nursing after being spawned in inshore coasts.

Small-sized adults and neonates of *Moina* may be fed *ad libitum* to sea bass larvae less than 15-days old. *Moina* of whatever size may be given

to older larvae. Sea bass fed *Moina* grow at about 9% per day; sea bass fed *Artemia* and grown at 32 ppt gain weight by about 12% per day.

*Moina* has a high nutritive value; it contains high levels of 20:5ω3 highly unsaturated fatty acid needed by most marine fish larvae.

*Moina* is also easy to propagate. Researchers at the University of the Philippines in the Visayas were able to culture *Moina* in tanks using the "sack" method. First, a 2 x 2 x 1.5 m tank with 1-m deep tap water is allowed to stand for two days. Then, 200 ppm hydrated chicken manure in a sack is suspended in the water. After five days, *Moina* can be harvested using a 800-1,000 µm mesh net. Large adults may be separated from nauplii and small adults using a 400-500 µm mesh.

Reference: AC Fermin. 1991. *Freshwater cladoceran Moina macrocopa (Strauss) as an alternative live food for rearing sea bass Lates calcarifer (Bloch) fry. Journal of Applied Ichthyology* 7:8-14.

### Alternative live food for milkfish

*Moina macrocopa* may also be fed to the milkfish *Chanos chanos* fry. At a feeding density of 10-20 *Moina* per milliliter, 6-mm milkfish fry grow by about 4% per day. Survival is 60% over a 30-day rearing period. Fry fed *Brachionus* grow by about 3.5% per day with 50% survival.

Freezing surplus zooplankton permits short term storage in anticipation of high hatchery demand. It can also ensure against failures in live cultures. But, feeding frozen *Moina* to milkfish fry

reduces growth (0.5% per day) and decreases survival (32%). Fry fed frozen *Brachionus* grow and survive better (3.5% per day; 50% survival).

Reference: CT Villegas and GL Lumasag. 1991. *Biological evaluation of frozen zooplankton as food for milkfish (Chanos chanos) fry.* *Journal of Applied Ichthyology* 7: 65-71.

### Multi-step method of producing microalgae and its economics

The use of phytoplankton as food for shrimp larvae is a basic component of hatchery operations. Microalgal species widely used in the Philippines include *Skeletonema costatum*, *Chaetoceros calcitrans*, *Chlorella* sp., and *Tetraselmis* sp. Of these, *Chaetoceros* was the highest produced in volume at SEAFDEC/AQD.

*Chaetoceros* culture is simple and can be easily adopted by hatchery operators. Culture starts with a pure inoculum of 50,000 cells per milliliter. The starter culture is aerated moderately, illuminated continuously, and maintained at 18-27°. *Chaetoceros* is grown in batches using successively larger containers. A cell density of

$2.65 \times 10^6$  cells per ml would be obtained from a final 4-day culture. The flow chart of *Chaetoceros* production at SEAFDEC/AQD is shown below.

To produce the microalgae, about P145,000 is needed for equipment and other materials. This amount is incurred as initial investment in the hatchery. Producing *Chaetoceros* using the multi-step method would cost P715.50 per ton. This includes the cost of the algae enrichment F-medium (P378 per liter) and TMRL (P63/l).

Reference: GPB Samonte, CC Espigadera, RD Caturao. *Economics of microalgae (Chaetoceros calcitrans) production using the multi-step method in the Philippines.* *Aquaculture* 112: 39-45.

### Other larval rearing studies at SEAFDEC/AQD

Progress on the larval rearing of fishes artificially spawned at SEAFDEC/AQD have been made. Among these are the grouper *Epinephelus suillus*, the red snapper *Lutjanus argentimaculatus*, the native catfish *Clarias macrocephalus*, and the bighead carp *Aristichthys nobilis*.

CULTURE CONDITIONS	TYPES OF ALGAL CULTURES							
	PRIMARY STOCK CULTURES		SECONDARY STOCK CULTURES		LARGE-SCALE CULTURES			
	TEST TUBE		ERLENMEYER FLASK (100 ml.)	DEXTROSE BOTTLE (1 liter)	GALLON JARS (3 liters)	CARBOYS GLASS/PLASTIC (10-20 liters)	VINYL TANKS (200 liters)	FIBERGLASS TANK (1 ton)
CULTURE CONTAINER (Volume)	AGAR SLANT (20 ml.)	BROTH (20 ml.)						
AERATION/AGITATION	none	manual shaking	manual shaking	aerated	aerated	aerated	aerated	
ILLUMINATION	1-2 units 40 watt Fluorescent Lamps (DAYLIGHT TYPE)				1/2-3 units Fluorescent lamps/sunlight	4-6 units Fluorescent lamps/sunlight	sunlight (ambient)	
TEMPERATURE	18-22°C	18-22°C	18-22°C	25-27°C	25-27°C	28-30°C	28-30°C	ambient
VOLUME OF INOCULUM	1 loopful	1 drop-1 ml.	1-10 ml.	20-50 ml.	100-200 ml.	1-3 liters	20-50 liters	200-500 liters
GRADE OF CHEMICALS	ANALYZED REAGENT GRADE				TECHNICAL GRADE		AGRICULTURAL FERTILIZERS	
CULTURE MEDIA	MODIFIED F MEDIUM				F MEDIUM	TMRL (Technical)	TMRL (Technical)	16-20-0 * Urea 46 21-0-0
WATER TREATMENT	AUTOCLAVED			BOILED (20 minutes)		FILTERED (MICROFILTER)		SAND FILTERED
STERILIZATION OF CULTURE VESSELS	AUTOCLAVED			OVEN-DRYING	OVEN-DRYING	10% HCl DISINFECTION (24-48 hours)		
CULTURE PERIOD	7-10 days		5-7 days	1-4 days	1-4 days	1-4 days	1-4 days	1-4 days

\* Dosage: 16-20-0 (12-15 g/ton)  
Urea 46 (12-15 g/ton)  
21-0-0 (100 g/ton)

### Flow chart of the microalgae *Chaetoceros calcitrans* production at SEAFDEC/AQD.





## HATCHERY MANAGEMENT

# Hazards in the hatchery

Hazards in hatchery operations include unfavorable environmental conditions, mechanical failures or power breakdowns, and human negligence. These can result to death of stock.

tors should be kept ready for timely use (see separate article on alarm systems, this issue).

### Human errors

### Environmental factors

Successful results in hatchery operations can be obtained by maintaining optimum water quality -- salinity, dissolved oxygen, and temperature. Constant aeration will not only provide enough oxygen but also check the cultures from oxygen, carbon dioxide, and ammonia building to lethal levels. While *Chlorella* is reported to keep the ammonia levels under check, excessive algal blooms cause serious oxygen problems during late night hours. Bear in mind that larvae are very sensitive to fluctuations in oxygen and temperature. Keeping the culture water clear and hygienic by regular exchange of clean water, by taking out unutilized feed, and by constant aeration will prevent disease agents from taking a foothold and give successful results.

### Mechanical failures

Power breakdowns, low voltage, poorly functioning aerators are the problems for which back-ups like generator, blower and spare aera-

Hatchery work calls for disciplined, devoted, skilled and trustworthy technicians. Caution and care are needed during feeding, cleaning, change of water and handling larvae. While changing water, identical temperatures are preferred to avoid thermal shocks, although a difference of 1 to 2°C is unavoidable at times. Utmost care should also be taken to minimize stress. Slow gravitational methods for water replacement is recommended. Contamination of feed, equipment, and larvae should be avoided as much as possible. Seawater needs to be collected in advance at high tides; a few days are required for settlement and aging. Clean chlorine-free freshwater is added with seawater to produce a mixture of desired salinity much in advance. This is used for changing water in the rearing tanks to avoid osmotic stress due to salinity fluctuation.

Timely cleaning or disinfection of all equipment prior to hatchery operations will facilitate hygiene and efficient larval rearing.

Reference: RM Rao. *Hazards in hatchery management*. Training in Freshwater Prawn Farming Held at Prawn Breeding Unit Kakinada. pp. 47-49. Central Inland Fisheries Research Institute Barrackpore.

# Recirculating systems

Recirculating systems re-use water. Intense filtering and aeration of the water allow aquaculturists to grow fish indoors. The process has some advantages like control of predators and easy removal of wastes.

## For grow-out farms

Recirculation systems do have a place in the market today, but it's strictly limited. While a closed system makes sense for fingerling production, headstarting, or overwintering fish, such a system is not as cost-efficient for growing fish to full market size.

The long-term future of closed fish-growing systems is bright. Someday we will grow fish that way. But in today's economy, large-scale closed systems for fish grow-out make no sense in strictly business sense.

