1998 Highlights

Aquaculture Department

SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER

Tigbauan, Iloilo, Philippines

RESEARCH ACTIVITIES

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On the cover:
Mangrove trees and plants stay where they grow even as natural canals are deepened and stocked with mudcrab, shrimp and seabass. Studies on mangrove-friendly aquaculture are being conducted by SEAFDEC/AQD in this site in Bugtong Bato, Ibajay, Aklan.

AQD in 1998

In the last two years, SEAFDEC Aquaculture Department (AQD) has made a few adjustments to better pursue its goals of food security and industry stability. We have streamlined our organizational structure and prioritized technology transfer activities. AQD has a reservoir of research results, many of which can improve farm productivity, for instance:

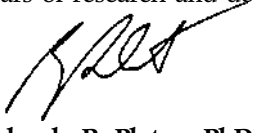
- AQD has demonstrated that backyard tiger shrimp hatcheries can be used to raise milkfish fry.
- The culture of the high-value grouper is a viable alternative to tiger shrimp culture in ponds.
- AQD has developed a successful model of a community-based fishery resources management scheme that was tested in Malalison Island in Antique, the Philippines. The model is being used in a collaborative project in Vietnam.

AQD implemented 27 research projects on 13 commercially important commodities in 1998. The significant research highlights for this year include advances in **crab culture** (we can now produce crablets, previously a production bottleneck), **grouper hatchery** (fry production), **milkfish broodstock management** (in the area of feeds), **abalone** (larval rearing techniques), **native catfish** (hatchery and nursery), and **tilapia** (on-farm broodstock management). With the collaboration of the European Union, we have established an updated scientific base for the sustainable and rational utilization of **Laguna de Bay**, the largest freshwater body in the Philippines, especially for fishery and aquaculture, and this was well-received by policymakers and local government executives.

Our technology transfer and extension program has changed AQD's R&D direction as it veered away from giving special consideration to the research and academic sectors. Today, AQD is an active participant in the aquaculture industry's development and in empowering people through community organizations towards poverty alleviation and the wise use of their aquatic resources. AQD implemented more than 10 verification programs and 11 training courses in 1998, and produced 12 extension materials (publications and video programs).

For the years ahead, AQD will continue to intensify its technology transfer efforts to be able to implement an integrated and environment-friendly approach to fish farming. We will emphasize **mariculture** due to the constraints in land-based aquaculture, and **participative research** that includes the private sector. AQD will take up **cutting edge technologies** (like biotech) to hasten solutions to some of the industry's problems. At present, AQD is building up its staff capability or expertise through collaborative research and training programs with institutions abroad. In support of these thrusts, AQD will also develop a training and information program tailored to different levels of knowledge and skills.

This volume documents AQD's achievements in 1998 with our heartfelt appreciation for the support of the Philippine government, the SEAFDEC family, and our collaborating program partners. It also includes AQD's celebration of its 25 years of research and development in aquaculture.



Rolando R. Platon, PhD
Chief

Community fishery resources management

The management of the Community Fishery Resources Management project of eight years on Malalison Island was formally handed over to the community through the barangay council on March 20, 1998. The milestones of the project include the construction and deployment of concrete artificial reefs and declaration of Guiob reef area as a fish sanctuary through a Barangay resolution.

In 1998, AQD assessed the impact of the project on the socioeconomic situation of the fisherfolk. The fishers' perception of the performance of the project in terms of equity, efficiency, and sustainability were all positive and statistically significant ($p>0.01$). Greater positive changes were perceived in the control of fishery resources, allocation of access rights, collective decision-making, conflict resolution, rule compliance, and information exchange of fisheries management.

In terms of the biological impact, AQD researchers found that abundance and biomass of four commercially important fish species were greater in reserve reef area (Guiob) than the non-reserve reef area (Nablag). The species monitored belong to the Acanthuridae, Caesionidae, Lutjanidae, and Scaridae.

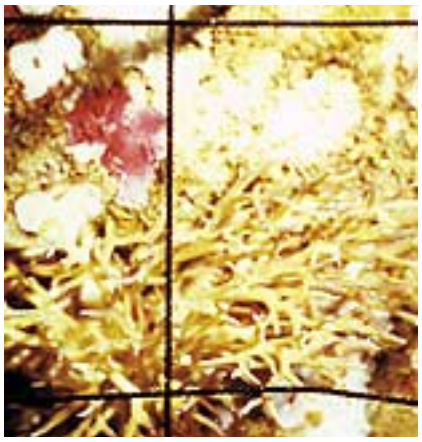
Community-based strategies are effective in addressing localized problems through localized solutions especially those pertaining to the exploitation of common property resources such as coastal resources. External agents – e.g. NGOs, academic and research institutions such as SEAFDEC – have predominantly initiated community-based coastal resources management activities. The relationship of these external agents to the community, however, should be temporary until the community has developed a sense of preparedness and self-reliance.

Beyond the community-based initiatives will be the bigger issue of legitimizing locally-accepted institutional arrangements by concerned agencies. This act of delegating authority to the community to use and manage coastal resources is a co-management arrangement between government and the local community. The process of co-management involves community participation in decision-making, power-sharing, and conflict management. The focus of co-management is the issues of property rights or rights to access and limit other users from the resource.

AQD Chief Dr. Rolando Platon and Barangay Malalison representatives sign the agreement to turn over the CFRM project and its facilities to the Malalison community

AQD Research Head Dr. Clarissa Marte discusses the artificial reefs and its colonization during the eighth and final Malalison Forum in March

One of the gains of the Malalison project is the deployment of concrete artificial reefs



A recruit of branching hard coral on an artificial reef a year after AR deployment

Tilapia

Availability of quality seed is considered to be a major constraint to the development of commercial tilapia culture in the Philippines and in other Southeast Asian countries. Several genetic improvement programs address this problem. Attention has been paid to developing and evaluating new strains of tilapia like the GIFT strain (genetically improved farmed tilapia) that is widely disseminated in Southeast Asia. Sex manipulation to produce all-male tilapia like the GMT (genetically male tilapia) was another focus of research studies in the Philippines. These genetic improvement technologies are centralized, large scale and expensive. While genetic technologies are available, they are not within the reach of small scale resource-poor farmers who are still dependent on dispersal centers for improved tilapia fingerlings. There is a need to develop appropriate and cheap selection technologies which will address the need of small-scale tilapia fingerling producers.

In 1998, AQD continued to refine the collimated mass selection procedure for developing tilapia broodstock. A 3% response to selection was obtained after just one generation of selection for growth in cages in Laguna de Bay. The procedure is simple enough to be a low-cost feature of small-scale hatcheries and is capable of generating economically significant improvement of a tilapia population after a single generation. This collimated mass selection procedure was pilot-tested in a small hatchery farm in Laguna, Philippines. The objective of this collaborative farmer participatory research on breed selection is to help farmers develop their own tilapia broodstock. Results of the farm trial showed a 6.79% positive response to selection after one month, 8.03% after the second month, and 9.25% after the third month of culture.

A quality assessment method for Nile tilapia fingerlings is also being developed. The general objective is to establish a standard fingerling assessment protocol which will help fish farmers assess the overall quality of their fingerlings. Preliminary tests were made on two AQD hatchery stocks of Nile tilapia (NIFI strain) to evaluate efficiency of the proposed technique. Lake-bred (mean length = 34.7 mm) vs. tank-bred (mean length = 35.5 mm) size 17 fingerlings were examined and scored separately using various biological criteria (swimming behavior, response to acute temperature shock, reaction to prolonged air exposure, eye diameter, body color, etc.). In terms of quality, from a scale of 0-2, tank-bred NIFI fingerlings scored higher (1.40), than lake-bred ones (0.97).

Since genetic variation is the basic resource of any successful artificial selective breeding program, it is imperative to monitor the level of genetic variation in hatchery-bred tilapia using protein and enzyme analysis. Preliminary results indicate that the level of genetic variation detected in the original population was maintained in the F1 and F2 generations.

An important implication of the collimated mass selection procedure for broodstock development that BFS is doing in collaboration with fish farmers is that fish farmers would have more control over their choice of good quality spawners. They can adopt simple and cheap selection procedure using their own tilapia breeds. The acquisition of broodstock is a significant cost to any tilapia hatchery and replacement of broodstock is always a big problem to hatchery operators. Dependence on a "franchise-dealer" type of seed production will be minimized and socio-economically self-sustaining genetic conservation will also be achieved.

Holding cages for tilapia fry

Tilapia are measured for length and weight

Milkfish

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 farm production fell the next year, and was only 364,500 mt valued at US$736 million in 1996. 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 total. In 1993, the Indonesian harvest surpassed that of the Philippines for the first time, and in 1996, the Philippines produced only 40.7%, Indonesia 43.2%, and Taiwan 16%. In 1997, milkfish contributed some 161,419 mt worth about P9 billion to Philippine aquaculture, which produced a total 957,546 mt worth P27.417 billion.

A closer examination of the milkfish industry in the Philippines reveals disturbing trends: declines in production, continued low average yields, high production costs, and unfavorable market forces. Total milkfish production reached a peak of 240,000 mt in 1982 when about 176,232 ha of brackishwater ponds and 15,000 ha of freshwater pens were used for milkfish farming. Thereafter, the pond area used for milkfish was reduced and production has fluctuated (stagnated at about 150,000 mt over the past decade) due to the shifts to and from shrimp farming, the loss of ponds in central Luzon to lahar from Mt. Pinatubo, the conversion of fishponds to other uses, the non-renewal of Fishpond Lease Agreements, low farm-gate prices, and decrease in fishpens in Laguna de Bay.

In 1995, some 114,795 ha of brackishwater ponds were reportedly used for milkfish, with the largest areas in Regions III, VI, IX, IV, and I. Accordingly, 81% of total milkfish production from ponds came from these five regions. In eight regions, the areas of brackishwater ponds in 1995 were only 25-80% of those in 1982; in six of the same regions, the milkfish harvests were reduced 27-77% during the same period. In 1995, Laguna de Bay had 3,992 ha of freshwater pens that produced 12,000 mt of milkfish and 5,000 mt of tilapia. The large areas of marine pens and cages in Region I, producing milkfish and rabbitfish, do not appear in government statistics.

Milkfish eggs from natural spawns of cage- or tank-reared broodstock

The reduction in milkfish pond area is inevitable and it is high time to increase yields per unit area or water volume in more farms. The national average yield reached the 1 mt/ha-yr mark in 1982, but was still only 1.2 mt/ha-yr in 1995. But, the better farms in Iloilo, Pangasinan, Negros, Bulacan, and Davao now produce as much as 4-12 mt/ha-yr, as in Taiwan. Indonesian annual yields are about 0.7 mt/ha.

Milkfish production and yields in fresh water have also declined. Before Laguna de Bay became overcrowded with fishpens, milkfish yields approached 6-7 mt/ha-yr. But in 1983, when pens occupied 34,000 ha, the average yield was reduced to 2 mt/ha-yr, and in 1986, the 20,000 ha of pens yielded about the same. Water pollution due to discharges from various industries and the unsewered urban population has badly affected milkfish farming in the lake. Production has suffered from fish kills, storms, and the ordered dismantling of illegal fishpens. In 1996, the 4,000 ha of

Milkfish have been spawning naturally in captivity for nearly 20 years. AQD researchers are temporarily holding anesthesized milkfish in a fiberglass tank to get egg samples and determine the stage of gonadal maturity

Milkfish broodstock tanks are equipped with egg collectors made of fine-mesh nets attached to an airlift pipe

Rotifers that serve as feed for milkfish larvae are cultured in this tank

pens yielded 4 mt/ha-yr of milkfish and tilapia, but only with added feeds.

Milkfish farming in marine pens and cages started in 1995 in Pangasinan, Davao, and Quezon, and harvests reached very high levels (as much as 30 mt from one cage 12 m in diameter and 8 m deep in 1997-1998). But harvests fell drastically soon after when water quality went bad, fish kills became more frequent and massive, the costs of feeds and cages became too high to recover, and many pens and cages were ordered dismantled or were destroyed by storms.

Milkfish fry from the hatchery

FRY SHORTAGE, HATCHERIES, AND BROODSTOCKS

Declines in milkfish production were hardly due to fry shortage, contrary to claims in the mass media in 1995. Some Filipino farmers with Taiwanese connections have imported hatchery-reared fry from Taiwan for the past five years or so, but this was more for convenience or low price rather than low catches at home. Since there are only about 114,795 ha of ponds now and 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 is not 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, one straightforward calculation may be made for a scenario where 300,000 mt of milkfish are produced by year 2010, double the average 1993-97 harvests. 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 a year. About one billion milkfish fry are available from the wild each year, and one billion fry will have to be produced by hatcheries in the Philippines in the next 10 years. To produce an initial target of 100 million milkfish fry by year 2000, about 9,000 females and 6,000 males must be available as broodstock.

