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Advances in aquaculture research and development

BIENNIAL REPORT 1998 AND 1999



Aquaculture Department
SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER
TIGBAUAN, ILOILO, PHILIPPINES

The Southeast Asian Fisheries Development Center (SEAFDEC) is a regional treaty organization established in 1967. It aims to promote fisheries development in the region. Its member countries are Japan, Brunei Darussalam, Malaysia, the Philippines, Singapore, Thailand, the Union of Myanmar, Vietnam, and Indonesia.

SEAFDEC is headed by a Secretary-General. The SEAFDEC Secretariat is based in Bangkok, Thailand. A Council of Directors composed of representatives from the member countries serves as SEAFDEC's policymaking body.

The Aquaculture Department (AQD), based in Tigbauan, Iloilo, Philippines, is one of four departments established that constitute SEAFDEC. The other departments are the Training Department in Samut Prakan, Thailand; the Marine Fisheries Research Department in Singapore; and the Marine Fishery Resources Development and Management Department in Kuala Terengganu, Malaysia.

SEAFDEC/AQD is mandated to promote and undertake aquaculture research relevant and appropriate to the region, develop human resources for the region, and disseminate and exchange information on aquaculture.

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October 2000

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To our valued stakeholders:

The Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC/AQD) left the old millennium and entered the new with major strides in its research and development (R&D) activities in the region.

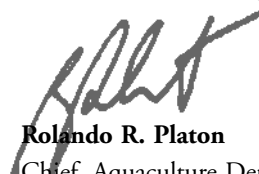
In 1998 and 1999, we continued to address four critical areas of concern: poverty alleviation, food security, environment-friendly technology, and export/cash crops.

In this regard, we take great pride in reporting to you that our researchers and scientists actively contributed to scaling more heights in technology development, training, and information dissemination activities. Our major achievements for the period include greater efforts in:

- Cloning of the growth hormone in rabbitfish and milkfish
- Bringing back the native Asian catfish to Philippine waters
- Developing a crablet mass production technology for mudcrab aquaculture
- Taking a closer look at probiotics and bioaugmentation products used in shrimp culture
- Developing a blueprint for sustainable aquaculture activities in mangrove areas
- Refining broodstock and hatchery techniques for abalone culture

- Developing a practical milkfish broodstock handling and transport technique
- Completion of the life cycle of the red snapper and ornamental seahorse in captivity
- Discovering toxin-producing algal populations in Laguna de Bay
- Refining social technologies in coastal resources management
- Studying cheaper substitutes for larval feed
- Formulating appropriate fish diets
- Developing a farmer-oriented screening procedure for tilapia broodstock
- Opening more doors for verifying and demonstrating aquaculture technologies
- Fine-tuning our training courses to serve current needs
- Initiating a college textbook production program

We wish to express our greatest appreciation and thanks to all our stakeholders and collaborators for their valuable support to our programs.



Rolando R. Platon

Chief, Aquaculture Department
SEAFDEC

We have cloned the hormone that controls growth in rabbitfish and milkfish: a breakthrough in aquaculture biotechnology



The aquaculture industry is bound to benefit from a recent breakthrough in biotechnology research. The growth hormone or GH, of rabbitfish and milkfish, the hormone that controls growth, has been cloned and may now be produced using recombinant DNA technology, according to Drs. Felix Ayson and Evelyn Grace de Jesus, SEAFDEC/AQD researchers.

Dr. de Jesus explains: “In our studies, we isolated the growth hormone from the pituitary gland of rabbitfish, purified it, and tested its growth-promoting activity in rabbitfish fry. When given as weekly injections, GH significantly increased body weight and length of fish. This means that with growth hormone supplementation, the normal culture period to reach marketable size could be shortened.”

The SEAFDEC/AQD researchers report that the yield

of GH after the purification process was low, only one milligram from one gram of pituitary glands. They cloned the cDNAs for both rabbitfish and milkfish GH and will now be able to produce these using recombinant DNA technology.

Our research’s relevance to the aquaculture industry

“This development has a strong impact on the aquaculture industry,” de Jesus points out. She says that since this technology promises shorter time for fish to attain harvestable size, the implications are attractive for both governments and the private sector in enhancing current efforts to achieve greater food security through aquaculture.

Drs. Ayson and de Jesus however stress that, while their studies show significant increases in the fish body weight, they need to run more tests to determine how much of the fish growth period is shortened with the use of the growth hormone.