Reference: *Seiche*. Winter 1994. University of Minnesota.

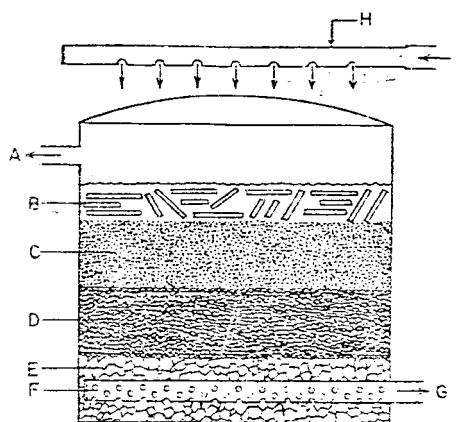
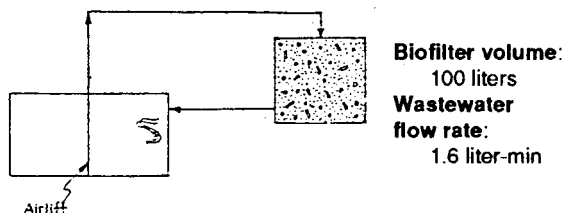
## For tiger shrimp broodstock and hatchery

For tiger shrimp broodstock tanks, a recirculating system with preconditioned biological filter (like that described below for larval rearing) is effective in maintaining good water quality. The system can maintain ammonia levels below 1 ppm, pH in effluent water at 7.8-8.3, and biological oxygen demand (BOD<sub>5</sub>) below 10 ppm. Dissolved oxygen, however, tend to drop due to the nitrifying activity of the filter. Reproductive performance of tiger shrimp seems to be better in this recirculating system than in a flow-through system.

Aeration systems (airstones and airlifts) and partial water change can not truly maintain good water quality in rearing tiger shrimp larvae. Instead, a system that also incorporates waste

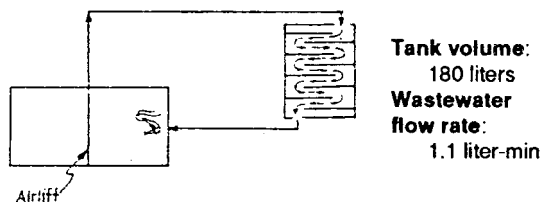
removal can do better. A choice can be made between biological filtration and zigzag stream sedimentation.

The biological filter designed and tested by SEAFDEC/AQD is constructed in a 100-liter tank and consists of coarse sand, gravel, and crushed rock:

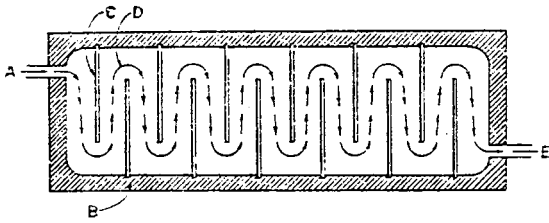


**Cross section of the biological filter:**  
**A, overflow; B, PVC nodules; C, coarse sand; D, gravel; E, crushed rock; F, perforated pipe; G, outflow; H, head pipe for wastewater; I, inlet**

The zigzag stream sedimentation tank measures 150 x 60 x 30 cm and is made of marine plywood and provided with six equally spaced wooden baffles that can deflect the water to zigzag in the stream.



# Managing a fish hatchery with oxygen injection



Top view of zigzag sedimentation tank: A, inlet; B, marine plywood; C, baffles; D, zigzag flow; E, outlet.

The recirculating systems can maintain BOD<sub>5</sub> values lower than 10 mg/l, dissolved oxygen values higher than 5 mg/l at all times, and tolerable levels of ammonia and nitrite. BOD<sub>5</sub> greater than 10 mg/l can adversely affect growth. The accumulated sediments can be flushed out periodically.

Reference: OM Millamena, CM Casalmir, PF Subosa. 1991. *Performance of recirculating systems for prawn hatchery and broodstock maturation tanks*. *Aquaculture Engineering* 10: 161-171.

Carrying capacity is based on two assumptions: (1) it is limited by oxygen consumption and accumulation of metabolites; and (2) the amount of oxygen consumed and quantity of metabolites are proportional to the amount of food given. Carrying capacity can therefore be increased by improving water quality. Space then is not the factor that limits production in hatcheries. Managing a fish hatchery with oxygen injection can increase the space -- effective water volume -- by twice its usual amount.

## Rainbow trout hatchery: an example

An oxygenation system that can supersaturate (about 100% O<sub>2</sub> saturation) a small portion of the water supply has been developed. The unit is fully automatic, including the control of low or high water level and low or high oxygen. It can automatically activate an auxiliary power system during power failures. The premise for such a system is that as high concentrations of oxygen are injected into the water, dissolved nitrogen, which can be lethal to fish, is stripped.

Growth of rainbow trout in raceways was compared in three levels of oxygen -- 5.15 ppm (natural spring water), 7.5 ppm (medium O<sub>2</sub>), and 8.4 ppm (high O<sub>2</sub>). After about 9 months, production parameters were as follows:

	Natural spring water	Medium O <sub>2</sub>	High O <sub>2</sub>
Mean daily length increase (cm/day)	0.38	0.58	0.58
Average weight per fish (kg)	10.0	24.0	23.5
Feed conversion	1.89	1.21	1.20
Fat index	2.9	2.95	3.00
Condition factor (K)	1.11	1.12	1.16

## Books on fish health published by SEAFDEC/AQD

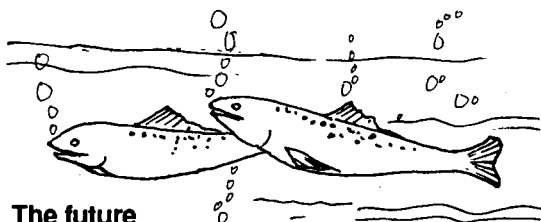
- **Diseases of Penaeid Shrimps in the Philippines.** 1992. By MCL Baticados et al. *Aquaculture Extension Manual* No. 16. 46 pp.  
The manual costs P100 in the Philippines or US\$20 for foreign orders.
- **Recommended Practices for Disease Prevention in Prawn and Shrimp Hatcheries.** 1992. By G. Lio-Po et al. *Aquaculture Extension Pamphlet* No. 3. 14 pp.  
The pamphlet costs P15 in the Philippines or US\$14 for foreign orders.

Under laboratory conditions, oxygen injection can improve growth of rainbow trout. The test in actual hatchery production yielded similar results:

Production parameters	Normal spring water	Oxygenated water
Dissolved oxygen (ppm)	6.2-5.0	8.6-5.0
Water flow (l/min)	2,000	2,000
Flow index	0.73	1.58
Fish produced:		
Total weight (kg)	1,050	2,300
Length (cm)	15	15
Mean length increase (cm/day)	0.5	0.6
Number of fish	27,800	60,300
Feed conversion	1.35	1.10

Both systems ended up with 5.0 ppm of dissolved oxygen at the end of the run. But the oxygenated water produced more fish.

If a hatchery has a raceway series, it is possible to supersaturate the water from the first series and deliver it to the next. A triple pass using oxygen saturated water is even possible.



The future

Managing a fish hatchery with oxygen injection is very challenging and the increased production potential astounding. There is no question that oxygen injection improves water quality and increases production capabilities. There are continuing efforts to reevaluate and to expand the oxygenation system to further increase production. Delivery channels between systems may be changed and additional injection sites selected.

Oxygen injection can help meet increased demands on our limited water resources.

Reference: RD Creer. *Managing a hatchery with oxygen injection*. *Aquaculture Magazine* Vol. 15. 1989.

## Inexpensive hatchery alarm system

The main component of the alarm system is a commercial security alarm controller with an autodialer and siren. This device is connected to sensors that monitor water-recirculating systems for failure and to infrared and intruder-entry switches.

In the recirculation system, two uninsulated steel wires 2 mm in diameter, parallel and 20 cm apart, are installed throughout the length of the hatchery. At one end, the parallel wires are connected by two-core insulated wire to one sector of the security controller. The circuit to this sector of the controller is normally open, and the alarm is triggered when the circuit is completed.

A series of sensors monitors air supply, dissolved oxygen level, water level, and water flow. Each sensor contains a switch, which is also normally open, and is connected by a two-core wire across the parallel wires. A failure in the system closes the sensor switch, bridges the parallel wires, and triggers the security controller.