As of 1998, the private sector already has about 5,000 sub-adult milkfish 2-4 years old in Mindoro Occidental and Negros and about 3,800 spawners 5-15 years old, mostly in Sarangani. The Department of Agriculture also maintains about 4,000 sub-adults and spawners, most of them in Aklan and Negros Oriental. Broodstock and hatchery facilities set up at appropriate sites in southern Mindanao are more likely to be profitable since the milkfish spawning season is nearly year-round at latitudes around the equator from about 8°N to 8°S. AQD continued to fast-track the transfer of the milkfish broodstock technology to the private sector. It has provided eggs and newly-hatched larvae to shrimp hatcheries to effectively transfer the technology and convert shrimp hatcheries to fish hatcheries. The Integrated Broodstock-and-Hatchery demonstration facility became operational in May 1998 and was stocked with about 40 females and 60 males; 88 spawnings and a total of 97 million eggs were recorded during the year.

An effective handling and transport method has been developed for milkfish broodstock. The fish are fasted for one day, anaesthetized with phenoxy-ethanol, transferred to chilled seawater (20-25°C) in open tanks or sealed oxygenated polyethylene bags, and may be transported for up to 10 hours without mortality for up to 30 days post-transport.

An effective diet has also been developed for milkfish broodstock in tanks and cages, and this diet has increased the number of spawnings and the volume of eggs produced in a year. Supplementation of this broodstock diet with Vitamin C resulted in greater egg viability and higher cumulative survival of larvae.

A study was done in Hamtik, Antique, one of the best fry collection grounds in the country to determine the acceptability of, and marketing systems for wild versus hatchery-reared milkfish fry. The fry gatherers in Hamtik perceive a decline in the fry catches, but the fry buyers do not. The fry gatherers are not aware of hatchery-produced fry; the buyers are, but see little competition. The fry buyers' main problem is the low price paid for the fry in Hamtik by the pond operators who are able to source fry also from Mindanao, Indonesia, and Palawan.

REDUCING DEFORMITIES IN HATCHERY-REARED MILKFISH

Hatchery techniques for milkfish were further refined and verified, particularly in terms of reducing the incidence of deformities in the resulting fry and juveniles. In one study, the milkfish larval diet developed at SEAFDEC AQD as supplement to rotifers and as complete replacement for Artemia, was tested against a commercial diet (Lansy A2). The diets were given to larvae at a rate of 1 g/ton-day starting at day 2, together with rotifers. Growth and survival of larvae to day 21 were

Large population of snails in milkfish farms

A snail-infested milkfish farm

better with the commercial diet. But, when the resulting fry were grown in nursery ponds for eight weeks, the fry that had been fed the SEAFDEC diet grew better and had only about half as many deformed members as the ones that had been fed Lansy A2.

In another study, milkfish larvae were fed live food with or without added Vitamin C and polyunsaturated fatty acids and the resulting fry were reared in nursery ponds for 55 days. Enrichment of live food resulted in better growth and survival of larvae in the hatchery and nursery ponds and reduced the incidence of deformities by 30-50%.

Deformities were more frequent in milkfish larvae reared in an intensive hatchery system (smaller tanks, stocking rate 30 larvae per liter, high feeding rates, with rotifers plus formulated diets) than in a semi-intensive hatchery system (larger tanks, fertilized to grow plankton, stocking rate ≤10 larvae per liter, rotifers and copepods available). In both systems, deformities were more common among the smaller fry.

Counting dead snails after the application of metaldehyde

MILKFISH GROWTH HORMONES

The cDNAs encoding milkfish growth hormone (GH) and insulin-like growth factor-I (IGF-I) have been cloned and sequenced, and found to have high sequence identity with those of carp and salmon. This work is in preparation for possible use of milkfish GH in growth enhancement trials.

FEEDS AND NUTRIENT BUDGETS IN PONDS

Detritus makes up 60-70% of the particles in the guts of milkfish in semi-intensive ponds, live food makes up 15-20%, and formulated diets make up the remainder. Even without natural food, the fish eat only half of the formulated diets provided. A feeding rate of 4% is wasteful, and may be reduced to about 2% of body weight per day. Milkfish do not feed when the dissolved oxygen is less than 1.5 mg/l, so feeds should only be given in mid-morning when oxygen has already reached high-enough levels.

Nitrogen and phosphorus budgets were estimated for milkfish fed either a 40% or a 27% protein diet in sea water (32 ppt) or brackish water (15 ppt). Total ammonia excretion was 2.6x higher, but the fraction of nitrogen consumed that is lost in feces was lower (37% versus 54-59%) in fish fed the high-protein diet. Phophorus excretion rates did not differ much between the two diets. Total ammonia excretion was 2x higher in milkfish reared in sea water than brackish water. Phosphorus is better utilized in sea water and most of the loss is in feces.

GETTING RID OF SNAIL PESTS IN MILKFISH PONDS

Experiments on the biodegradable molluscicide metaldehyde were continued. Technical grade (99% pure) metaldehyde is most effective against pond snails at salinities of 40-50 ppt and water temperatures of 35-40°C, and may thus be used during pond preparation during the dry season.

Research on the biology of the pond snail *Cerithidea cingulata* shows that: (i) they are deposit-feeders, with little lablab intake; (ii) they are able to retract into

CONTINUED ON PAGE 27

Mangrove-friendly aquaculture

There is a growing awareness among international environmental groups about the destructive effects of aquaculture on the environment, the mangrove ecosystem in particular. SEAFDEC's proactive response is the mangrove-friendly aquaculture program that was implemented by AQD in 1998. Through this program, mangrove protection is promoted alongside the need for coastal communities to derive livelihood through aquaculture.

In 1998, AQD researchers started testing a mangrove-friendly aquaculture model where a shrimp pond is situated beside a mangrove pond, the latter serving as filter of shrimp pond effluents. The concept is not new, as Indonesia has been practicing aquasilviculture traditionally.

Results for the initial 1998 run showed that tiger shrimp had a survival of 39% though this low performance was traced to El Nino. Shrimp harvested were about 15 g on average. Water quality monitoring showed lower DO and pH (more acidic) in the mangrove pond (MP) compared to shrimp pond (SP). Nutrient and salinity readings were similar for SP and MP. *Sonneratia* saplings in the MP died due to flooding of their pneumatophores, indicating non-suitability for aquasilviculture. In contrast, *Avicennia* (natural growth) and *Rhizophora* (planted) were more resistant to inundation.

Instead of *Sonneratia* saplings or trees, *Rhizophora* propagules were used because of their resistance to flooding and the ease in monitoring growth of seedlings (vs. trees). Since they were planted in April-May, *Rhizophora* propagules grew faster in the MP (64 cm height) compared to adjacent controls (59 cm), perhaps due to the nutrients from the SP effluents.

AQD researchers also conducted a study on *imbao,* scientifically known as *Anodontia edentule,* a bivalve associated with mangroves, to test its potential for aquaculture. *Imbao* samples were collected from Estancia, Iloilo at a mean depth of 25-30 cm (range: 12-48 cm). Mean values of pore water are 33-36 ppt salinity, 5.29-6.19 pH and 0.51-0.97 ppm dissolved oxygen. Monthly range of sizes was 42.8-51.1 mm mean shell length (SL) and 21.3-43.0 g total weight (TW).

Imbao female and male adults were induced to spawn in the laboratory. Serotonin (0.3 ml of 4 mMo) was effective but not temperature shock and ammonium hydroxide injection. Females that spawned ranged from 60 g, 57.4 mm SL to 125 g, 73.1 mm SL. Maximum eggs spawned was 892,000 from a 71 g female.

Developmental stages monitored were first polar body (45 min from fertilization), 2-cell stage (1 h 30 min), morula (5 h), ciliated gastrula (6 h), trocophore (11-24 h), veliger (26-28 h), and hatching of D-veliger (~ 30 h).

AQD researchers measure the growth of mangroves in the mangrove pond

AQD's farm model is visited by foreign scientists. In Kalibo, Aklan mudcrab are raised in a mangrove area reforested by the local community

Imbao

An aquasilviculture farm in Bugtong Bato, Ibajay, Aklan where tiger shrimp are raised in a pond with old mangrove stands

Laguna de Bay

AN ECOSYSTEM APPROACH FOR SUSTAINABLE MANAGEMENT

This project was started in 1995, and ended in 1998. The project's main objective was to develop an updated scientific base for the sustainable and rational utilization of Laguna de Bay, especially for fishery and aquaculture. Different collaborating agencies had specific assigned tasks to attain the goal. The European Union funded the project. AQD was responsible for collecting primary data on water quality and plankton on a monthly basis from April 1995 to September 1997.

More frequent samplings were done during periods of rapid changes in the lake such as after heavy rains (1995 and 1996), during plankton bloom (1996) and during saltwater intrusion (1997 and 1998) to better understand the processes occurring in the lake. Most of the data collected for the project were used in the calibration/validation of the model(s) developed by other collaborating agencies.

Data on water quality, nutrients and plankton showed that:

(1) Laguna de Bay is a well-mixed lake. This is due to its wide surface area, shallowness, and the winds (direction and strength) that normally affect the lake. Hence, an integrated sample from various depths (surface, middle and bottom layers) for water quality measurement is adequate.

(2) Water quality parameters (temperature, dissolved oxygen, pH, alkalinity, ammonia-N) important for wild and cultured fishes were within favorable ranges.

(3) Low transparency (or high turbidity of the lake water) is the first factor that limits primary productivity in Laguna de Bay. Saltwater intrusion, a naturally occurring phenomenon particularly when the water level of the lake is below the mean sea level of the Manila Bay (usually during summer months), increases water transparency (or lowers turbidity) due to the flocculating effect of the cations in the saltwater on the colloidal suspended solids.

(4) Based on the high frequency samplings, high algal growth followed the increase in light penetration. Biomass of the diatoms peaked first followed by a second but higher peak for blue-greens. The green algae were always present but at low levels. The increase in algal biomass was accompanied by a decrease in the total inorganic nitrogen in the water. When light is a limiting factor, total inorganic nitrogen in the water is high. However, when light is not limiting, nitrogen becomes the next limiting factor which triggers the dominance of nitrogen-fixing blue-green algae. Concentrations of phosphate-P did not vary much. Zooplankton biomass which was much lower than that of the phytoplankton fluctuated but the trend was unclear.

(5) Close monitoring made possible the mapping of the movement of salt water and clearing of the diferent areas of the lake as a result of saltwater intrusion.

Fish cages in Laguna de Bay, the largest freshwater lake in the Philippines

(6) After heavy rains, nutrients increase in concentration in the lake water due to loading from the watershed through runoffs and outflows from river tributaries. However, concentrations decrease with time suggesting some nutrient uptake by the algae and other losses.

Important to the development of a component of an ecological model for Laguna de Bay is the determination of the growth kinetics of dominant algal species representing different groups. Experiments on the kinetics of nitrogen and phosphorus utilization by *Microcystis aeruginosa* in batch cultures were conducted using various concentrations of nitrate-nitrogen (0.01-50 mg N/L) and phosphate-phosphorus (0.001-20 mg P/L). Values obtained were as follows: maximum growth rate = 0.675/day; half-saturation constant = 0.589 mg N/L; nitrogen level of saturated growth yield = 5 mg N/L; minimum cellular quota = 2.75 pN/cell; and maximum cell yield = 6.49 log, cells/ml. The result of the phosphorus experiment is presently being analyzed. Similar experiments are being conducted using axenic cultures of *Pediastrum duplex* and *Cyclotella meneghiniana.*

Tilapia is just one of the commodities cultured in the Bay

Mud crab

AQD has designed a holding system for mud crab broodstock maturation

Mud crab are checked for injuries

Harvest in the mud crab-mangrove pen culture system

Research at AQD on all phases of the mud crab *Scylla serrata* culture has produced significant results towards developing reliable techniques for broodstock management, feeds and feeding, water quality management in hatcheries, nursery culture in *hapa* nets in ponds, and grow-out culture systems in ponds and in mangrove pens. Reliable techniques will be pilot-tested and assessed for technical viability and economic feasibility.