Meanwhile, Dr. Ayson explains, “Our next challenge is finding the best way of getting the hormone inside the fish body system. Something that can be fed is obviously better than injection considering the large number of fish involved.”

Dr. de Jesus believes that this technology will most likely affect the development of fish diets that incorporate the fish’s own growth hormone. Scientists in Japan and Israel have used formulated feeds “enriched” with fish GHs with promising results.

While the use of growth hormone can significantly speed up the slow growth of rabbitfish and milkfish as observed in aquaculture ponds, Dr. de Jesus cautions that there is a need to further study the conditions that cause slow fish growth. For example, it is highly probable that, without a good knowledge of the fishpond conditions, fish fed with GH-fortified feeds may not grow as fast as expected. This could mean more expenses for feeds.

Our cDNA sequence is getting patented

“We are applying for patent for the cloned cDNA sequence. Such patents are usually held by big corporations. While we encourage users of this technology, we ought to have some protection. On our part, we want to protect the work of SEAFDEC/AQD scientists and our research institution itself. At the same time, we want some assurance that with these patents, our technologies are accessible to more people, especially the small fish farmers. This way, more people will benefit in the long term,” Dr. de Jesus concludes.



Dr. Evelyn Grace de Jesus (left) and Felix Ayson (below), SEAFDEC/AQD researchers: “SEAFDEC/AQD’s successful cloning of the growth hormone in rabbitfish and milkfish bodes well for the aquaculture industry.”

We are helping bring back the long lost Asian native catfish to Philippine waters



SEAFDEC/AQD has developed a technology for the mass production of Asian catfish (*Clarias macrocephalus*) that may possibly revive the native catfish industry in the Philippines. At present, the prevailing catfish industry is producing the introduced African catfish (*C. gariepinus*).

According to Dr. Josefa Tan-Fermin, SEAFDEC/AQD scientist, producing the seed is the major constraint in artificial propagation of catfish since they do not spawn under culture conditions. Artificial propagation involves hormone injection of females and sacrifice of males.

In their natural habitat, catfish spawn at the onset of the rainy season. In captive conditions, catfish attain sexual maturity but do not release egg and sperm spontaneously. Release of eggs is possible only by injecting various hormones to gravid females.

Data from Dr. Tan-Fermin’s studies show that the best time to strip the eggs is 16-20 hours after hormone injection. Stripped eggs are then mixed with milt, the fluid in which sperm are suspended. To get the milt, males are sacrificed and their reproductive tracts are dissected and macerated.

Dr. Tan-Fermin reports that they have developed a technique to minimize the sacrifice of male catfish. By diluting the milt with a low concentration of salt solu-

tion, milt from one male can fertilize eggs from three hormone-injected females. Previously, one male was used to fertilize eggs of one female.



SEAFDEC/AQD then continued to test the growth of hatchery-bred fry and fingerlings in tanks and ponds using different stocking densities and formulated diets. In some experiments, SEAFDEC/AQD engaged local fish farmers as collaborators.

The SEAFDEC/AQD research showed that fry were heavier and longer when grown in ponds than in tanks, and when reared at a stocking density of 200 fry per square meter than at 400-1,200 fry per square meter.

Catfish fingerlings were also bigger when fed SEAFDEC/AQD-formulated diet than those given with commercial diets or a combination of blanched chicken entrails and rice bran. When given as a supplemental feed, the formulated diet should contain at least 34% crude protein (CP). However, in the absence of natural food when fingerlings are grown in tanks or under intensive culture, catfish juveniles should be given feed containing 40% CP.

Spillover to technology users

News of SEAFDEC/AQD's production of native catfish fry and fingerlings through its induced spawning technology has spread to catfish enthusiasts.

"We received many requests for fry and fingerlings from all over the country. We may say that there now exists a great demand for the native catfish," Dr. Tan-Fermin reports.



SEAFDEC/AQD scientist Dr. Tan-Fermin: "A great demand for the native catfish is now felt. We need to disseminate our artificial propagation technology to encourage more people to grow this fish."

Due to this demand, SEAFDEC/AQD has created a production unit to supply fry and fingerlings to interested growers, cooperatives, hatchery operators and backyard-scale farmers.

Dr. Tan-Fermin believes that this technology should be made more available to prospective hatchery operators and culturists. She explains that SEAFDEC/AQD has moved to this direction by initially conducting a short-term training course for local government officials and technicians of the Philippines' Bureau of Fisheries and Aquatic Resources (BFAR).