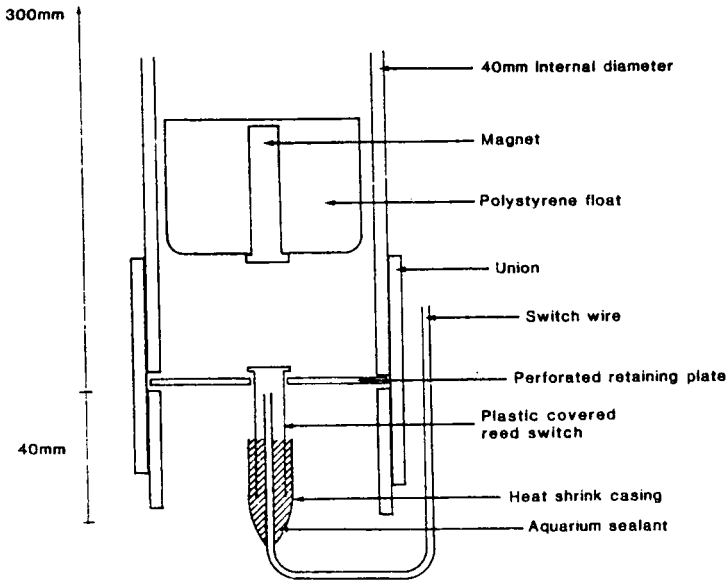
The sensors are connected to parallel wires via alligator clips so that each sensor can be easily removed without disrupting the rest of the system.

All sensors, except the dissolved oxygen sensor, are designed around a simple float-switch assembly. The switch assembly (see figure) is used to monitor water level, air supply, and water flow through the filter, and can also be used to operate water-valve solenoids or pumps through appropriately rated power relays.

The water-level sensor consists of a 300-mm length of tube with the float-switch assembly in the base. The sensor is hung over the side of the tank, and the height adjusted with the cord. The magnet float is retained inside the pipe by the suspension cord.

These sensors have proved to be more reliable than commercial float alarms. Commercial designs include a mercury switch which closes when the float is tipped. These mercury-switch sensors are triggered by fish movements as well as by falling water levels. The homemade water-



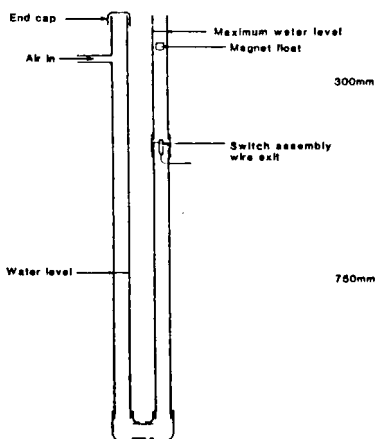


**Cross section of the switch assembly for water level, air supply, and water flow sensors.**

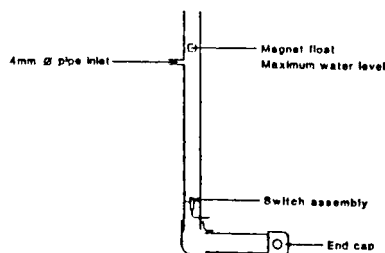
level sensor can be tipped through 45° without closing and returns readily to the vertical position.

A water-filled manometer and switch assembly at the end of the water supply line can monitor air pressure.

To create a delayed-action water-flow sensor, a 4-mm tube diverts a small proportion of the water, from the top of the supply to the biofilter, into a 40-mm vertical pipe. The top of the vertical pipe is above the maximum water level of the header tank, and the outlet is closed by a loosely fitted end cap. A 4-mm diameter hole is drilled



**Water-flow sensor**



**Air-flow sensor**

Reference: NH McCarter. *Inexpensive sensors for a hatchery alarm system.* **The Progressive Fish-Culturist** Vol. 5. 1990.

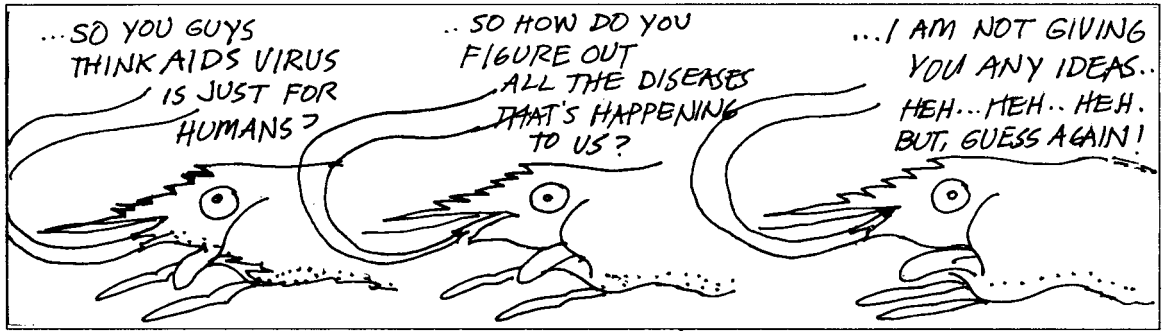
through the wall of the end cap and pipe. In use, the end cap is rotated to restrict the water exit so inflow exceeds outflow and the pipe is always full. If the pump fails, the water level in the pipe falls, and the floating magnet closes the reed switch. The interval between flow failure and sensor closure can be set to between 5 to 30 min to allow time for the pumps to reprime in case of temporary failure.

The dissolved oxygen sensor is designed to operate with a YSI model 54 or 57 oxygen meter (Yellow Springs Instruments Corp., Yellow Springs, Ohio). These models give a

recorder output at a full range of 120 mV. The trip circuit is designed so the relay closes and triggers the alarm if the trip-circuit or meter batteries fails or if the dissolved oxygen concentration falls below a preset level.

At high oxygen levels, current from the batteries is diverted through the relay, thus opening the switch. If the output from the oxygen meter falls below the preset trip value, the current is diverted away from the relay so the switch closes. The trip value can be adjusted by a trim or variable potentiometer to between 25 and 50 mV. In practice, this corresponds to 2-6 ppm of dissolved oxygen on the 0-10 scale and 4-12 ppm on the 0-20 scale on the YSI meter.

The cost of components for the dissolved oxygen sensor is about \$16 from an electronics supplier. A competent electronics technician should be able to alter the values of the balancing resistors to adjust the circuit for other brands of potentiometric oxygen meters with differing recorder outputs or impedance requirements.



## NEW TRENDS

# Disease control in hatcheries

Shrimp aquaculture is a major industry in a number of countries in Asia, where 89% of the global output was produced in 1989. However, diseases and health management constrain the sustainable development of the industry. Viruses, bacteria, fungi, and protozoa are all common pathogens causing morbidity and mortality in farmed Asian shrimps. Besides the infectious diseases that involve pathogens, a number of noninfectious diseases caused by poor nutrition, poor water quality, and environmental pollution have surfaced.

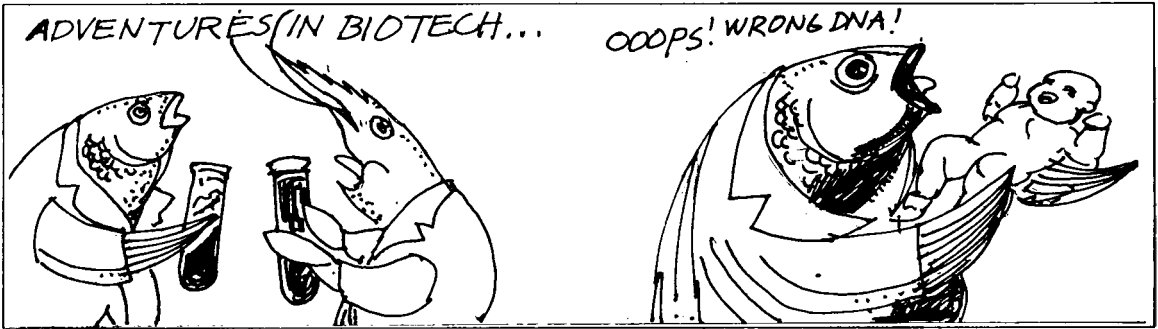
Reference: M Shariff and RP Subasinghe. 1992. *Major diseases of cultured shrimp in Asia: an overview*. p. 37. In: W Fulks and KL Main. *Diseases of cultured shrimp in Asia and the United States*. The Oceanic Institute, Hawaii.