BROODSTOCK

Pond-reared *Scylla serrata* (body weight, 350-400 g) previously reared on a mixed diet of 75% mussel meat and 25% fish by-catch in grow-out ponds were further reared in 3-units of broodstock maturation tanks.

Broodstock reproductive performance and larval quality were enhanced in females fed a mixed diet than either natural or formulated diet alone. Eyestalk ablation of females shortened the latency period from gonadal maturation to spawning. Generally, pond-reared females performed better than wild-sourced in previous runs. This was partly attributed to their diet in ponds which fortified their nutrient reserves needed for egg development.

Shell disease due to chitinoclastic vibrios affected broodstock held in captivity for two months or more. The condition seldom led to mortality, but extensive shell erosion and perforation created portals of entry for bacteria, protozoans and nematodes. Shell fouling among tank-held crabs may be prevented if the environment can continually accommodate the burrowing habit of the animals. The shells need light scrubbing to avoid build up of ectocommensals.

Simulated 6-hour transport experiments showed that lowest mortality can be obtained if newly-hatched zoea larvae are transported at a loading density of 10,000 zoea per liter compared to 20,000 or 30,000 zoea per liter.

HATCHERY

Reliable hatchery techniques developed in small-scale experiments were adopted in large-scale production of mud crab juveniles. Production runs in 1.5 - ton and 10 - ton tanks at stocking rates of 30-50 zoea per liter showed survival of less than 1 to 15% (Z1 to megalopa) and 19 - 47% (megalopa to crablet, C4-C5).

Mortality of crab larvae is mainly due to systemic bacterial infection. The main sources of bacterial pathogens are: developing eggs in berried females, untreated water supply, *Brachionus* culture and *Artemia.*

NURSERY

Three to five-day old hatchery-reared megalopae (body weight, 0.004-0.006 g) produced at AQD were stocked in 20 m^2 hapa nets installed in a brackishwater pond at densities of 10, 20 and 30 ind per m^2. Survival (35 to 53%) did not significantly differ among stocking densities. Final body weights (2.9 to 3.5 g) were about 5-10 times higher in ponds than in the hatchery. Results indicate that stocking of megalopae directly in nursery ponds is feasible.

POND CULTURE

The economic viability of using a diet without vitamin-mineral supplements for pond cultured *Scylla serrata* was comparable with that of a diet with vitmin, though not economically advantageous. Both diets gave similar cost of production and return on investment (ROI) of over 50%. A formulated diet can be used as an alternative feed to unprocessed feed (brown mussel and fish by-catch). Economics of artificial diet feeding outweigh the greater growth obtained with unprocessed feed.

Tiger shrimp

The major problems in tiger shrimp culture (*Penaeus monodon*) are unreliable supply of good quality spawners and postlarvae, and the lack of innovative farming systems for sustainable production and disease control. There is a need to develop captive broodstock as alternative source and culture systems that are compatible with the environment.

BROODSTOCK DEVELOPMENT, SELECTIVE BREEDING

Initial efforts are aimed at developing technology for producing reliable supply of captive broodstock. A polymorphic base population will be identified, a husbandry protocol developed, and a screening protocol established to determine the population's health status using non-lethal procedures. Results of the genetic diversity assessment of wild and cultured tiger shrimp obtained from Capiz, Negros Occidental, Quezon, Palawan and Antique showed that wild shrimps (66-71%) are more polymorphic than cultured shrimps (54%). Among the wild samples, those from Palawan were the most polymorphic followed by Capiz, Negros Occidental, and Quezon samples. Hence, the broodstock base population for the breeding program will be collected from Palawan.

Application of terramycin after eyestalk ablation

Tiger shrimp

Morphometric and nonmorphometric characters in captive (F3 generation) tiger shrimp obtained from a commercial facility were compared with wild shrimp. A total of 24 morphological abnormalities affecting either specific organs and appendages or whole body and associated with the Runt Deformity Syndrome were documented for the first time in cultured 17-18 month *P. monodon*. The cultured shrimp were found to be IHHNV positive by PCR and histopathology. These morphological criteria may be useful in shrimp breeding programs to complement screening protocols for diseases and growth rates.

To improve reproductive performance of pond-sourced tiger shrimp broodstock (body weight, 92-101 g), these were fed diets supplemented with various astaxanthin levels (0, 50, 100, 150 mg/l). One group was given rations of squid and mussel meat (control). Results showed that shrimp fed diet supplemented with 50 ppm astaxanthin attained the highest fecundity (2,276 eggs per g female body weight). Egg hatching rate and metamorphosis of nauplii to zoea stage did not vary among groups given various diets. Based on the analysis of astaxanthin in the feeds, actual levels (0, 4.5, 16.9, and 4.3 mg/l) were much lower than the amounts originally incorporated. There is a need to study the method of feed processing that will not destroy astaxanthin.

REFINEMENT OF SHRIMP CULTURE SYSTEMS

Studies focused on osmoregulation, nutrition and feeding, and pond effluents.

Osmolality, chloride and sodium concentrations in the hemolymph of tiger shrimp juveniles varied proportionately with salinity levels of 6-50 ppt at 22, 28 and 33°C and stabilized within 24 h after start of acclimation.

In terms of dietary requirement for amino acid tryptophan, shrimp juveniles showed highest weight gain and specific growth rate and best feed conversion ratio when fed diets with 0.2% tryptophan (0.5% protein). Partial replacement of fish meal, shrimp head meal, and soybean meal in AQD-formulated diet improved growth rates of shrimp compared to commercial feeds. Results

of tank and pond trials on effects of various dietary levels of L-carnitine on shrimp growth and survival were not conclusive.

Effluents from an intensive shrimp pond (10 per m^2) were drained into a mangrove pond and retained for a few days prior to release to open waters. Water quality monitoring over 24 hours showed higher temperature, salinity, DO and NH_3 levels in the shrimp pond compared to the mangrove pond; pH, NO_3 and PO_4 levels fluctuated in both ponds. Therefore, mangrove seedling growth was used to evaluate the effect of effluents. *Rhizophora* seedlings were taller (64 cm vs 60 cm) and had more leaves (12 vs 7) in mangrove pond compared to adjacent (control) mangrove area. (See also mangrove-friendly aquaculture project.)

HEALTH MANAGEMENT

Viral epizootics have led to economic devastation in various shrimp growing regions in the world. Thus, baseline information on the various viral diseases of cultured and wild tiger shrimp was gathered. The more serious threat to the sustainability of the industry in the Philippines is bacterial disease due to luminescent vibrios. Shrimp health studies in 1998 focused on the epidemiology, serology and virulence factors of the disease as well as on alternative control methods. A study has found a significant difference in quantitative luminous *Vibrio* (LV) load of hatchery-reared and wild-caught shrimp postlarvae. While the latter had only up to 350 colony forming units (cfu) of LV per postlarva (PL), hatchery reared PLs can harbor as much as 300,000 cfu LV per PL. Possible approaches to alter the PL gut flora will be done in 1999.

Luminescent vibriosis was dealt with in the past by chemotherapy and it resulted in the persistence of antibiotic resistant strains in the culture environment. The need to develop reliable alternative control measures through the addition of benign bacteria to compete with potential pathogens, or use up excess nutrients in the environment (bioaugmentation) is necessary. Many such products are available in the market, but the potential problem that the industry faces regarding their use is the lack of recommended protocols accompanying the products as well as the lack of qualitative and quantitative information regarding their components.

Grouper

Grouper broodstock from the wild are transported to AQD for studies on breeding

Grouper fingerlings are raised by AQD in its hatcheries

Feeding studies on grouper fry

Egg and larval quality are the major concerns in grouper aquaculture. Several approaches have been tested to address these concerns: manipulating sex ratio to optimize egg production, determining effects of broodstock nutrition on egg and larval quality, examining embryonic development and hatching under different incubation conditions to identify some of the factors affecting larval quality, and determining the microbial flora of grouper eggs and its possible relation to developmental success.

AQD has continued its efforts to apply nutritional, environmental and hormonal manipulations to improve survival and produce healthy juvenile groupers. AQD verified in larger scale the use of copepod nauplii as initial food in a semi-intensive production system. Researchers have also continued efforts to verify the effectivity of thyroid hormones in accelerating and synchronizing metamorphosis in 3-week old larvae.

Another thrust of AQD's grouper research is developing practical diets for grouper to replace fish bycatch as food in the nursery and grow-out operations. One study screened the protein digestibility of various feed ingredients, including indigenous protein sources to replace the more expensive fish and soybean meals.

Studies to identify parasites associated with cage- and pond-reared groupers were also conducted.

Mangrove red snapper

Mangrove red snapper

Interest in mangrove red snapper (*Lutjanus argetimaculatus*) culture has gained prominence in Southeast Asia and Australia due to its relatively high market price. The red snapper is cultured in marine cages and brackishwater ponds, however, culture is not extensive because growers rely entirely on wild-caught fry. Thus, AQD has undertaken research on breeding and fry production in hatcheries for sustainable aquaculture. A study on feed development for grow-out culture was also conducted in 1998.

Wild-caught and hatchery-reared fry grown to broodstock size in concrete tanks or floating marine cages have spontaneously matured. Spermiating males and females with mature oocytes were noted in 4- and 5-year old broodstock, respectively, during the natural breeding season (April to October).

In the absence of natural spawning, red snapper were induced to spawn through a single intramuscular injection of human chorionic gonadotropin (1,000 IU per kg body weight) or luteinizing hormone-releasing hormone analogue (100 ug per kg). The induced spawns, however, gave poor egg and larval quality compared with the spawns of wild-caught adults. From a total of 10 spawns, mean percent egg viability was 37%, hatching rate 27%, and percent normal larvae 22%. The low production of normal larvae per spawn (<50,000) was inadequate for larval rearing trials.

As the present grow-out culture still relies solely on trashfish as feeds, formulation of a cost-effective practical diet was initiated beginning with the determination of the optimum protein requirement. Juveniles (25 g) fed diets at 3 protein (35.0, 42.5, and 50.0%) and 2 lipid (6 and 12%) levels for 100 days had 100% survival in all treatments and attained average final weights of 116-165 g. The optimum protein requirement was determined to be 42.5% and the protein-to-energy ratio was estimated at 130 mg per kcal similar to that of sea bass.

The second experiment utilized defatted soybean meal to substitute for the dietary animal protein (fishmeal, squid meal, and *Acetes*). Substitution of up to 30% of the dietary animal protein was sufficient for growth. However, higher percent substitution affected liver histology. The results provide significant contribution for practical diet formulation which can then be tested in grow-out ponds or cages.

Sea bass

The sea bass project focuses on seed production and nutrition and feed development. Three studies were conducted in 1998.

The first study identified physical and biochemical characteristics of sea bass eggs to assess egg quality. The study showed direct correlation between total saturated fatty acids and percentages of cleaving eggs, normally cleaving eggs, surviving eggs at the embryonic body formation stage, hatching rate, percentage of normal larvae and cumulative survival.

Inverse relationship was observed between total w3 fatty acids and percentages of cleaving eggs, normally cleaving eggs, and surviving eggs at the embryonic body formation stage. The ratio of DHA to EPA did not result in any significant correlation.

The effect of possible immune modifying compounds and hormones on the non-specific immune response in sea bass was assessed by measuring plasma lysozyme levels and the phagocytic ability of leukocytes. In previous experiments this study showed negative effect of handling stress and water quality deterioration on the immune response in sea bass and the positive effect of some compounds such as glucans on the immune system of this fish. The immune modifying effect of some hormones is currently being studied.

For nutrition and feed development, AQD researchers have already determined the sea bass juvenile requirements for seven of the essential amino acids – argenine, lysine, methionine, threonine, tryptophan, phenylalanine and histidine – while experiments for two more – isoleucine and valine – are in progress. Researchers have also worked out the fatty acid requirements for juvenile sea bass. These data will be used to develop a cost-effective feed.

Seabass broodstock

Rabbitfish

The activities of the project for 1998 were geared towards developing tools for growth enhancement. An important first step is to understand how growth is regulated in rabbitfish. This involves characterization of the so-called growth axis (the growth hormone – insulin-like growth factor I axis) under different culture conditions.

To achieve this, growth hormone (GH) was isolated from pituitary glands of rabbitfish by gel filtration and high performance liquid chromatography (HPLC). The yield of pure GH was 1 mg per g wet weight of pituitary glands. The pure GH will be used for assays to test its biological activity. Part of the pure GH was also used to raise GH antiserum in rabbits. In the process of purifying GH, prolactin and somatolactin, two pituitary hormones which are related to GH, were also purified. Antiserum against rabbitfish prolactin was also produced in rabbitfish.