The technology has also caught the attention of local government officials in Iloilo province. The Iloilo provincial government has entered into a memorandum of agreement with SEAFDEC/AQD. This agreement taps SEAFDEC/AQD for training the local government officers on catfish technology and for providing fry and fingerlings to restock the many farms and rivers in the province.



In the ceremonial stocking held at Tigum River in Maasin, Iloilo and led by SEAFDEC/AQD and Iloilo provincial officials, it was obvious that there was a silent wish among the participants amid the celebration – the native catfish would once again teem in Iloilo's waters.

We can now produce crablets for mudcrab aquaculture



A growing mudcrab aquaculture industry in the Philippines is in the offing. SEAFDEC/AQD researchers have enhanced maturation and spawning of mudcrab broodstock and have produced crablets from these broodstock.

“We were able to achieve seed production of the mudcrab *Scylla serrata* species with our initial broodstock,” says Dr. Oseni Millamena, SEAFDEC/AQD scientist, “and these matured and spawned in our laboratories as we fed them a good diet and reared them in a good maturation system. We completed the mudcrab’s life cycle in captivity. Our pond-grown broodstock spawned in the hatchery and produced crablets that matured and spawned after six months.”

Dr. Millamena reports that a sufficient supply of crablets is still a major constraint to the development of the mudcrab industry in the Philippines. She adds that in Japan, culture of the blue crab *Portunus* is a well-developed industry. She reports that in Kuching, Malaysia, the source of seeds is a natural mudcrab nursery in mangrove areas. “They have a government project in a mangrove area where their cooperators raise mudcrab in pens. They gather the crablets from ca-



*Dr. Oseni Millamena, SEAFDEC/AQD scientist:
“We can now produce crablets through technologies we have developed. Our technologies can address the urgent need for seed stock in mudcrab aquaculture.”*

nals leading toward the sea from the pens in the mangrove area. They use these seeds for pond culture of mudcrab. In addition, the cooperators are protecting their mangroves. On the other hand, the Philippines has very few remaining mangroves. That is why a technology for producing crablets to supply our aquaculturists becomes a necessity,” Dr. Millamena points out.

Our research efforts

In 1998 and 1999, much of the SEAFDEC/AQD work centered on developing and refining broodstock, hatchery, and nursery culture techniques.

Highlights of this work include the following:

1. A suitable holding system and broodstock diet that promote consistent maturation and spawning and production of good quality larvae has been developed.
2. A larval diet combined with natural food, *Brachionus plicatilis* and *Artemia* sp., and a water management scheme involving water conditioning and salinity manipulation have been developed and used to successfully grow mudcrab larvae into megalopa in the hatchery.
3. Megalopa were successfully reared in hapa nets in nursery ponds. Survival rates ranged from 50 to 60%. Average body weights of 4-5 grams were obtained in 30 days. Megalopa also grew 6-10 times faster when reared in ponds than in tanks.

Large-scale production of mudcrab juveniles

Meanwhile, SEAFDEC/AQD continues to refine its mudcrab broodstock and hatchery technology. It is currently testing the technical and economic feasibility of producing juveniles in collaboration with identified fish farmers as collaborators.

Entrepreneurs in the mudcrab hatchery business expect to benefit from the results of this study. SEAFDEC/AQD hopes to fill the gap in the demand for crablets. At present, crablets come mainly from catch from the wild.



We are taking a closer look at probiotic products for shrimp culture



Probiotics are increasingly becoming popular as a tool in preventing bacterial infection in farmed shrimp. They are commercially available, within easy reach of fish farmers for use in their farms.

Probiotics are viable monoculture or a mixed culture of complementary benign bacteria that are given with feed to inhabit the digestive tract and contribute to good health by inhibiting disease-causing microorganisms. In

the aquaculture industry, they are applied in the pond water to stimulate population growth of “friendly bacteria” and to prevent disease-causing organisms from establishing their colonies in the fish gut.

Some farmers report that they find probiotics effective. Some resort to adding more quantities of probiotics without really knowing the true effects. In addition, this practice is bound to be continued in instances where farmers see that their shrimp grow well and do not get diseases. However, how effective are these products?