## Microbiological techniques

Live microorganisms have been successfully applied to eradicate organic or inorganic wastes in water or mud. There have also been many attempts to maintain a stable and superior culture environment for fish or shrimp using microorganisms. The probiotic microbes for potential application in aquaculture are as follows:

- **Bacillus sp.** These are a group of facultative anaerobes. The enzymes they produced may utilize or dissolve solid or insoluble proteins, lipids or carbohydrates. For example, they may convert insoluble lipid into water-soluble glycerol and fatty acid.
- **Pseudomonas sp.** These are also facultative anaerobic bacteria. They may dissolve various solid organic substances in sludge.
- **Nitrosomonas sp.** and **Nitrobacter sp.** These two groups of bacteria play a major role in the nitrification process that convert toxic nitrogenous substances into non-toxic substances. Nitrification is performed in two steps: conversion of ammonia to nitrite by *Nitrosomonas*, followed by further conversion of nitrite to nitrate by *Nitrobacter*. Both *Nitrosomonas* sp. and *Nitrobacter* sp. are autotrophic. They can utilize CO<sub>2</sub> as the carbon source and nitrogen as the energy source.
- **Cellulomonas sp.** This group of bacteria is aerobic and may dissolve cellulose in sludge.
- **Aerobacter sp.** They may convert carbohydrate into fatty acid and ethanol.

Based on their characteristics, heterotrophs like *Bacillus* and *Pseudomonas* can remove sub-



stances toxic to shrimp under aerobic or anaerobic conditions. Autotrophs like *Nitrosomonas* and *Nitrobacter* can remove ammonia and nitrite.

Experiments have been conducted to demonstrate the use of bioaugmentation processes with live microorganisms. Non-pathogenic autotrophic and heterotrophic bacteria can effectively reduce the multiplication of pathogenic bacteria like *Vibrio harveyi* and enhance the survival of shrimp larvae (*Penaeus monodon* and *P. penicillatus*). This technique has also been successfully used in some hatcheries in southern Taiwan.

Reference: *Asian Shrimp News*, 4th quarter, 1991.

### Biotechnology in disease diagnosis for shrimp viruses

Twenty years have elapsed since the first shrimp virus *Baculovirus penaei* (BP) was described from the Gulf of Mexico shrimps. Today, more than a dozen penaeid viruses are identified, and all except BP are discovered in the past 12 years. Despite the considerable economic importance of penaeid viruses to world aquaculture, relatively little is known about these pathogens.

Until recently, the diagnostic methods available to pathologists were traditional – light microscopy, histopathology, electron microscopy, direct serological methods, enhancement, and bioassays – and these have been employed in other areas of animal and human pathology. Now, advanced biomedical methods are being applied to improve diagnostic procedures. Monoclonal antibodies for the infectious hypodermal and hematopoietic necrosis virus (IHHNV) and gene

probes for IHHNV and BP have been developed. These are the first of their kind as research tools and diagnostic reagents.

To develop the antibodies, IHHNV was injected to mice, and the mice spleens cultured. Spleens normally produce antibodies. Researchers characterized the antibodies in a series of tests. But, they found that the murine monoclonal antibodies to IHHNV are bound to substances that may be lectins. Lectins are large glycoprotein molecules that bind to specific polysaccharides on other glycoproteins. They are important components of the immune or defense mechanisms of crustaceans. Researchers are now trying to develop methods to block lectins to be able to use the IHHNV antibodies.

Gene probes for IHHNV and BP are developed by extracting the DNA of the viruses and having the DNA transformed by the bacterium *E. coli* cells. The gene probe for IHHNV can detect virus-containing areas in shrimp cytoplasm and nucleus. The BP gene probe can detect the virus (and latent infection) from the sample from which it was derived but not so successfully of other samples.

Reference: DV Lightner, BT Poulos, L Bruce, RM Redman, J Mari, and JR Bonami. 1992. *New developments in penaeid virology: application of biotechnology in research and disease diagnosis for shrimp viruses of concern in the Americas*, p. 233-253. In: W Fulks and KL Main. *Diseases of cultured shrimp in Asia and the United States*. The Oceanic Institute, Hawaii.

**Support sustainable  
aquaculture**

# Developing a specific pathogen-free shrimp: the case for IHHN virus

The IHHNV or the infectious hypodermal and hematopoietic necrosis virus has determined to some extent the direction of shrimp farming in the United States. The wide-spread use of *Penaeus vannamei* rather than the faster growing *P. stylirostris* is largely because *P. vannamei* is more resistant to IHHNV.

Juvenile *P. stylirostris* with acute IHHN disease exhibit reduced feeding, mottling of the cuticle, unusual swimming behavior, and ultimately, 80-95% mortality. The infection in *P. vannamei* induces no clear signs of disease and no dramatic mortality but can cause disease syndromes in grow-out farms. In 1989, an extensive epizootic of IHHNV in *P. vannamei* occurred throughout the western hemisphere. There were reports of runtling, deformities, and decreased production in farms. There was also concern over the possible release of the exotic virus into coastal waters.

The Gulf Coast Research Laboratory Consortium (GCRLC) in the U.S. which was formed in 1984 developed a strategy to control the spread of IHHNV. They wanted to relocate IHHNV-free postlarvae to an isolation facility, grow them to broodstock, and produce the next generation of IHHNV-free postlarvae for stocking in farms.

## IHHNV In wild penaeids

IHHNV is distributed in wild penaeids of the Pacific Coast of the Americas. The highest density is in the Gulf of California, where all samples of wild adult *P. stylirostris* were IHHNV-positive. The Gulf of Panama is next. The lowest IHHNV density seem to be north central America. No IHHNV-positive samples were found from Guatemala or northern Costa Rica; however, the virus was detected in samples from Nicaragua and El Salvador during quarantine. Wild penaeids in Ecuador may have IHHNV, but survey has not been extensive. Southern Mexico has not been surveyed.

The geographic distribution of *P. stylirostris* is as extensive as that of *P. vannamei*, and presumably that of IHHNV in the latter species.

## Acquiring specific-pathogen free stock

Selecting specific-pathogen free stock from the wild rests on the assumption that not all animals from a contaminated wild population carry the pathogen. If the prevalence of a pathogen in the wild is known, securing animals free of the pathogen is a statistical sampling problem -- that is, what is the optimum sample size to be certain no infected animals are present in a given sample? The American Fisheries Society "blue book" provides a table that recommends how many fish should be examined. For example, if a parasite is present in 10% of fish and the lot being evaluated contains 4,000 fish, 27 should be examined in order to be at least 95% confident that the pathogen will be detected, if present.

In principle, obtaining specific pathogen-free stock from contaminated farms is the same as obtaining them from the wild. However, the likelihood of finding specific pathogen-free individual is reduced because the animals in culture are at higher densities than in nature. Prevalence of infection can be 100%.

## Quarantine and detection of viruses

The assumed specific pathogen-free stock are quarantined. Quarantine provides the time necessary for shrimp to develop signs of infection. It is usually stressful and can also provide the stimuli to amplify the presence of pathogens which can then be detected by examining a few samples.

If IHHNV is not detected by histology after 60 days in quarantine, a bioassay diagnosis for IHHNV is performed. This is done by feeding an IHHNV-infected *P. vannamei* to the more susceptible *P. stylirostris*. After 9-30 days, infected *P. stylirostris* will die and show intranuclear inclusions characteristic of IHHNV infection.

During quarantine, water that is routinely settled, filtered and disinfected with chlorine is



used. Routine sanitary work procedures include restricted access, the use of foot baths at the entrances to all doors, segregation of equipment by tank, regular cleaning and disinfecting of equipment and rooms, disinfection of shrimp waste and debris, and clean feed preparation areas. Effluent water is disinfected with chlorine prior to discharge into municipal sewers that terminate at landfills.



## Farming high-health shrimps

### Founder populations

If collected from 10 sites, about 240 breeders (120 males and 120 females) are needed to maintain, if not increase, genetic diversity in founder populations. This number is based on the resources available, the biology of the shrimp, and the experiences in animal breeding programs.

Other than IHNV, several pathogens and potential pathogens are excluded from founder populations. These are:

- hepatopancreatic parvo-like virus, *Baculovirus penaei* and other baculoviruses. The reo-like viruses can not be excluded because no diagnostic method exists.
- rickettsia-like bacteria. Other bacteria are secondary invaders and exclusion is fruitless.
- microsporans like *Ameson* sp., *Agmasoma* sp., *Pleistophora* sp., and *Thelohania* sp.
- intermediate hosts of gregarine protozoans and of helminths

Fungi like *Fusarium solani* and fouling protozoan ciliates like *Zoothamnium* sp., *Acineta* sp., and *Hyalophysa* sp. are not excluded. They may only indicate stress. Crustaceans like the bopyrid isopods can be eliminated by removing infected *P. vannamei*. Their intermediate hosts are not found in quarantine tanks.