Since future activities for growth enhancement in rabbitfish will require large amounts of pure GH, rabbitfish GH cDNA was cloned for recombinant rabbitfish GH production. Excluding the poly-A tail, rabbitfish GH cDNA is 860 base pairs long. It contains a 588 base pair open reading frame encoding a signal peptide of 18 amino acids and a mature protein of 178 amino acid residues. These information will be useful in recombinant hormone production and in the design of DNA probes to examine the expression of the GH gene at different developmental stages and under different culture conditions.

Catfish

Induced breeding and hatchery techniques of the native catfish *Clarias macrocephalus,* a favorite freshwater food fish fast disappearing in its natural habitats, were verified in 1998 to mass produce the fry. Nursery and grow-out techniques were likewise developed, especially the formulation of diets and determination of optimum stocking density.

Nursery production of catfish was done by rearing the fry simultaneously in net cages installed in ponds and in tanks for 28 days. Stocking densities tested were 200, 400, 800 fry per m² in the first run and 400, 800, 1200 fry per m² in the second run.

In the first run, fingerlings were both heavier and longer when grown in ponds than in tanks. In the second run, tank-reared fingerlings have comparable mean total length at all stocking densities (2.99-3.27 cm), but were heavier at 400 per m² (0.34 g) and 800 per m² (0.25 g) than at 1200 per m² (0.20 g). There were no significant differences in mean total length and weight of pond-reared fingerlings at all stocking densities tested. Growth of catfish fry was generally faster when reared in ponds than in tanks in both runs. Fingerlings were bigger at 200 fry per m² than at higher stocking densities (400-1200 fry per m²). While survival rates were comparable in fingerlings grown in both tanks (85-89%) and ponds (78-87%) in the first run, survival rates were much higher in tanks (89-92%) than in ponds (19-37%) in the second run.

Grow-out culture of catfish was carried out by stocking 10 fingerlings (weight = 3.6 g; length = 7.8 cm) per m² in twelve 25 m² (5 x 5 m) pens installed in a 440 m² pond. AQD-formulated diets of 17% (Treatment 1) or 32% (Treatment 2) protein were tried together with the industry practice of feeding a commercial pellet containing 27% protein (Treatment 3; Tateh brand), or a combination of blanched chicken entrails and rice

AQD researchers artificially induce the spawning of the native catfish

Catfish fry from AQD hatcheries in 1998 are raised in nets installed in ponds to determine growth and survival

bran (Treatment 4). After 60 days of culture, fish in Treatment 2 showed the highest growth, followed by those in Treatments 3 and 4, and then fish in Treatment 1. Specific growth rates and feed conversion ratios of the fish in Treatments 2, 3, 4, 1 were 4.2, 3.2, 3.1, 2.6%, and 0.9, 1.1, 2.5, 1.7, respectively.

An important implication of this project is that Filipinos can now start propagating their favorite native catfish using AQD's hatchery and nursery techniques.

Eggs of mature female catfish are mixed with the sperm of male catfish to facilitate fertilization of eggs

Bighead carp

The commercial production of bighead carp broodstock is hampered by the shortage of quality broodstock. There is a need therefore to explore a cost-effective broodstock development strategy before any stock improvement program can be initiated. Likewise, there is also a need to study the genetic structure of the population.

The study on growth retardation as a tool for development and management of bighead carp broodstock was continued in 1998. Preliminary results indicated growth compensation in fish that were stunted in fiberglass tanks for multiple of six months. After 12 months of rearing in cages, bighead carp that were stunted for 6 months attained average weights ranging from 1312 to 1698 g from initial weights of 3.1 to 3.5 g.

Carp that were stunted in tanks for 12 months and subsequently reared in cages for 6 months attained average weights ranging from 669 to 912 g from initial weights of 3 to 3.4 g. Control fish that were reared entirely in cages for 18 months attained average weights ranging from 2126 to 2726 g.

Seaweeds

The project focuses on two seaweed species – *Gracilariopsis* and *Kappaphycus* – with three studies conducted in 1998.

A study on the sequestration of heavy metals by the thallus and agar from the red seaweed *Gracilariopsis bailinae* was done to determine the amount and pattern of absorption of four types of heavy metals under different concentrations (50, 100, 150, 200 and 250 ug metal per liter) and time regimes (12, 24 36 and 48 h). Seaweed thalli can rapidly or continuously take up heavy metals until the 48th hour when these are gradually released. Among the metals tested, the most absorbed by the thalli was copper and the least was lead. In between are zinc and cadmium. Analysis also showed that all metals were detectable in agar, the commercial extract of seaweed. Copper showed greater affinity to agar while lead hardly penetrated. Copper rapidly penetrated the agar followed by gradual release until the 48th hour, while zinc and cadmium gradually penetrated until the 48th hour. The results suggest that metals coming from domestic and industrial effluents are easily absorbed by *G. bailinae* and are detectable in the agar extracts.

The study on the life history of *Gracilariopsis* is on-going. *G. bailinae* were cultured in tanks, and their nitrogen-phosphorus uptake and salinity tolerance tested. The optimum salinity for growth was at 25 ppt. As source of nutrients, ammonium-nitrogen at 40 ppm promotes better growth than nitrate-nitrogen. Phosphate in the form of disodium phosphate at 1 ppm also yielded good growth. The gel strength of agar from *G. bailinae* was better at higher concentrations of nutrients.

Experimental set-up for the study on sequestration of heavy metals by the thalli and agar of seaweed

The study on *Kappaphycus* dealt with spore liberation from carposporophytes at different photoperiod regimes. Seedling production from spores of fertile *K. alvarezii* was to generate viable seedlings for outplanting. This study will continue through next year.

Abalone

It is a worldwide experience that abalone hatchery production is still limited by the very low postlarvae settlement rates. Thus, research priority is centered on refinement of hatchery techniques in order to increase harvest of juveniles. In addition, hatchery-produced juveniles have become the only source of seeds for grow-out culture due to the fast decline of wild populations caused by heavy fishing pressure. Reseeding with hatchery-produced stocks will take years before it can have an effect on the restoration of natural abalone population. Refinement of present techniques should improve production and make available more seedstocks.

PRODUCTION TANKS

AQD maintains production tanks for early juveniles which are then used in experiments in the secondary nursery and grow-out experiments.

AQD has 150 abalone breeders (*Haliotis asinina*) that are wild or hatchery-reared. These breeders kept in tanks are fed *Gracilariopsis*. Abalone spawn spontaneously throughout the year, producing 32 million eggs (about 0.2-6.5 million eggs per month) in 1998, of which more than 10 million veligers were hatched. Broodstock reproductive performance may still be improved by feeding more nutritious formulated diets.

Newly-hatched larvae are collected and held in static seawater tanks until the pre-settlement stage. Before the larvae are stocked at densities ranging from 150-300 per liter, corrugated PVC plates are placed in the tanks and benthic diatoms – preferably *Achnanthes, Amphora, Cocconeis, Navicula* – are allowed to settle on the plates.

Larval tanks are illuminated at night during the first 10 days to induce activity of postlarvae during settlement. Illumination can also prevent decrease of dissolved oxygen levels due to microalgal respiration. On the 10th day, filtered seawater is continuously supplied under ambient photoperiod, and this enhances growth of both microalgae and abalone. Current early juvenile production data showed a low 1.3% survival after 60 days of culture. Early juveniles (5-10 mm shell length) are ready to feed on macroalgae (typically *Gracilariopsis* sp.)

Within the next 60-80 days, juveniles can attain 25-28 mm shell length, the stocking size for on-growing to market size. With *Gracilariopsis* sp as major feed, market size abalones (55-60 mm shell length, 50-60 g body weight) can be harvested following a 12-month culture period. This is far better than their counterparts in the sub-tropical and temperate regions where abalones are harvested after 24-36 months of culture.

Hatchery-reared tropical abalone, Haliotis asinina, *adult. Abalone spawn spontaneously in tanks throughout the year*

ADDRESSING RESEARCH GAPS

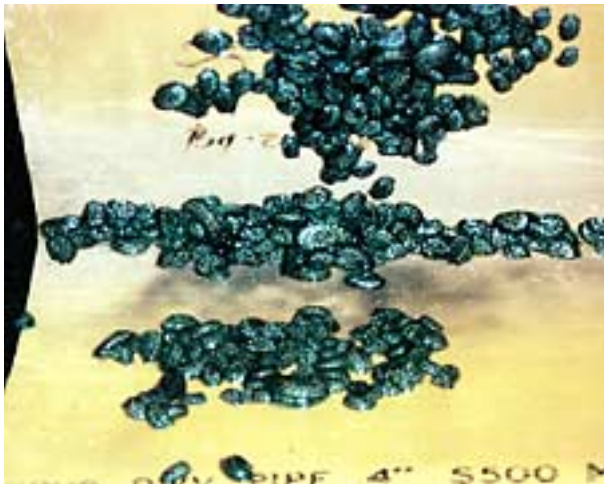
In 1998, studies have focused on hatchery, nursery and grow-out culture. Highlights include:

A broodstock diet has been developed and is being tested as a possible replacement for seaweed. Broodstock reproductive performance is evaluated in terms of maturation and rematuration rates, spawning rate and frequency, fertilization rate and veliger production. Initial observations are indicative of a good response to the diet.

In the hatchery, a 24-h light regime enhanced postlarval settlement to 12.1% while a 24-h dark regime induced the lowest settlement of 3.12%. There were more larvae that settled on the tank bottom (2.0-9.4%) than on the plate substrates (1.0-2.7%). The density of diatoms as food did not affect survival of abalone postlarvae after 30 days of culture. Survival of abalone ranged 1.0-1.5% at the lowest (3,500 cells per ml) or highest (125,000 cells per ml) algal density.

Weaning early juveniles (5-13 mm shell length) to macroalgae or extending the period of diatom feeding did not show significant effects on abalone growth and survival. Growth and food consumption (seaweed) during secondary rearing of juveniles were affected by photoperiod. Under ambient light, juveniles had a daily feeding rate (DFR) of 14% and growth rate of 160 µm per day, attaining a size of 23.2 mm shell length and 2.6 g body weight after 106 days of culture. Juveniles reared under a 24-h dark regime consumed more food (DFR=17.4%) but had lower daily growth rate of 143 µm per day to reach a size of 21.5 mm and 1.9 g. Abalone under 6L:18D photoperiod had intermediate daily growth rate (155.8 µm) and DFR (15.6%) but with better survival rate (77%) than those under ambient light (47%) and 24-h dark regime (21%).

At stocking density of 285 individuals per m^2, food consumption of abalone juveniles (initial size: 17.25 mm, 1.1 g) reared in an outdoor tank was higher by 40% over those reared indoors. Temperature and salinity in both tanks ranged 30-31°C and 28-29 ppt, respectively. Final body size after 65 days was 28.14 mm and 5.12 g for outdoor-held juveniles compared to 24.5 mm and 3.36 g for indoor-held juveniles. However, percent sur-



Juvenile abalone attach themselves to a PVC shelter. These can be stocked in grow-out culture. The seaweed Gracilariopsis *is still the best feed for growing abalone to market size*

vival of either group was generally high at 99.5-100%. Furthermore, size-sorting prior to nursery rearing can be beneficial to smaller juveniles (5-8 mm) but not necessarily to larger juveniles (14-16). At a stocking density of 247 per m², sorted "small" juveniles grew to a final body size of 25.8 mm and 3.4 g after 113 days of culture. When mixed with larger juveniles, the smaller juveniles attained a final size of 23.6 mm and 2.7 g only. Large juveniles with or without the presence of smaller juveniles attained final body sizes ranging 30.2-32.1 mm and 6.7-7.6 g.

Biological testing of practical diets for juvenile abalone showed that an optimal crude protein level of 27% with 5% lipid and 40% carbohydrates may be sufficient. With a total weight gain of 252% and a specific growth rate of 1.52%, juveniles fed the artificial feed grew much faster than those juveniles fed seaweeds. The latter had lower total weight gain and specific growth rate of 134% and 0.92%, respectively.

Grow-out trials in indoor tanks showed that abalone juveniles (31.9 mm, 7.4 g) stocked at 68 per m² and fed *Gracilariopsis* ad libitum attained a marketable size of 59.3 mm and 55.3 g after 290 days of culture with 96% survival. But this is not different from juveniles stocked at 17 and 34 individuals per m².