Some private fish farms in the U.S. are test-farming the specific pathogen-free fry produced from SPF broodstock provided by GCRLC.

Reference: JM Lotz. 1992. *Developing a specific pathogen-free (SPF) animal populations for aquaculture: a case study for IHNV virus of penaeid shrimp*. p. 269-283. In: W Fulks and KL Main (eds). *Diseases of cultured penaeid shrimp in Asia and the United States*. The Oceanic Institute, Hawaii.

### Pond trials

Harlingen Shrimp Farms in Texas, U.S.A. has obtained yields ranging from 2.5 to 4.5 metric tons per hectare-crop. To achieve more consistent yields, the farm entered into a cooperative research agreement with the Gulf Coast Research Laboratory Consortium (GCRLC) in September 1990. The GCRLC supplied the farm with specific pathogen-free (SPF) broodstock to produce postlarvae for commercial-scale comparisons with selected farm stocks, named Texas broodstock source (TBS), which were IHNV positive. The SPF broodstock were maintained in isolation from the farm stocks housed in the same facility. Regular inspection of the postlarvae indicated that the offspring were also SPF. The ponds stocked with postlarvae produced from SPF broodstock outperformed the TBS postlarvae in terms of survival, overall yield, and decreased size variation.

Reference: F Jaenike, K Gregg and L Hamper. 1992. *Shrimp production in Texas using specific pathogen-free stocks*. In: W Fulks and KL Main (eds).

In late 1982, Amorient Aquafarm in Hawaii initiated work on *Penaeus vannamei* at their maturation and hatchery site in Kahuku. From 1983 to 1989, no known viruses and other obligate pathogens were detected in the shrimps. In early 1989, however, infectious hypodermal and hematopoietic necrosis virus (IHNV) was discovered in *P. vannamei*. The effect on shrimp production was dramatic, very slow growth rate that is characteristic of runt-deformity syndrome (RDS). In the IHNV-infected RDS groups, the coefficient of variation in size (CV) increased from

10-20% to 40%, and pond yields decreased accordingly. In mid-1990, *Baculovirus penaei* (BP) infections were also found but without adverse impact on production. In January 1992, the farm was stocked with the progeny of SPF *P. vannamei* broodstock. As a result, RDS disappeared and production and yield improved.

Reference: N Carpenter and JA Brock. 1992. *Growth and survival of virus-infected and SPF Penaeus vannamei on a shrimp farm in Hawaii*. In: W Fulks and KL Main (eds).

## Shrimp production in the U.S.

Over 2,600 metric tons of farmed shrimps were produced in the U.S. in 1993, continuing the dramatic climb in production that began in 1992. Texas, by far the largest producer, harvested 2,100 metric tons of heads-on shrimp, despite problems in some areas with (parasitic) gregarines. South Carolina continued its steady growth. Hawaii, which is still bearing the effects of severe flooding in 1991, maintained its production.

The availability of affordable and reliable supply of high health shrimp stocks has been credited with the industry's success. Because SPF stocks increase production, producers are expanding their culture area. In Texas, for example, just over 180 hectares of ponds were stocked in 1990. In 1993, that increased to about 590 hectares. Further increases are projected in succeeding years.

Major problems with low yields and profitability are being experienced in many shrimp farms outside the United States. It is generally agreed that the deteriorating quality of stock and water experienced by foreign producers is magnifying the faults that already exist in ineffective disease control programs. These problems open opportunities for U.S. producers to become world suppliers of high health and genetically improved shrimp stocks. The combination of increased domestic production of shrimp and seed export is projected to become a \$500 million industry in the coming years.

Reference: *Newsline*, Vol. 7, No. 7, Winter 1994. The Oceanic Institute.

# Recent studies on fish health at SEAFDEC/AQD

## Luminescent vibrios in hatcheries

One of the major problems in the otherwise successful *Penaeus monodon* hatchery industry in the Philippines is the occurrence of the luminescent bacterium *Vibrio harveyi*. The possible sources of the bacterium were investigated by SEAFDEC/AQD.

Eggs within the ovaries of wild-caught and ablated females in stage II and IV of ovarian development do not harbor the bacterium. But guts of these spawners and of pond-reared juveniles contain numerous luminescent bacterium. *V. harveyi* is also found in the exoskeleton-associated flora of females.

The marine diatom *Chaetoceros calcitrans* that is fed to shrimp larvae does not harbor *V. harveyi* at any phase of its growth. One-day old *Artemia salina* does not harbor resident *V. harveyi* population although its culture water contains small populations.

To reduce the incidence of luminescent vibriosis in hatcheries, preventive measures should be adopted. The eggs must be separated from the mothers and from feces as soon as possible after spawning. The present practice of spawning many females in big tanks should be modified because the set-up makes it difficult to remove the mothers and allows longer contact between them, their feces, and the eggs. *Artemia salina* nauplii should be rinsed well before being introduced into the larval rearing tanks as feed. Chlorination, ultraviolet irradiation, and filtration of the rearing water should be done to reduce the initial bacterial load. Reduction of the larval stocking density may also prevent luminescent vibriosis in shrimp hatcheries. Diatoms should continue to be used (rather than replaced completely with artificial feeds) for its antibiotic effect at high densities.

15

Reference: CR Lavilla-Pitogo, LJ Albright, MG Paner, and NA Suñaz. *Studies on the sources of luminescent Vibrio harveyi in Penaeus monodon hatcheries*. p. 157. In: IM Shariff et al. (eds). **Diseases in Asian Aquaculture**. Asian Fisheries Society, Manila.

### **Vibrio infection in grouper fingerlings**

*Vibrio* sp. is consistently isolated from the grouper *Epinephelus suillus* infected with bacteria. Grouper fingerlings are highly susceptible, dying within 48 hours if already injured prior to exposure to the bacterium. Vibrios are opportunistic pathogens and can invade through the injuries inflicted during handling. Mortalities observed among impounded, transported, and newly stocked grouper fingerlings are not surprising, considering that they have been injured during collection by hook and line, bamboo trap, and dip net. Fingerlings are held under crowded conditions with few provisions for water change. Grouper held in tanks have been observed to harbor monogenean parasites that cause lesions in the gills and that can provide entry to vibrios.

Disease and mortality of grouper can only be avoided if the collecting gears, transport techniques, and holding facilities are improved. Although *Vibrio* sp. is sensitive to chloramphenicol, nalixidic acid, and oxytetracycline, application of these antibiotics in grouper rearing facilities is not recommended. Data on the safe administration of these antibiotics are lacking, and indiscriminate use leads to development of antibiotic resistance among pathogens.

Reference: CR Lavilla-Pitogo, AR Castillo, and MC de la Cruz. 1992. *Occurrence of Vibrio sp. infection in grouper, Epinephelus suillus*, *Journal of Applied Ichthyology* 8: 175-179.

### **Vibrio causes eye lesions in milkfish juveniles**

Opaque cornea is the first sign of bacterial infection in the eye of fishes. A combination of injury and exposure to *Vibrio* can produce eye lesions which are not reversible. Injury can be inflicted during fry or fingerling collection, sorting,

counting, and transport. In the Philippines, milkfish juveniles are usually held in high density impoundments before distribution and counting is done using perforated plastic buckets that can hold 500-2,000 juveniles. The method is fast, but very stressful.

If the eyes of the milkfish are impaired, fishfarmers must decide whether to stock them for grow-out culture or not. Clouding of the cornea impairs vision and, when severe enough, may affect the ability of milkfish to perceive and escape a predator. If possible, the fish should be held until their corneas are cleared. Fish with advance lesions such as cataract-like tissue formation around the lens should be culled as this lesion has been proven irreversible.

Reference: CR Lavilla-Pitogo. 1991. *Physico-chemical characteristics and pathogenicity of Vibrio parahaemolyticus-like bacterium isolated from eye lesions of Chanos chanos (Forsskal) juveniles*. *Fisheries Research Journal of the Philippines* 16 (1-2): 1-13.