Artificial feeding for grow-out culture of abalone may not be as advantageous as in the nursery. A 90-day experiment showed that growth of juveniles (38.7 mm and 11.65 g) fed artificial feed (27% crude protein) was not different from those fed seaweeds (38.31 mm, 12.81 g). Percent survival (95%) of seaweed-fed abalone was significantly higher than artificial diet-fed groups (32%). A feed containing lesser crude protein of 17% proved to be comparable to seaweed in terms of abalone survival. However, growth of animals was lower at 36.24 mm and 9.27 g than those fed seaweed.

Partial results of yet another experiment where alternate feeding of artificial diets (first 90 days) and seaweeds (another 90 days) and vice versa showed that during the first 90 days, growth and survival of artificial diet-fed abalone were lower (5.6-6.2 g and 52-71%) than those fed seaweed (10.9-12.2 g and 74-88%).

Marine ornamental fish

BREEDING AND SEED PRODUCTION OF SEAHORSES

Dried seahorses are much prized in traditional Chinese medicine and live ones are traded on the aquarium fish market. But overfishing and habitat degradation are threatening seahorses to extinction. In some areas, a 50% decline in population over the last five years has been reported. This alarming trend has prompted AQD to develop breeding and seed production techniques for two species of seahorses *Hippocampus kuda* (previously mislabelled as *H. erectus* and *H. whitei*) and *H. barbouri* (previously mislabelled as *H. histrix*). Initial rearing and breeding trials resulted in small brood size and low survival rates of both broodstock and juveniles, mainly due to lack of information on appropriate food organisms, feeding rates, and stocking densities.

To improve reproduction performance, established mating pairs *of H. kuda* (body weight, 10-20 g) were offered HUFA-enriched live *Artemia* adults (at 30% of body weight) alone (single diet) or a combination diet of HUFA-enriched *Artemia* adults (at 15%) and mysids (at 6%) or tilapia fry (at 5%). After 90 days, *H. kuda* fed a combination diet showed more parturition events (7-8 per pair) and greater brood size (87-91 juveniles per g female) than those given a single diet (2-3 parturition per pair and 18-26 juveniles per g female). When groups of newly born *H. kuda* were fed *Brachionus* alone, copepods alone, or their combination, only seahorses on a combination diet survived until day 10.

In preparation for the planned grow-out culture of seahorses in illuminated sea cages, the effect of illumination on daily feeding patterns (feed used was 0.013 g tilapia fry) was determined under laboratory conditions. Food consumption of *H. kuda* juveniles (mean weight, 1.9 g) was significantly higher during daytime (0600-1800 h; 7.4 fry per g body weight) than during nighttime (1800-0600 h; 3.1 fry per g body weight). When exposed to continuous illumination, however, similar amounts of food were consumed during the two consecutive 12 h feeding intervals per day. Moreover, when food was made available only for 12 h under continuous illumination, *H. kuda* consumed comparable amounts of food per day as when food was made available for 24 h under continuous illumination or natural photoperiod (12L:12D). This indicates that seahorses may not eat for 12 h when food is not available but will compensate for the 12 h non-feeding period when food becomes available.

Preliminary simulated transport experiment on 33-day old *H. kuda* (stretched height, 16-38 mm) showed that seahorses at higher loading densities (10 and 20

Seahorses have been breeding in captivity at AQD

juveniles per 500 ml) were grasping each other by the tail and had higher survival rates 48 h post-transport than those at lower loading density (5 juveniles per 500 ml). This result indicates the importance of providing a holdfast during transport at low loading densities.

Pairing trials to establish mating pairs among wild and hatchery produced *H. barbouri* resulted in 30 successfully mated pairs but only six pairs have been regularly mating. A preliminary experiment on the feeding cycle *of H. barbouri* under natural photoperiod showed a distinct diurnal feeding behavior, that is, food consumption was significantly higher during daytime (about 3-7 times) than food consumption during nighttime.

Following improved techniques based on the above results, seahorse production in 1998 for both species have considerably increased compared with 1997 production. The total number of hatchery produced potential broodstock has doubled in *H. barbouri* (190 in 1997; 319 in 1998) and has increased by seven-fold in *H. kuda* (59 in 1997; 409 in 1998). The total number of broods of 51 from 20 mating pairs of *H. barbouri* in 1997 increased to 103 broods from 30 mating pairs in 1998; broodsize remained within 1-287 but average broodsize increased from 39 in 1997 to 86 in 1998. Similarly, a total of 43 broods from six mating pairs of *H. kuda* increased to 74 broods from 7 pairs while broodsize range and average increased from 1-721 and 325 in 1997 to 44-1751 and 749 in 1998, respectively.

BROODSTOCK DEVELOPMENT OF PANTHER FISH AND BLUE TANG

The panther fish (*Cromileptis altivelis*) in its juvenile stage and blue tang (*Paracanthurus hepatus*) are among the highly-priced marine ornamental fishes. When grown, *C. altivelis* is one of the high-valued species in the live food fish industry. Hatchery propagation of these species will reduce dependence on wild populations, thus minimizing reef resource depletion and reef habitat degradation. Since very little is known on the biology and life history of these fishes, investigation of the reproductive biology was initiated. AQD will look into factors that trigger spawning, so these can be manipulated to enhance artificial propagation.

All panther fish broodstock were still in the female phase as shown by the presence of yolky oocytes (mean diameter, 0.38-0.45 mm).

Two of the 37 blue tang expressed milt in April, another 7 in August. In this group, 15 females were noted (mean weight, 145 g) as being immature or maturing females (mean oocyte diameter, 0.3 mm). No gonadal tissues were obtained from the rest.

Larval food project

Not all cultured species attain good growth with the present crop of larval food used in hatcheries as live feed. AQD therefore initiated a larval food project with the aim of screening potential larval food species that can be mass-produced for hatcheries. In 1998, efforts were focused on a zooplankton and two phytoplankton species.

A prototype 20-liter egg production and egg collection tank for *Acartia* sp. was developed. Preliminary result indicates that the initial stocking density of *Acartia* adults inversely affects egg production. *Acartia* eggs can be collected daily up to one week with maximum egg production of about 9,000 eggs per liter per day. Hatching rate of collected eggs was as high as 90%. Embryonic development until hatching at ambient temperature was documented.

Toxicity of various cryoprotectant concentrations to *Acartia* eggs was examined. More than 80% of the eggs hatched when exposed up to 10% DMSO or glycerol for 30 min. DMSO or glycerol concentrations at 15% or higher significantly lowered hatching of eggs. Methanol concentrations up to 15% have no significant effect on hatching. Bread yeast or a test oil emulsion was evaluated as an alternative feed for copepods. Lower egg and nauplii production were observed in copepods fed bread yeast alone compared to those fed with *Tetraselmis* or *Tetraselmis* plus a test oil emulsion.

Studies on *Pseudodiaptomus annandalie* population, growth, reproduction and its suitability to milkfish and sea bass larvae are underway.

A bacteria-free culture of newly isolated *Navicula* sp. was achieved by treating the alga with triple antibiotic (Peniccilin G-600 ppm, Streptomycin sulfate –300ppm, Chloramphenicol –60 ppm). The same triple antibiotic treatment was also tested on *Chorella* – like alga isolated from Oton. A bacteria-free culture was not obtained out of the three trials conducted.

Collaborators

- **Australian Center for International Agricultural Research (ACIAR)** for research on broodstock diet development, and development of hatchery and pond culture techniques for mud crab. The collaborative research effort started in June 1995
- **European Union (EU)** for research on the ecosystem approach to sustainable management of Laguna de Bay, started in January 1995; and research on bioencapsulated feed for larval fish based on nutritionally enriched nematodes, started in 1998
- **International Foundation for Science (IFS)** for research on nutrition and feed development for sea bass. Started in July 1991
- **Lonza, Ltd, Switzerland** for research on the use of metaldehyde as molluscicide in milkfish ponds. Started in February 1996
- **University of Hohenheim, Germany** for research studies on milkfish and tiger shrimp, doctoral fellowship to AQD staff, and short-term assignments of German scientists to AQD. Started in August 1996
- **Tufts University, USA** for research studies on genetic diversity of wild and cultured tiger shrimp populations in the Philippines. Started June 1997
- **Hamlet Protein A/S, Denmark** for research on shrimp feeds. Started in March 1997
- **Japan International Cooperation Agency (JICA)** for research on the culture of grass carp. Started September 1998
- **Japanese Government Research Scholarship Program, Ministry of Education (Monbusho)** for doctoral fellowships to AQD staff at Nagasaki University and Tokyo University of Fisheries
- **Japan Society for the Promotion of Science (JSPS)** for doctoral fellowships to AQD staff under the Ronpaku Program at Kagoshima University and Hokkaido University
- **Philippine Council for Aquatic and Marine Resources Research and Development (PCAMRD)** for doctoral fellowship to AQD staff at the University of the Philippines
- **International Center for Living Aquatic Resources Management (ICLARM)** and the **Bureau of Fisheries and Aquatic Resources (BFAR)** for milkfish fry resource assessment, started 1997.

Centennial Fisheries Award for AQD

AQD was awarded the **Centennial Fisheries Award** by the Department of Science and Technology in the Philippines on January 30, 1998 for "pioneering the development of the prawn hatchery technology in the 1970s, led by Dean Domiciano K. Villaluz, which boosted prawn production in the country." AQD later saw the decline of the industry in the late '80s.

Today, AQD has joined the Philippine government's effort to rehabilitate the tiger shrimp industry through the 'Oplan Sagip-Sugpo' program. Its assigned tasks include the development of specific disease-resistant strains through selective breeding and the re-engineering of shrimp ponds to better deal with effluents coming from intensive culture.

Researcher Award

The paper of AQD researcher Nelson V. Golez was awarded the **Best Published Paper in Aquaculture** at the 12th Dr. Elvira Tan Memorial Awards for 1998, the most prestigious in the country. Golez' paper was entitled "Influence of pyrite oxidation and soil acidification on some essential nutrient elements," and it was published in the research journal Aquacultural Engineering, Vol. 16 (1997), pages 107-124.

More than 20 AQD research papers have been given citations or awards by the scientific community.

Nelson V. Golez

Scientific publications

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CONTINUED ON PAGE 22

Technical meetings

Collaborating agencies involved in mud crab research are represented by (from left to right): PCAMRD Head Dr. Rafael Guerrero, UPV Vice-Chancellor Dr. Ida Siason, ACIAR's Dr. Clive Keenan, Australian Embassy in the Philippines representative Cecilia Honrado and AQD Chief Dr. Rolando Platon

Poster exhibit at the crab conference

The **First International Forum on the Culture of Portunid Crabs** was successfully held at the Pink Patio Hotel in Boracay in the Philippines on December 1-4. Over a hundred scientists from the Philippines and abroad attended. Overall, the researchers agree that large-scale production of mud crab seeds is already technically feasible.

Grow-out technology on the other hand is not only technically feasible but economically viable as well, as trials have shown. It is now ready for adoption by the industry.

Grow-out culture of mudcrab may be done in abandoned shrimp ponds or in mangroves, an environment-friendly culture system.

The crab conference was organized by ACIAR, AQD, UP Visayas, and Queensland Department of Primary Industries.

The **Interdepartmental Workshop on Management for Sustainable Coastal Fisheries (Phase 1, Vietnam)** was convened by the SEAFDEC Secretariat in collaboration with AQD in Iloilo City, on July 6-8. This was attended by officers and researchers from SEAFDEC Secretariat, and its various departments, as well as representatives from the Government of Vietnam.

The project in Vietnam is the first collaborative effort of all the SEAFDEC Departments based in different countries.

Officials and researchers of the SEAFDEC family

Dr. Platon and AQD researcher Celia Pitogo present papers at the 1998 prawn industry congress

AQD also helped organize the **4th National Prawn Industry Congress** with the Department of Trade and Industry, the *Oplan Sagip-Sugpo* Task Force of the Department of Agriculture, PhilExport and Shrimppex. The congress was held in Iloilo City on October 27-29, and was attended by over 100 shrimp farmers, shrimp exporters, government officials, and researchers.

AQD Chief Dr. Platon is the head of the *Oplan Sagip-Sugpo* task force, the interagency and multisectoral team that spearheads the rehabilitation of the shrimp industry in the Philippines.

Seminar-workshop on media networking for aquaculture information. AQD hosted this workshop in November 19-20, 1998 which was attended by over 60 researchers, information officers and media practitioners in the Philippines.

Participants of the First Seminar-Workshop on Media Networking for Aquaculture Information

Scientific publications FROM PAGE 20

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Technology verification and extension

AQD's technology verification and extension program promotes the commercialization of mature aquaculture technologies by demonstrating the technical feasibility and economic viability of these technologies in commercial farms in the Philippines.

In 1998, AQD decided to fast-track the commercialization of its milkfish technologies. Two new programs were launched in July during the 25th anniversary celebration. These were the **Accelerated transfer of milkfish hatchery technology** and the **Pond cooperators' program**.

AQD also conducted ten studies in 24 project sites situated mostly in the Visayas region. Private fishfarms and government institutions – 24 of them – assisted in the implementation of these studies (listed below). The results attained by AQD in grouper culture in brackishwater ponds and tilapia culture in small farm reservoirs have caught the attention of the aquaculture entrepreneurs. This resulted in the increased number of cooperators over the previous year.

- **Accelerated transfer of milkfish hatchery technology.** The project is intended to encourage the backyard shrimp hatchery operators to diversify into milkfish fry production. This was carried out by training the hatchery operators at the AQD milkfish hatchery and nursery facilities, after which they were given milkfish eggs to rear in their respective hatcheries. The cooperators sell the fry they produce while AQD researchers collect the production data.

  The first cooperators of the project include: the hatcheries of Luis Rojas in Batan, Aklan; the hatcheries of the Aquaculture Specialists Inc. in Guimbal, Iloilo; and other small-scale hatcheries operating near AQD's Tigbauan Main Station. Results of the project indicated that the prospect of making milkfish hatchery operation viable as an enterprise is very encouraging.

- **Pond cooperators' programme:** nursery and grow-out of hatchery-reared milkfish fry in ponds. AQD is tracking the performance of hatchery-reared milkfish fry in several private fishfarms like the Gatuslao and Jalandoni farms in EB Magalona, Negros Occidental; Naranjo farm in Carles, Iloilo; Arches farm in Capiz; Hautea farm in Iloilo; and at the BFAR station in Pagbilao, Quezon.

  Results showed very few malformed fry (0.23%) in the nursery phase. Milkfish were stocked at 10 per m^2 in 0.5 ha pond. Survival was about 68%, and average fish body weight after the nursery phase was around 10 g.

  In semi-intensive grow-out culture, deformity was also nil (0.05%). Milkfish (weight, 70 g) were stocked at 1 per m^2 in four ponds ranging in size from 0.6 to 0.8 ha, and reared for 60 days. Survival was 94%, with market-sized fish weighing 290 g. Average yield per ha was calculated at almost 3 tons.

  In the modular method (=progression system) of milkfish grow-out, deformity was nil (0.003%). Contiguous ponds of size 0.6 and 2.4 ha were used in this trial. Survival of fish after 105 days was 99%, with the total biomass estimated at 2.4 tons. With the modular system, fishfarmers can stock three times a year.

- **Grouper culture in brackishwater ponds.** Grouper culture is a viable alternative for fish farmers, especially tiger shrimp producers, who prefer the culture of high-value commodities.

  AQD conducted the first trial in the Sanson Farm in Sum-ag, Bacolod City. The cooperator harvested 1.5 tons of grouper (450 g on average) after 7 months of culture. Survival rate was 79%. Net profit after tax is over P140,000. Return-on-investment is 79% and payback period is 1.25 years. These results have been documented in a manual written by AQD aquaculturists (please see information materials).

  Another trial is on-going at AQD's recently acquired brackishwater ponds in Dumangas, Iloilo which was donated by the Philippine Department of Agriculture. Grouper are stocked at 10,000 per ha.

- **Improved tiger shrimp pond culture techniques.** This project is conducted by AQD under the "Oplan Sagip-Sugpo" program of the Department of Agriculture in intensive tiger shrimp farms in Sum-ag (Sanson farm), Talisay (Sta. Clara farm), and EB Magalona (Golden Prawn farm) all in Negros Occidental. AQD tested the use of reservoirs, sludge collectors, biological manipulators (fish), bacterial inoculants (probiotics), and/or low salinity levels. These are schemes to prevent the occurence of diseases which had devastated the industry in the last decade.

  The stock in the Sum-ag farm weighed 18 g on average after 109 days of culture. In other pond, shrimp attained an average body weight of 13 g after 88 days.

Luis Rojas' tiger shrimp hatchery in Batan, Aklan was converted into milkfish hatchery with AQD's technical assistance

In the Talisay farm, tiger shrimp weighed 32 g after 125 days. Some stocks were harvested earlier (at 20 g) after these were adversely affected by teaseed application.

In EB Magalona, the first study site is about 0.4 ha, and stocked with 78,000 pieces of tiger shrimp fry from AQD and reared for 164 days. Harvest after 164 days of culture was about 2,800 kg. Survival rate was 94%, and shrimp weighed 38 g. Tiger shrimp were sold at P255 per kg.

AQD held field days or foodfests to boost interest in technologies that can be commercialized by fishfarmers or local communities: grouper culture, mussel and oyster culture, and tilapia cage culture in small freshwater reservoirs

The second study site in EB Magalona is about 0.5 ha, and stocked with 102,000 pieces of 16-day old postlarvae. Harvest after 168 days is 3,400 kg of tiger shrimp weighing 36 g on average. Survival rate was 92%. Shrimp were sold at P255 per kg.

AQD is also verifying the above environment-friendly schemes in its own brackishwater ponds in Dumangas, Iloilo though at a higher rate of stocking, 30 shrimp per m². This trial will be completed next year.

- **High-density milkfish pond culture.** Milkfish culture with stocking density of 10,000 per ha is being tested in commercial-scale in AQD's brackishwater ponds in Dumangas, Iloilo.
- **Polyculture of milkfish and the seaweed *Gracilariopsis* in brackishwater ponds.** The trial is conducted in collaboration with the Iloilo State College of Fisheries, Barotac Nuevo, Iloilo.
- **Culture of mudcrab in brackishwater ponds.** This was conducted in six half-hectare brackishwater ponds in Negros Occidental. The average harvest of 724 kg per pond per crop. Return-on-investment is 46% and payback period is 2 years.
- **Culture of mudcrab in net enclosures in mangroves.** AQD tested this technology in a 0.4 ha mangrove area in Barangay Manalo, Puerto Princesa, Palawan. With a local cooperative and the local government unit as cooperators, AQD harvested 485 kg of mudcrab from an initial stock of 2,040 pieces of mudcrab weighing 9-22 g. Average weight of mudcrab at harvest is 275 g. Culture period was 5 months; survival rate is 86%; return-on-investment is 59%; and payback period is 1.6 years.

  A similar set-up is being tested in tidal flats with reforested mangroves situated in New Buswang, Kalibo, Aklan, but the design of the net enclosure is different. In this set-up, net enclosures are uniformly sized – 200 m² – and mudcrab are stocked at 0.5-1.5 per m² (see also page 10).
- **Netcage culture of genetically improved male tilapia (GIFT tilapia).** AQD cooperated with a people's organization and the local government unit in using small-farm freshwater reservoirs to raise all-male tilapia (GIFT strain). The first harvest came from 11 netcages in Bingawan, Iloilo. Return-on-investment of this run was 49%, with a payback period of 2 years.

  The second run is still on-going in 24 cages situated in four small-farm reservoirs, also in Bingawan. Initial stock sampling showed tilapia weighing 12-14 g after 60 days of culture. Stocking density was at 50-75 per m². Partial harvest will start on the last week of January 1999 when the stock is estimated to weigh an average of 150 g.
- **Mariculture of grouper, siganids, and milkfish.** AQD stocked grouper and siganids at various densities in netcages at its Igang Marine Substation. These stocks will be harvested in February 1999 when grouper would have reached 450 g in size and siganids will be about 200 g. Milkfish are also reared in cages.

- **Broodstock management and seed production of economically-important fishes.** This is a project conducted in collaboration with the Department of Agriculture's Inland Searanching Station in Tiniguiban Cove, Puerto Princesa, Palawan. The project site is Senorita Island, Honda Bay.

  AQD pursues the same project at the Igang Marine Substation. The present broodstock consists of 40 groupers weighing 5-15 kg and 8 red snappers weighing 2-5 kg.

- **Oyster and mussel culture in rafts.** AQD is helping communities and the local government units in Aklan and Capiz improve their oyster-mussel harvest through the use of the hanging raft culture method.

AQD field-tests mariculture of economically important commodities at its Igang Marine Substation in Guimaras

Mussel-oyster project site in Capiz

Harvest of mudcrab from the mangrove site in Barangay Manalo, Puerto Princesa, Palawan

Sanson farm and AQD collaborate in field-testing improved tiger shrimp culture techniques that incorporate effluent treatment. AQD will eventually develop a zero discharge system for intensive tiger shrimp culture

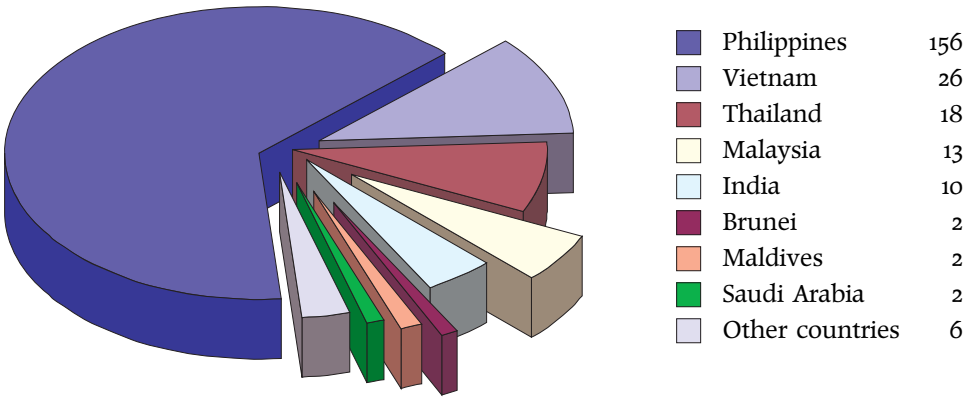
Training activities

AQD continues to train aquaculture manpower for the region. In 1998, 205 participants attended the regular formal courses and the *Special Training Program.* The trainees mostly come from SEAFDEC Member-Countries. For the individual training program, 70 participated in the *On-the-job Training* and *Internship Training* programs.

Training activities	Date	Number of participants	Venue
REGULAR TRAINING PROGRAM			
• Aquaculture management	Mar 16 to 30	26	AQD
• Fish health management	May 18 to June 11	15	AQD
• Marine fish hatchery	June 16 to July xx	19	AQD
• Freshwater aquaculture	Aug 18 to Sept 11	11	AQD
• Shrimp hatchery operations	Sept 16 to Oct 15	12	AQD
• Fish nutrition	Oct 20 to Nov 25	14	AQD
SPECIAL TRAINING PROGRAM			
• Sustainable aquaculture and coastal resource management	May 21 to June 8	20	AQD[1]
• TCTP / Coastal aquaculture resource management	Aug 3 to Oct 1	27	AQD[2]
• Mangrove-friendly aquaculture and CRM	Aug 19 to 21	27	Ibajay, Aklan[3]
• Oyster-mussel culture	Sep 7 to 11	27	Roxas City and Ivisan, Capiz[4]
• Biology and culture of molluscs	Nov 16 to 28	22	AQD[5]
INDIVIDUAL TRAINING PROGRAM[6]			
• On-the-job training	whole year	53	AQD
• Internship training	whole year	17	AQD

1 In collaboration with the Technical Education and Skills Development Authority (TESDA – Region IV Bicol)
2 This is a Third Country Training Programme (TCTP) funded by Japan International Cooperation Agency
3 In collaboration with local government units
4 In collaboration with LankBank of the Philippines
5 In collaboration with DANIDA, the SEAFDEC Secretariat, and the Tropical Marine Mollusc Programme based in Thailand
6 Areas of individual training include phycology, fish health, nursery / hatchery work, seahorse and abalone laboratories, and pond studies

Attendance in AQD training courses



Participants of one of AQD's yearly courses pose with the AQD Chief and training staff

Laboratory work for Vietnamese participants of the mollusc biology and culture training

Participants from the Philippines construct a hanging raft for oysters and mussels as part of their training

AQD conducts a seminar-workshop on mangrove-friendly aquaculture

Milkfish FROM PAGE 7

the shell and go into anaerobic metabolism for extended periods to survive normal environmental fluctuations in ponds; (iii) they are intolerant of fresh water and hypersaline water, sun-drying, very high and very low pH, and very high ammonia levels; (iv) they grow fast and mature sexually at one year of age; (v) they spawn year-round, with a peak in March-September; (vi) they have high fecundity, high hatching rates, low dispersal, and high recruitment within the pond system. Thus, the pond environment becomes very conducive to snail growth and reproduction under the following conditions, which are characteristic of semi-intensive and intensive operations: (i) high fish stocking rates and feces production; (ii) overfeeding, (iii) constant brackishwater conditions, (iv) short pond preparation period and incomplete drying of the pond bottom, (v) more frequent water exchange and aeration to maintain good water quality.