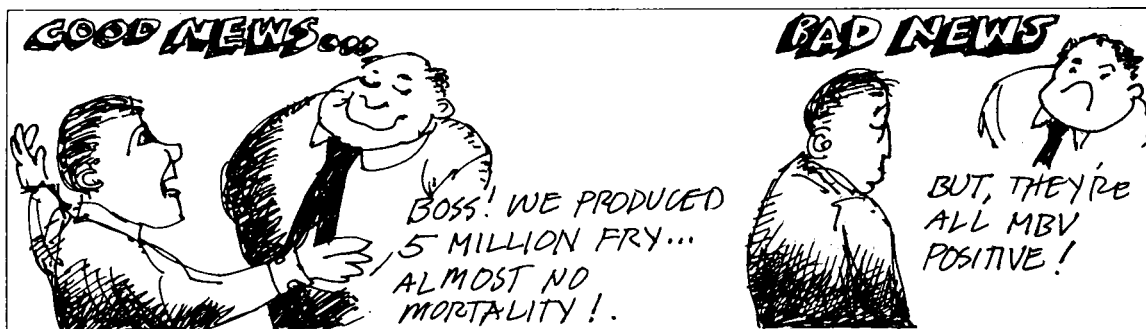
### **Monodon baculovirus infection in hatcheries and ponds**

Juveniles that have monodon baculovirus (MBV) infection grow slowly in grow-out culture. Slow growth is due to the destruction of the hepatopancreas, the target organ of MBV. Consequently, digestion of food and assimilation of nutrients are difficult. With MBV, the hepatopancreas appears discolored and necrotic. MBV is indicated by occlusion bodies in the hepatopancreas.

In the Philippines, spawning the tiger shrimp involves putting several breeders in the tank and allowing them to spontaneously spawn. After spawning -- during which fecal matter may also pass out -- the breeders and scum are removed while the eggs are left to be hatched. The nauplii are later transferred to rearing tanks but not before it may have ingested MBV occlusion bodies. The infection is latent and shrimp succumbs later. The earliest stage found infected with MBV is PL 3.

Reference: MCL Baticados, CL Pitogo, MG Paner, LD de la Pena, and EA Tendencia. 1991. *Occurrence and pathology of Penaeus monodon baculovirus infection in hatcheries and ponds in the Philippines*. *The Israeli Journal of Aquaculture - Bamidgah* 43 (1): 35-41.





- Choose larvae that have not been excessively treated with chemicals, drugs, or growth hormones. These substances reduce the natural defenses of larvae to diseases. Although these chemicals have no apparent adverse effect while in the hatchery, shrimp larvae often become weak after stocking in ponds. The larvae are unable to adjust to changes in the environment and die.
- Get larvae from healthy spawners and from the first two batches of eggs after eyestalk ablation.
- Choose larvae that can withstand stress tests. Commonly used are salinity shock, temperature shock, and exposure to 100 ppm formalin (37% aqueous solution). Stress tests are performed in the hatchery, not in the pond.

The salinity stress test exposes larvae to a salinity drop of 15-20 ppt. No mortalities should occur over 2 hours and PL should recover and resume feeding within 24 hours. This has been used on commercial scale in Ecuador, Philippines, and Thailand.

In the temperature stress test, larvae are introduced to 22-24°C for 5-10 minutes. No deaths should occur and larvae should quickly recover. Larvae are normally reared at 28-32°C.

PL can be subjected to 100 ppm formalin for 2 hours. Strong, healthy PL will survive.

References: *C.P. Shrimp News*, Vol. 1, No. 2, 1993; *AustAsia Aquaculture* 8 (1), Jan-Feb 1994.

### For marine fishes

Like in shrimps, a salinity stress test can evaluate the physiological condition of fish larvae. It may be assumed that weak fish will not survive in identical extreme conditions as healthy and more tolerant fish can. The differences in condition among larvae will be reflected in extended or reduced survival proportional to the capacity of larvae to bear stress. In this way, the survival time under stress of a small group of fish can be considered a good criterion for the actual physiological state of the fish population.

The stress test for *Lates calcarifer* can be made by immediate transfer of 25-day old larvae to 65 ppt from its rearing water of about 32 ppt. Mortality is monitored every 5 min. A "stress index" is obtained by adding the cumulative mortalities in the 5-min time intervals. This index is more useful than the mortality sequence -- (1) onset of mortality, (2) mortality rate, and (3) total mortality -- because it can reflect the condition of the fish by condensing the three parameters into one. The index can hence be used to test differences among different groups of larvae.

For *Siganus guttatus*, 30-day old larvae are subjected to a salinity of 70 ppt.

If the stress test is applied in nutritional studies, it seems that *Lates* needs fatty acids to combat stress. Additional fatty acids can be sourced from the *Artemia* food enriched with highly unsaturated fatty acids (HUFA). *Siganus*, however, do not benefit much from feeding HUFA-enriched *Artemia* if stressed.

Reference: P Dhert, P Lavens, and P Sorgeloos. 1992. A simple test for quality evaluation of cultured fry of marine fish. *Med. Fac. Landbouww. Univ. Gent* 57/4b.



## Hatchery vs. wild fry

Fisheries biologists and managers note that hatchery fish are perceived to be inferior to wild fish, and that hatchery fish degrade natural populations. These perceptions are not without foundation and these seem to be supported by studies on genetics and on the varying behavior between wild and hatchery fish. But it can be argued that the problems are the fault of how hatcheries are managed, and not with the potential hatcheries can offer.

### The salmon: an example

Wild salmon populations are thought to be lost because of disproportionate harvest rates promoted by hatchery programs. It seems doubtful that hatcheries can actually supplement natural runs. Of over 300 hatchery supplementation projects in the U.S., only a few are successful. These failures may be caused by ignoring salmon life history, and by forgetting the compatibility between the fish and the environment. Perhaps, innocently, but nonetheless effectively, the management policy has been "existential disruption" where local species are eliminated or mixed with stocks that can be more conveniently bred in the hatchery.

It is imperative that the nature of the fish must be understood. The phenotype is shaped by the environmental features of the habitat, hence, genetic traits that evolve to accommodate those features are stock-specific.

The point that needs to be continually re-emphasized is that if a phenotype is to survive, the synchrony between the environment and genetics has to be maintained. Of course, environments are dynamic, and stocks are able to accommodate a certain amount of change either by the inherent structure of the population or by adaptation given sufficient time. However, when an environmental change is very severe, it is disruptive, and results either in reduced survival or the extinction of the phenotypic form.

This is the major problem with hatchery programs. Hatcheries tend to grow large numbers of fish, and those in excess of production (of donor streams) have often been released in natural waters. This practice imposes the most severe environmental changes possible for fish, and those adapted to given environmental limits are poorly equipped to handle new situations. From the fish culturist's perspective, however, as long as live healthy fish are released, there seems to be an immutable faith that they survive and return to perpetuate their form. There rests the dilemma. The expectations far exceed what is biologically realistic for the fish, and there is little continuity between the criteria used to judge fish quality and what the genetics of the fish will permit.

Some of the environmental features that influence population characteristics are very obvious (see tables). Temperature, for example, is probably the most important for salmonids; it affects nearly every phase of their life history and is certainly the major influence in stock separation and isolation. Other environmental influences are

### Environmental factors that influence population traits

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- Geographical location
  - Distance of freshwater migration
  - Velocity of migratory pathway
  - Relative direction of migratory pathway
  - Migration temperatures
  - Incubation temperatures
  - Oxygen level during incubation
  - Productivity of the habitat
  - Predator populations
- 

### Population traits under some level of genetic control

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- Marine distribution
  - Adult orientation
  - Adult return time
  - Spawning time
  - Morphometrics
  - Incubation rate
  - Fry migration
  - Fingerling distribution
  - Smolt timing
  - Smolt orientation
- 

more subtle, such as the effect of population size in altering patterns of distribution or migration.

Ethological patterns that involve substantial genetic control contribute to the fitness or the ability to pass on greater numbers of offspring. Certain traits are so important that they become fixed in the population to insure higher performance in subsequent generations. Disruption of the environment-genetic relationship lowers fitness proportional to the level of disruption, and the stock performance decreases.

Adult orientation and distribution in the marine environment is not random, but rather a characteristic pattern in time and space. These patterns are believed to follow ancestral pathways that provide the most efficient access to food resources based on historical distributions and sizes of fish populations sharing the marine habitat. Some populations distribute south, others north, some distribute over great distances, and others stay longer in local waters, but patterns within stocks tend to be consistent. Therefore, patterns that have evolved based on historical size and abundance constraints in natural populations may no longer be appropriate when the size or number of fish in the population has been substantially increased by artificial propagation. These differences constitute environmental changes to which the stock must respond to accommodate the new population boundaries.

Throughout the history of fisheries management, the fact that fish populations are an integral component in a complex environmental system has been ignored. The health of these populations is dependent on existing in synchrony with a given environment. If the requirements of fish populations are neglected, hatchery programs

will continue to fail. Appropriate hatchery technology is a key to preparing hatchery fish for release to complete in the natural environment, but the seed stock used in such operations will always be the critical component that must be addressed first.

Reference: EL Brannon. 1993. *The perpetual oversight of hatchery programs*. **Fisheries Research** 18:19-27.

## Lessons from Norway

The rapid development of farming and ocean ranching in Norway has led to an increased proportion of reared salmon in nature. Survival and migration of hatchery bred salmon appear to be strongly dependent on season. Adults escaping in summer seem to behave like homeless fish, and enter rivers at random for spawning. Salmon escaping at the smolt stage return to the area from which they escaped and enter rivers in the same area for spawning.

The fluke *Gyrodactylus salaris* has spread to 32 rivers, probably by stocking fish from infected hatcheries. The salmon lice, which normally are considered harmless to wild salmon, have been shown to affect salmon reared in net pens. Bacterial and fungal diseases are found among free-living as well as among cultured salmon; wild populations may act as reservoirs for these pathogens.

Escaped salmon may cause gene flow between cultured and wild populations, thus reducing the variation between natural populations.

Hybridization, with possible hybrid vigor and short-term adaptation, is another potential consequence, which may reduce the capacity of the population to adapt to local environments. Initiatives to protect natural gene pools include the technical improvement of farming facilities, the establishment of gene banks (now in operation), restrictions on the transfer of living material, and the use of indigenous fish for enhancement and establishment of areas protected from fish farming. Experiments to gain additional knowledge of the genetic resources are being conducted.

Reference: E Egidius, LP Hansen, B Jonsson, and G Naevdal. 1991. *Mutual impact of wild and cultured Atlantic salmon in Norway*. J. Cons. Int. Explor. Mer. 47:404-410.

## On feeding, aggressive behavior, and distribution

Feeding, aggressive behavior, and spatial distribution of differently ranked individuals of hatchery and wild trout *Oncorhynchus clarki clarki* have been compared. Both hatchery and wild groups establish stable dominance hierarchies that seem to be based on size differences. Hatchery and wild fish within a hierarchical rank feed at similar rates. Hatchery fish are more aggressive than their wild conspecifics, irrespective of rank. Dominant hatchery fish are evenly distributed in pools and riffles, whereas dominant wild fish are three times more often in pools than in riffles. In both groups, socially intermediate fish are almost evenly distributed between pools and riffles, and subordinate fish spend most of their time in pools. On average, hatchery fish spend 57% of their time in pools and 43% in riffles, whereas wild fish spend 71% of their time in pools and 29% in riffles. These results support the hypothesis that excessive expenditure of energy for unnecessary aggression, use of fast-flowing water, or other purposes contributes to poor survival of hatchery fish after they are stocked in streams. Poor survival would reduce the efficacy of using hatchery stocks to supplement wild production.

Reference: MG Mesa. 1991. *Variation in feeding, aggression, and position choice between hatchery and wild cutthroat trout in an artificial stream*. Transactions of the American Fisheries Society 120: 723-727. pp. 723-727.

## A final word

# Role of hatcheries

*For fisheries to recover, the natural patterns of genetic diversity between populations and within populations must be maintained. Many hatchery policies and guidelines do not recognize this basic premise.*

*A hatchery program should be only one component of a comprehensive rebuilding strategy for depressed populations. The best possible role for a hatchery is to temporarily rebuild a population while the causes of its decline are reversed, for example, while habitat is being repaired. This approach also reduces the long-term cost of running a hatchery program.*

*Hatcheries should not be used indefinitely to maintain fisheries. This does not address the real causes of the fisheries' decline, such as dams, habitat loss, water pollution, among others.*

*Instead, a more holistic approach to restoring fisheries is necessary. Solely focusing on a hatchery, no matter how well designed and managed, cannot compensate for the root causes of the species' decline. It will not result in sustainable restoration of naturally spawning populations.*

*Hatcheries alone do not solve the problems of dams or irrigation runoff or habitat loss. In fact, they create new problems, such as hatchery fish sometimes straying into other rivers and disrupting the genetic diversity of those fisheries. At best, hatcheries prevent the total extinction of depleted populations by allowing us to buy time to carry out restoration efforts.*

-- Selche, Winter 1994. University of Minnesota.



# Aquaculture clinic

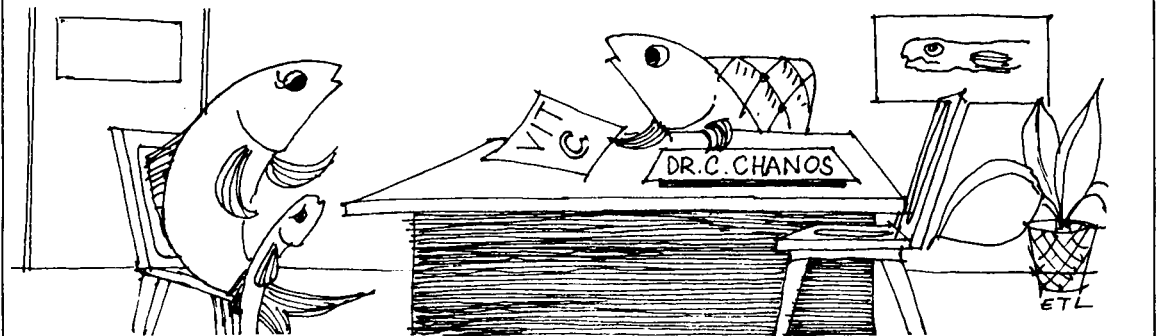
**QUERY** Some of the milkfish fry from hatcheries are deformed. What causes the deformity and how can this be treated?

**REPLY** SEAFDEC/AQD Research Associate Grace Garcia is conducting experiments to understand how abnormalities came about. One form of handling that was examined for adverse effects was the packing and transport of milkfish embryos. It seems that lesser number of deformed larvae will hatch when oxygen is added to the transport water before stocking the embryos or when the embryos are not subjected to bubbling. Or when embryos are immediately incubated in tanks and not transported. Follow-up studies are ongoing.

Another possible cause of the deformity is Vitamin C deficiency in the diet as has been noted for trout and channel catfish. Vitamin C is an important nutrient in fish feeds. While most land animals do not require it in their diets, most fishes are extremely sensitive to a deficiency which not only reduces growth rate but causes physical deformities like crooked backs, slows wound healing, and reduces resistance to infections, environmental contaminants (nitrites, chlorinated hydrocarbons, etc.), and other stresses.

L-ascorbic acid is the vitamin C source used in commercial feeds. It is sensitive to oxidation; heat and moisture in feed processing also destroy a significant amount. Coating ascorbic acid with various compounds offers limited protection during processing. About 40-60% of the ascorbic acid is lost in the manufacture of extruded (floating) feeds and 20-30% is lost in making pelleted (sinking) feeds. The half-life (time required for 50% to be lost) of vitamin C in dry feeds during storage is less than 90 days.

(Reference: T Lovell. *New sources of Vitamin C for fish feeds*. **World Aquaculture** Vol 21 (2), June 1990.)



Research and development  
1995-1997

## New direction for SEAFDEC/AQD

The 3-day seminar-workshop on *Aquaculture Development in Southeast Asia* concluded on August 28, 1994 with recommendations for SEAFDEC/AQD's 1995-1997 research and development activities and direction.

### Research

- The principles of sustainability must be incorporated in all phases of the R & D process, but especially for feed formulation, preparation and handling; in the use of drugs and agrochemicals; and in the culture of indigenous species.
- Research should address the general cross-commodity problems of sustainability like the socioeconomic, marketing, and equity issues. To assemble efficient multidisciplinary research teams, collaboration with other institutions will be strengthened.

The following will be pursued for the **Community Fishery Resources Management project** at Malalison Island in west central Philippines:

Economic studies on grouper monoculture and polyculture; grouper fry source areas; socioeconomic and market development studies for sea bass; technology adaptation and transfer for milkfish; rabbitfish culture as alternative livelihood; studies on the effects of social equity and the Comprehensive Agrarian Reform Program of the Philippine government; seaweed polyculture

studies; seaweed processing at village level; biological and socioeconomic aspects of integrated seafarming; policy issues.

- Technology-oriented research will be continued:

**For the milkfish *Chanos chanos*:** refinement of broodstock management; induction of maturation and spawning by hormonal and photoperiod manipulation; refinement of hatchery techniques and performance of hatchery bred fry; verification and economic assessment of hatchery and nursery techniques by private cooperators; bioenergetic and nutrient cycle studies; genetic studies.

**For the grouper *Epinephelus* spp.:** broodstock development; hatchery and nursery techniques; artificial feeds for nursery and grow-out; fish health control; grow-out culture systems.

**For the snapper *Lutjanus argentimaculatus*:** broodstock development; rearing techniques for hatchery, nursery, and grow-out.