An integrated management of the pond environment is required to keep the snail population at acceptable levels: (i) keep milkfish ponds at the semi-intensive level of operation; (ii) do not overfeed; (iii) if possible, let fresh water stand in snail-infested ponds for a week after harvest; (iv) always dry the pond bottom completely before starting another crop; (v) apply lime and ammonium sulfate in remaining puddles with snails; (vi) physically remove large numbers of snails and find economic uses of them, such as lime production, shellcraft, road filling, duck feeds, etc.; and (vii) avoid synthetic pesticides in aquatic food production.

Information dissemination

Information dissemination activities in 1998 continue to focus on the production of extension materials (both print and audiovisual materials), the maintenance of the AQD website, the release of news and features to the mass media (mainly newspapers), and the operation of the library.

EXTENSION MATERIALS

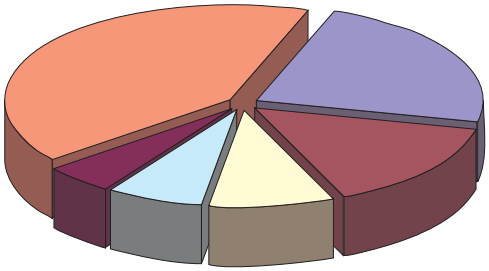
AQD produced and released the following extension materials in 1998:

- **SEAFDEC Asian Aquaculture**, six issues, with special features on:

Vol. XIX	No. 6	Integrated farming
Vol. XX	No. 1	Seaweed culture
	No. 2	Tilapia culture
	No. 3	Sustainable aquaculture
	No. 4	Mussel and oyster culture
	No. 5	Pen and cage culture

  This newsletter has a circulation of 2,500 copies

Newsletter readership



General public	1,039
Extensionists	564
Academe	370
Private sector	230
Researchers	179
Policymakers	118

- **Grouper culture in brackishwater ponds**, a manual based on AQD's technology verification efforts, written by Dan Baliao et al
- **Seabass hatchery operations**, an update of the manual first published in 1992, written by MM Parazo et al
- **Biology and culture of siganids**, an update of the monograph by MN Duray
- **Milkfish broodstock and hatchery production**, a flyer on AQD's milkfish technologies
- **Conserving our mangrove resources**, a video program
- **Mussel and oyster culture**, a video program
- **Grouper culture in brackishwater ponds**, a video program

AQD also released the following institutional reports and promotional materials:

- **1997 Highlights**, a summary of AQD's 1997 activities
- **1996-1997 AQD Report**, the detailed accomplishments of AQD for the period covered
- **Publications & video catalogue**, a list of available titles for sale
- **Press kit folder**, for visitors and guests

AQD IN THE MASS MEDIA AND THE INTERNET

AQD appeared in 103 stories in daily newspapers and TV-radio networks in the Philippines, and in specialized publications published in Southeast Asia in 1998. These news and features include stories about metaldehyde research, milkfish hatchery technology, AQD's 25 years of R&D, among others. The number of stories about AQD in the mass media has gradually increased since 1996 (26 stories) and 1997 (70 stories).

AQD also contributes stories regularly to the SEAFDEC *Newsletter*, the publication of the SEAFDEC Secretariat based in Thailand. AQD arranged media tours to its main station, and to the farms of its cooperators.

AQD's website in the internet (www.seafdec.org.ph) was visited by 2,003 browsers, a four-fold increase of browsers that logged on during the first six months of the website's construction (July – December 1997). AQD also contributes news articles and features to the SEAFDEC website (www.seafdec.org) maintained by the SEAFDEC Secretariat.

AQD LIBRARY AND DATABANK SERVICES

AQD added more than 500 materials to its collection in 1998, bringing the total library collection to over 30,000 monographic volumes, pamphlets, SEAFDEC publications, and journal volumes. Inputting of these collections to databases for easy searching and access is ongoing. The Library, reputed to have the most extensive aquaculture collection in Southeast Asia, served about 7 readers per hour in 1998, and about 60 requests for information from 18 countries. The AQD Library has over 500 gifts and exchanges agreements with agriculture / fisheries libraries and institutions worldwide.

AQD publishes an aquaculture newsletter six times a year

Extension materials and institutional reports produced in 1998

AQD is a favorite field trip destination of high school and college students interested in aquatic biology. AQD has around 10,000 visitors each year

Senator Sergio Osmena III who heads the Senate's agriculture committee visited AQD in November

Infrastructure and facilities

- The **Integrated Fish Broodstock and Hatchery Demonstration Complex** was completed and inaugurated on July 9, in time for AQD's anniversary celebration (see also special section on the silver anniversary)
- AQD acquired a 16-hectare brackishwater farm in Punta Pulao, north of Iloilo City. The facility – now known as the **Dumangas Brackishwater Station** – was donated by the Department of Agriculture on October 27.
- The **Abalone Hatchery** was also completed.

Integrated Fish Broodstock and Hatchery Demonstration Complex

AQD acquired 16 hectares of brackishwater ponds in October. The ponds are in Punta Pulao, Dumangas, north of Iloilo City

Cesar Drilon, DA Undersecretary for Fisheries and Legislative Affairs and SEAFDEC Council Director for the Philippines, hands over the facsimile of the Punta Pulao land title to AQD Chief Dr. Platon

The complex has broodstock tanks, 'catchment canals' for easy harvest of fry, larval food tanks, water filters, waste treatment tanks, and other live support facilities

Administration

AQD's top management include: Rolando R. Platon, PhD, Chief; Yasuho Tadokoro, AQD Deputy Chief; Clarissa L. Marte, PhD, Research Division Head; Renato F. Agbayani, Training and Information Division Head; Dan D. Baliao, Administration Division Head and also concurrent Finance Division Head.

As of 31 December 1998 the permanent staff of AQD totalled 312 with 143 in Research, 32 in Training and Information, 96 in Administration, 21 in Finance, and 18 in the Office of the Chief.

The new organization structure and staffing pattern of AQD was duly approved by the SEAFDEC Council at its 30th Meeting in Brunei Darussalam on March 17-21. This was implemented in April. Among the significant changes are (1) the creation of a section on Technology Verification and Extension under the Training and Information Division or TID; (2) consolidation of the various units that handle information dissemination into one section now called Information Services Section under TID; and (3) phasing out, renaming, transferring, or expanding the functions of various units and offices especially under the Administration Division.

Rolando Platon, PhD

Yasuho Tadokoro

Clarissa Marte, PhD

Renato Agbayani

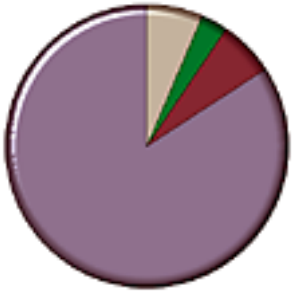
Dan Baliao

Finance

The contribution, grants and other income received by AQD from January 1- December 31, 1998, are as follows:

Contributions	In Peso	In US Dollar
Philippine Government	198,250,999	5,064,529
Government of Japan	12,094,096	281,249
	210,345,095	5,345,778
Grants		
JICA	2,136,467	54,578
Bio Integrated Technology	2,169,322	51,043
DA/BFAR	1,200,000	30,655
Aarhus University	837,861	19,949
University of Hohenheim	161,663	4,089
ACIAR	161,221	4,017
TESDA	114,395	2,922
ICLARM	101,800	2,583
Hamlet Protein	43,342	1,099
	6,926,071	170,936
Other Income	10,367,508	264,849
Total	**227,638,674**	**5,781,562**

Contribution, grants and other income

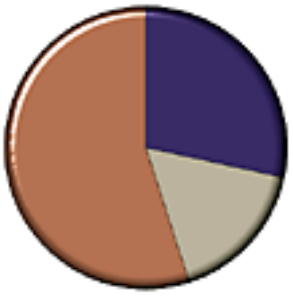


Grants

SUMMARY OF EXPENSES

By classification	Amount In Peso	Equivalent in US Dollar
Personnel services	115,324,838	2,946,094
Operating cost	55,444,757	1,416,394
	170,769,595	4,362,488
Capital outlay	33,645,015	859,497
Total	**204,414,610**	**5,221,985**

By classification



By function		
Research	77,137,251	1,970,552
Training and Information	28,630,833	731,405
Administration	46,455,233	1,186,748
Finance	9,384,934	239,748
Management Group	9,161,345	234,036
Total	**170,769,595** *	**4,362,488**

By function

*Unaudited

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

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

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

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

SEAFDEC/AQD is mandated to:

- promote and undertake aquaculture research that is relevant and appropriate for the region
- develop human resources for the region
- disseminate and exchange information on aquaculture

Tigbauan Main Station

Igang Marine Substation

Binangonan Freshwater Station

Dumangas Brackishwater Facility

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seafdec.html

SEAFDEC/AQD celebrates 25 years of aquaculture research and development

The Aquaculture Department (AQD) of SEAFDEC celebrated its silver anniversary with week-long activities that culminated on July 9, 1998. AQD has much to celebrate, 25 years of research and technology development that made significant impacts to the aquaculture industry in Southeast Asia.

SOLIDARITY *The Chiefs of the different SEAFDEC departments in Thailand (Mr. Udom Bhatiyasevi), Philippines (Dr. Rolando Platon), Malaysia (Mr. Ismail Taufid Bin Md. Yusoff) and Singapore (Mr. Tan Sen Min); and Mrs. Elizabeth Platon open the anniversary week by releasing festive balloons*

m e s s a g e s

Dr. William Dar, Secretary of the Department of Agriculture, reaffirms the Philippine government's support to SEAFDEC and lauds AQD's accomplishments particularly the breakthroughs in milkfish and giant tiger shrimp breeding and hatchery

Mr. Udom Bhatiyasevi, Secretary-General of SEAFDEC, commends the extraordinary dedication and cooperation among AQD staff in developing aquaculture technologies that have helped fishfarmers in Southeast Asia for the past 25 years

Dr. Rolando Platon, AQD Chief, presents the milestone accomplishments in AQD's 25-year history while promising to intensify technology transfer activities and fast-track commercialization of AQD-generated technologies

Guests and AQD staff at the anniversary program

Broodstock, hatchery, and pond grow-out technology for tiger shrimp

The rapid expansion of the shrimp industry in the Philippines and in the region owes much to SEAFDEC/AQD's research on the tiger shrimp *Penaeus monodon*. Since 1973, technologies have been generated on broodstock development, hatchery operations and management, and pond grow-out culture.

In 1975, the life cycle of *P. monodon* was first completed in captivity using eyestalk ablation. Larval supply of the SEAFDEC/AQD large-tank hatchery has evolved from total dependence on wild spawners (1975-1976) to the use of ablated females matured in pens (1977) and land-based tanks (1979 to the present). In 1977, SEAFDEC scales down hatchery technology from large tanks to a small-scale "barangay" hatchery system characterized by simplified production and reduction in investment which was readily adopted by the private sector. The hatchery requirement for natural food was reduced by supplementation with egg yolk in 1981 and use of a kappa-carrageenan microbound larval diet in 1990.

In 1979, hatchery-reared postlarvae were already used in pond culture. Pond production of tiger shrimp was adversely affected by chronic soft-shell syndrome.

Identification of a number of factors particularly inadequate nutrition, water pollution, and poor pond soil quality became the basis for establishing measures to prevent and control soft-shelling in 1986. A broodstock diet and a cost-effective diet for grow-out pond were formulated in 1986.

Milkfish breeding and hatchery fry production

Milkfish culture in the Philippines has recently expanded from traditional culture in brackishwater ponds and freshwater pens to marine cages and pens. Furthermore, it has evolved extensive (low stocking density, no supplemental feeding) to intensive (high stocking density with supplemental feeding) culture. Yet, the fry needed for culture still comes almost exclusively from the wild where the supply is seasonal and subject to climatic and pollution constraints.