**For the sea bass *Lates calcarifer*:** broodstock management to control inbreeding; artificial feeds; culture systems.

**For the rabbitfish *Siganus guttatus*:** refinement of broodstock management; viability for searanching; socioeconomics.

**For the mullet *Mugil cephalus*:** broodstock development; adoption and refinement of hatchery and nursery techniques; grow-out culture.

**For the Nile, red and other tilapias:** selective breeding; improvement of feeding practices; bioenergetic studies; development of synchronized spawning techniques; refinement of hatchery techniques; grow-out culture; fish health management.

**For the catfish *Clarias macrocephalus*:** refinement of induced maturation and spawning techniques; refinement of hatchery and nursery techniques; feed development for nursery and grow-out; grow-out culture; genetic studies.

**For the bighead carp *Aristichthys nobilis*:** Feed development for broodstock and nursery; broodstock management and genetic improvement.

**For marine ornamental fishes:** development of breeding techniques; holding techniques for wild-caught fish.

**For the giant tiger shrimp *Penaeus monodon*:** identification of areas for possible restocking; development of pond-reared broodstock including improvement of larval quality; genetic studies of local strains; impact of pond culture on carrying capacity of the environment; soil quality studies of new and old ponds; characterization of ponds along coasts and bays; aqua-silviculture technology to rehabilitate abandoned ponds; fish health management including vaccination and immuno-stimulants; substitution of fish meal in shrimp diets; feeding management studies; alternative species to *P. monodon* in grow-out culture (*P. indicus*, *P. merguensis*, *Metapenaeus* spp.)

**For the mud crab *Scylla serrata*:** farming techniques; broodstock and larval rearing techniques.

**For the abalone *Haliotis asinina*:** resource evaluation; site identification; refinement of hatchery operations; development and refinement of grow-out techniques.

**For the window-pane oyster *Placuna placenta*:** spatfall forecasting; development and refinement of hatchery techniques and for grow-out; transplantation; site identification; product development.

**For slipper oysters *Crassostrea* spp.:** spatfall forecasting; evaluation of culture technology; transplantation; refinement of grow-out techniques; product development.

**For the green mussel *Perna viridis*:** their use as biofilters in semi-intensive tiger shrimp culture.

**For the seaweeds *Gracilaria* sp.:** inventory of seaweed species; selection and development of species with high agar quality; their use as biofilters; monoculture and polyculture in ponds; refinement of production methods; product utilization; village or municipal processing (semi-refined); socioeconomics; development of hatchery techniques; genetic studies and creation of seedbank.

**For the seaweeds *Kappaphycus* sp.:** development of productive strains; development of efficient seed production technology; refine-

ment of the hanging longline culture method; socioeconomics; identification of suitable farming sites; village or municipal processing (semi-refined); follow-up studies on the "ice-ice" phenomenon.

**Other studies:** ecological impacts of introduced and exotic strains; environmental management studies of inland and coastal waters for aquaculture.

## Training

- To increase general awareness throughout the region, the work on training on environmental impact and sustainability of aquaculture will be divided between AQD, the academe and other national institutions in Member Countries.
- The role of AQD in training extensionists in improved technologies and in extension methodologies will be strengthened. AQD will continue to provide resource persons to the extension programs of the Philippine Bureau of Fisheries and Aquatic Resources.
- The five courses offered yearly and the two others offered every other year will still be conducted by AQD (see next page for the 1995 schedule). Re-developed courses will also be included like Freshwater Aquaculture (phased out during the 1980s) and Coastal Aquaculture (formerly, Brackishwater Pond Culture).

## Information

- Technology packages for small farmers, especially on environmentally compatible aquaculture technologies, are to be developed.
- Available data on pesticides, antibiotics, and other chemicals for shrimp culture are to be collated and packaged.
- To promote a balanced public opinion, the method of providing information to the general public, especially on sustainable aquaculture, will be improved.



## CONFERENCE

### Second International Conference on the Culture of Penaeid Prawns and Shrimps 14-17 May 1996, Iloilo City, Philippines

SEAFDEC/AQD convenes the conference to review the status of research on penaeid culture, to identify problems and research directions, and to provide a forum for interaction between scientists and industry practitioners. The scientific sessions will cover:

- biology, ecology, and physiology
- seed production
- grow-out
- nutrition and feeds
- diseases and environmental issues
- genetics and biotechnology
- socioeconomics, processing, marketing

Registration fee: US\$ 200 for international participants and US\$ 100 for local participants. Students get a \$50-discount. Fee covers conference materials, lunch, snacks, cocktails, and banquet.

### 1995 Training Courses TENTATIVE SCHEDULE

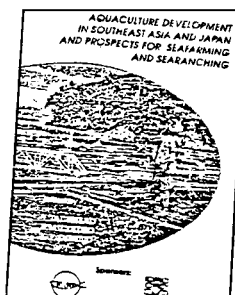
Coastal Aquaculture	16 Jan - 15 Mar
Culture of Natural Food	7 Mar - 3 Apr
Seaweed Culture	20 Mar - 11 Apr
Fish Health Management	18 Apr - 29 May
Marine Fish Hatchery	6 Jun - 25 Jul
Aquaculture Management	28 Aug - 26 Sep
Freshwater Aquaculture	4 Sep - 13 Oct
Fish Nutrition	18 Oct - 28 Nov

Coastal Aquaculture and Freshwater Aquaculture are new courses.

**Coastal Aquaculture** covers small-scale technologies for coastal areas including brackishwater pond culture; their economic, social and ecological considerations.

**Freshwater Aquaculture** covers breeding, hatchery, nursery, and grow-out of tilapia, carp and catfish. Also includes feeds and feeding, disease prevention and control, and ecological impact of culture.

## NEW PUBLICATIONS



**Aquaculture Development in Southeast Asia and Japan and Prospects for Seafarming and Seafarming** Edited by F. Lacanilao, R.M. Coloso, and G.F. Quintio. Reviews SEAFDEC/AQD research on sea bass, grouper, milkfish, rabbitfish, mullet, tilapia, carp, catfish, shrimps, bivalves, and seaweeds from 1988 to 1991; aquaculture development and prospects for seafarming and sea ranching in Japan, Philippines, Singapore and Thailand from 1988 to 1991; and ecological, social and economic considerations for seafarming and sea ranching.

The book was launched by AQD Chief Dr. Efren Ed. Flores during ADSEA III. The first to receive copies were Iloilo Governor Arthur Defensor, Deputy SEAFDEC Secretary-General Mitsuyoshi Murakami, UPV Chancellor Arsenio Camacho, Songchai Sahavacharin of the (Thai) Department of Fisheries, Imre Csavas of the FAO Regional Office for Asia and the Pacific, and Cesar Solis of San Miguel Corporation.

Copies cost P100 in the Philippines or US\$17.50 for foreign orders.

### Feeds and Feeding of Milkfish, Nile Tilapia, Asian Sea Bass, and Tiger Shrimp (*Aquaculture Extension Manual 21*)

By the Feed Development Section. SEAFDEC/AQD technology for small-scale feed development and formulation. The book costs P50 in the Philippines or US\$17.50 for foreign orders.

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AFN is a production guide for fishfarmers and extension workers. It discusses the technology for cultured species and other recent information excerpted from various sources.

In citing information from AFN, please cite the institutional source which is not necessarily SEAFDEC/AQD. Mention of trade names in this publication is not an endorsement.

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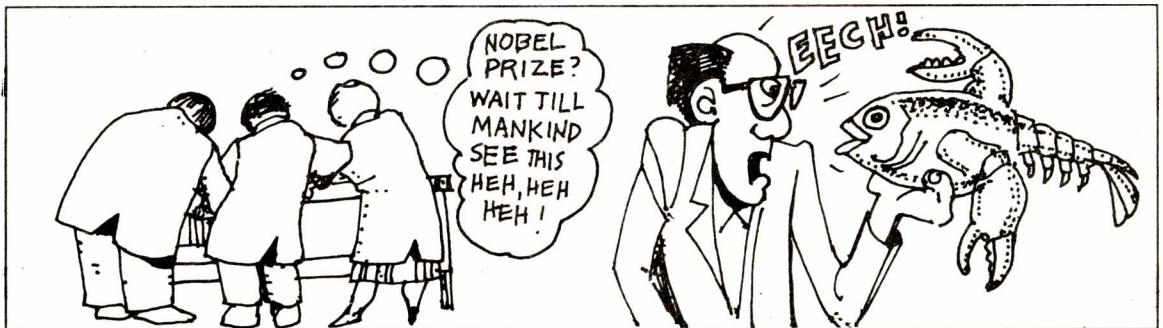
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### Adventures in biotech ...



by A. SURTIDA



Better life through aquaculture