With the ultimate goal of ensuring an adequate supply of milkfish fry to sustain its aquaculture, SEAFDEC AQD in Tigbauan, Iloilo has embarked on milkfish breeding and seed production research. In the late '70s wild milkfish breeders were successfully induced to spawn but the difficulty of obtaining milkfish breeders and the unreliable production of viable eggs saw the need to develop a stock of captive breeders (broodstock). After five years of rearing, milkfish spontaneously spawned in floating net cages in 1980 and in concrete tanks in 1990. Egg productivity of broodstock in these holding facilities were found adequate to support hatchery fry production.

With the consistent supply of eggs from captive breeders hatchery fry production technology has been verified for its biotechnical and economic feasibility. Fry from the hatcheries has been raised by several fishfarmers in Iloilo, Negros Occidental, and Guimaras provinces. Pond production using hatchery-produced fry was similar to that of wild fry.

The breeding and seed production research at SEAFDEC AQD has generated a technology that can reliably mass produce fry to meet the requirements of fishfarmers. Adoption of this technology will guarantee the sustainable growth of milkfish aquaculture in the country.

Hatchery technology for grouper

Groupers are among the highly exploited reef fishes for the live seafood market. With little potential to increase production from capture fisheries, production to satisfy the increasing demand for grouper should come from aquaculture. Grouper fingerlings for culture at present largely depend on the dwindling and erratic supply from the wild.

The successive spawning of grouper *Epinephelus coioides* in a concrete tank and in a floating net cage in 1990 paved the way for research on seed production. Thereafter, studies to determine the appropriate stocking density of the larvae, tank size and color, feeding biology, and salinity adaptation were conducted. By 1994, a workable larval rearing scheme for the intensive seed production of *E. coioides* was developed. Growth and survival of the larvae was further improved in 1996 by providing nauplii of the copepods *Acartia* sp. and/or *Pseudodiaptomus* sp. in the early feeding stages. In 1997, survival at metamorphosis was improved when complete metamorphosis was advanced to 30 days from 45-60 days with the use of thyroid hormones, tri-iodothyronine (T3) or thyroxin (T4).

Breeding and hatchery technology for catfish

Artificial propagation of catfish *Clarias macrocephalus,* a dwindling but popular freshwater food fish in the Philippines has been revived at SEAFDEC AQD since 1989. Under captive conditions, gravid female *C. macrocephalus* are injected simultaneously with 0.05 ug luteinizing hormone-releasing hormone analogue (LHRHa) on 1 ug pimozide (PIM), followed by manual stripping of the eggs 16 to 20 hours thereafter. Fewer males (ratio to females) are needed to fertilize eggs from LHRHa + PIM – injected females since short-term storage of milt was made possible with the development of an artificial seminal plasma for *C. macrocephalus* in 1997. Upon yolk resorption (4-5 days after hatching), catfish larvae are fed with *Artemia* nauplii for 3 days, and with adult *Moina* for the next 7 days. Fifteen-to 30-day old catfish larvae are then given an artificial diet of 42% crude protein at 20% of the body weight (BW), and at 5% BW thereafter.

Broodstock and hatchery technology for bighead carp

The significant achievements in culture and breeding have intensified research and development efforts in carp propagation, particularly the bighead carp *Aristichthys nobilis*. Encouraging results in the polyculture of carps, tilapia, and milkfish in pens and cages have been attained by SEAFDEC's Binangonan Freshwater Station in 1980. This led to a collaborative project with other agencies and resulted to the popularity of carp industry around Laguna de Bay. Two outstanding contributions of SEAFDEC to the seed production of bighead carp are (1) the determination of optimum water hardness for egg hatching and (2) the successful gonadal maturation and rematuration of bighead carp reared in cages in Laguna de Bay. Maturation in lake has not been documented in other places.

Bighead carp has now gained acceptance as an important food fish in the country. At present, the research activities at SEAFDEC are focused on broodstock management and genetic improvement in response to the shortage of quality seeds. There is an urgent need for a cost-effective broodstock development strategy for large scale production of bighead carp. A study on growth retardation as a tool for broodstock development and management aims at developing a sustainable and efficient technique for broodstock development and management using compensatory growth character. Initial results indicate compensatory growth in fish stunted in tanks and subsequently reared in lake cages. The project will also investigate the genetic structure of bighead carp population and correlate genetic diversity with sex ratio and number of breeders used for spawning in different hatcheries.

SEAFDEC develops a technology for mudcrab culture

A major constraint to grow-out culture of the mudcrab *Scylla serrata* is insufficient supply of "seeds" which at present is gathered from the wild. Reliable techniques for broodstock management, larval rearing in the nursery and culture in grow-out have been refined at SEAFDEC AQD since 1996. Significant progress has been achieved in all areas:

- SEAFDEC/AQD has developed a suitable holding system and broodstock diet that promote consistent maturation and spawning of good quality larvae
- Mudcrab larvae are raised to megalopa in the hatchery using a micro-particulate larval diet combined with natural food (*Brachionus plicatilis* and *Artemia* spp) or natural food alone and water management scheme that involves water conditioning and salinity manipulation
- Megalopa are successfully reared in hapa nets in nursery ponds with survival rate of 50-60% and final weights of 4-5 grams in 30 days. Growth rates of megalopa were 100 times faster in ponds than in tanks.
- Grow-out culture of mudcrabs, 5-10 grams stocked at 0.5-1.5 m², with gulaman *Gracilaria* as shelter, reached weights of 440 grams (males) and 330 grams (females) in four months with survival of 57-98%.
- The completion of the mudcrab life cycle in captivity was achieved when pond grown females spawned in the hatchery and produced crablets that themselves matured and spawned after 6 months in ponds.

Rabbitfish breeding and fry production

Although the mariculture potentials of rabbitfishes were pointed out as early as 1962, it was much later that research and farming were carried out. Among the various species of rabbitfishes, *Siganus guttatus* drew the most interest because of its faster growth and tolerance to stress due to crowding, handling and environmental changes. In 1983, SEAFDEC/AQD successfully induced to spawn wild *S. guttatus.* Hence followed the development of its larval rearing techniques. Observations in 1985 have established that males mature at an age of 10 months and females in 12 months. Year-round spawning of captive fish and mass production of fry in the hatchery was achieved in 1985 as a result of an improved broodstock diet. A broodstock diet rich in pollack or cod liver oil with about 18% fat and 42% protein resulted in the production of larvae with better survival. Larvae were successfully weaned over to artificial diet at 25 days after hatching with high survival (78-84%), thus reducing dependence on natural food. A larval diet containing 35% protein with 3832 kcal/kg energy was best for growth in early juvenile stage. Refinement of hatchery techniques continued until 1988, however, seed production on a commercial scale was never tried. With the collapse of the shrimp industry, alternative aquaculture species have been demanded by fish farmers. This rekindled interest in rabbitfish culture. At present, the hatchery phase of rabbitfish culture takes 45 days; the use of growth-promoting substances can be tried to accelerate metamorphosis and shorten the rearing phase.

Continuing research, technology verification and technology transfer

AQD continues research and technology development for the following commodities that are economically important to Southeast Asia:

Tilapia
Milkfish
Mudcrab
Giant tiger shrimp
Grouper
Mangrove red snapper
Seabass
Rabbitfish
Catfish
Carp
Seaweeds
Abalone
Ornamental marine fishes like seahorses

There have been breakthroughs in breeding, seed production, culture systems, feed development and fish health management. Technology verification and technology transfer through training/information dissemination go hand-in-hand with these research activities.

AQD has also completed an 8-year community-based fishery resources management (CFRM) project in Malalison Island off Antique in west central Philippines. The "social technology" from this project is being applied in other sites.

SEAFDEC inaugurates a new facility and launches milkfish hatchery program

AQD opened its newest facility – the Integrated Fish Broodstock and Hatchery Pilot Demonstration Complex – and launched the Milkfish Cooperators' Program on July 9, 1998 with DA Secretary William Dar as Guest-of-Honor.

The integrated complex has (1) two units of fish broodstock tanks of size 10 x 25 x 2 meters deep; (2) two units of rectangular larval rearing tanks that can hold 10 tons of water for semi-intensive culture of fish larvae; (3) four units circular larval rearing tanks of 20-ton capacity for intensive culture of fish larvae; (4) four units of natural food production tanks, 20-ton capacity, for the culture of rotifers and *Brachionus;* and (5) two units of 40-ton algal tanks. It has support systems such as recirculating seawater system, continuous aeration, filter reservoir, settling / sedimentation tanks, and a small office.

The complex is meant to showcase AQD's fish breeding and hatchery technologies, and demonstrate to fishfarmers and entrepreneurs the commercial viability of such technologies.

The milkfish pond cooperators' program on the other hand is intended to encourage milkfish farmers to use hatchery-reared instead of wild fry. The cooperators are given up to 100,000 hatchery-reared fry for free with the agreement that AQD can monitor pond production and other data.

From left: Dr. Anicia Hurtado, Dr. Arnil Emata, Dr. Platon, Mr. Udom of SEAFDEC; Dr. Meryl Williams of ICLARM; Dr. Dar; Mr. Dennis Araullo of BFAR; Dr. Clarissa Marte of SEAFDEC; Felix Gonzales of CFAR; and David Gorres of Red Foundation

A cooperator from Iloilo is ceremonially given hatchery-reared milkfish fry

Towards environment-friendly Filipino citizens

SEAFDEC/AQD plans to build a theme park to be called FishWorld in an effort to help upgrade environment education. The theme park will feature a large permanent ecosystems exhibit that will show the interrelationships and interdependence of land and water ecosystems – the oceans, coral reefs, seagrass beds, mangroves, estuaries, rivers, lakes, mountains, forests – together with human communities, fishponds, agriculture farms, and factories.

Visitors to FishWorld will walk through these ecosystems and learn about the interconnectedness of all life and all natural and man-made systems.

FishWorld will be constructed by AQD with a seed fund of P2 million, but will later be maintained as a public facility supported by contributions and admission fees. The cornerstone laying ceremony was held on July 9.

A lecture, a book launching, and awards for loyal employees

Dean Domiciano K. Villaluz Memorial Lecture

This year's speaker was Dr. Meryl Williams, Director-General of ICLARM, who discussed "Aquaculture: the last frontier for sustainable food security?" She noted that fish has become a political commodity, thanks to its increasing scarcity and its high value. Aquaculture offers opportunities as the last frontier for sustaining the contribution of fish to food security.

Authors sign complimentary book copies

SEAFDEC/AQD booklaunched the first of its manuals resulting from the Technology Verification Project (TVP) that was launched in mid-1996. The manual is entitled "Grouper culture in brackishwater ponds." TVP facilitated the change in AQD's thrusts, giving more focus on technology transfer and commercialization.

Two other books – seabass hatchery and biology/culture of siganids – were also reintroduced after they were updated.

Authors Dan Baliao (for the grouper manual) and Luis Ma. Garcia (for the seabass hatchery) signed complimentary copies for AQD's anniversary guests.

A silver jubilarian and 26 loyalty awardees

SEAFDEC/AQD honored its employees who had stayed for more than 20 years. Mr. Gregorio Genzola is the lone jubilarian while 26 other employees received loyalty rings for 20 years of service.

Certificates were also given to award-winning researchers and to new appointees.

SEAFDEC/AQD Deputy Chief Yasuho Tadokoro and Dr. Platon look on as Mr. Udom hands over a plaque of appreciation to a representative of the late Arturo Tanco during the testimonial dinner in honor of the AQD collaborators

Our heartfelt appreciation to the following collaborators to whom we owe our first 25 years of accomplishments:

Felix Gonzales
Japan International Cooperation Agency
Government of New Zealand
International Development Research Centre (IDRC) of Canada
Dean Domiciano Villaluz (posthumous)
Dr. Quiterio Miravite (posthumous)
Mindanao State University
University of the Philippines – Brackishwater Aquaculture Center
Municipality of Tigbauan
Ricardo Ealdama Jr (posthumous)
Arturo Tanco (posthumous)
West Visayas Federation of Fish Producers

SEAFDEC/AQD for a sustainable future

Toasting AQD's next 25 years (from left):

Dr. Shiro Konagaya, *SEAFDEC/MFRD Deputy Chief;*

Damrong Silpachai, *SEAFDEC Secretariat's Program and Policy Coordinator;*

Dr. Rolando Platon, *SEAFDEC/AQD Chief;*

Ismail Taufid Bin Md. Yusoff, *SEAFDEC/MFRDMD Chief;*

Tan Sen Min, *SEAFDEC MFRD Chief; and*

Masao Shimomura, *SEAFDEC Deputy Secretary-General*