“We started to look at the probiotics picture by gathering some very basic information about these products,” reports Ms. Celia Lavilla-Pitogo, SEAFDEC/AQD scientist. Ms. Lavilla-Pitogo explains that probiotics products now currently in the market are actually intended for wastewater treatment of effluents from factories, hospitals and other commercial establishments. They were in a sense, “borrowed” for use in aquaculture.

Probiotics are now widely used to artificially restore microbial diversity by augmenting the beneficial bacteria population in ponds. Because of the current monoculture systems practiced in aquaculture, bacterial diversity in ponds has narrowed down.



Ms. Lavilla-Pitogo reports that their examination of 15 commercially available probiotic products reveals a bacterial content of only 10,000 to 1 billion colony-forming units. She emphasizes that the expected efficacy of probiotics hinges on the number of viable bacterial cells at the time that the probiotics is applied in the pond. This means that the cells present in the probiotics products should be one billion or more per gram or milliliter of product to be effective.



Ms. Celia Pitogo, SEAFDEC/AQD scientist: "We need to further study the real effects of probiotics, especially on the pond ecosystem."

The probiotics products were also found to have low cell counts especially those supplied in liquid form. These liquefied products suffer loss of cell viability during transport and storage and have a shelf life of less than three months.

Ms. Lavilla-Pitogo relates: "From the professed efficacy and benefits derived, these products claim to remedy a wide range of disease and environmental problems in aquaculture."

What needs to be done?

It appears that the aquaculture probiotics trade is still unregulated. Product labels do not contain much information that can guide users.

Detecting the appropriate cell count for efficacy is not within the easy grasp of the ordinary fish farmer. Diagnostic laboratories are needed to do this. Shrimp farmers need to be informed where they can go for such service. Ms. Lavilla-Pitogo suggests that, in the Philippines, farmers can avail of this service in SEAFDEC and in the laboratories of the Bureau of Fisheries and Aquatic Resources. Or they can tap the medical diagnostic clinics to examine samples.

Ms. Lavilla-Pitogo hopes that their study can influence some changes in the probiotics market. "Policies, rules and regulations can use our scientific data to institute some quality standards for this very important aquaculture measure against diseases," she stresses.

On the other hand, a wide area is still unknown in the use of probiotics. For instance, effectiveness of the product and its high cost should be examined further. While the pond water is also wastewater, the nutrients in the pond water needed by bacteria to survive and grow are much lesser compared with wastewater from industrial or similar wastes. Thus, the probiotics now being used in aquaculture ponds cannot thrive well. So the tendency to add more quantities of probiotics in the ponds continues. And this means higher production cost for the shrimp farmer.

Ms. Lavilla-Pitogo proposes that the real effects of these probiotics on the pond's environment and ecosystem should be further studied.

We're developing a blueprint for sustainable aquaculture in mangrove areas



SEAFDEC/AQD researchers are currently investigating ways of harnessing degraded mangrove areas for aquaculture with a fresh, environment-friendly approach.

"We're actually developing a blueprint for sustainable aquaculture in both degraded and existing mangrove areas. We believe the areas can be rehabilitated or conserved by an aquaculture system that maximizes production of forest and aquatic products and integrating as

many of the varied functions of the mangrove ecosystem as possible," says Dr. Jurgenne Primavera, SEAFDEC/AQD scientist.

According to Dr. Primavera, SEAFDEC/AQD's mangrove-friendly aquaculture project is gathering relevant information on the mangrove ecosystem that can guide planners and aquaculturists. She explains that this information will be much needed as the aquaculture industry moves farther into the intensive culture systems for

milkfish, shrimp, and other aquatic animals.

“We are addressing two levels of aquaculture: the intensive system which requires a high capital investment and the extensive system which is suitable at the village level. In the high stocking density, intensive system, we are investigating the capacity of mangroves as filters of effluents. In the low stocking density, extensive system, we are studying the profitability and acceptability of using ponds and pens inside mangrove areas for aquaculture,” Dr. Primavera emphasizes.

An initial study focused on mangroves as filters for pond effluents, potential pollutants of receiving waters. SEAFDEC/AQD researchers evaluated the capacity of mangrove stands to absorb dissolved nutrients from a monoculture shrimp pond.

The researchers drained water from the shrimp pond through an impounded mangrove that was alternately stocked with tilapia and milkfish as side crops.

In one trial, the shrimp pond had higher levels of temperature, salinity, and nutrient concentration than the mangrove pond. Earlier, *Rhizophora* seedlings were planted inside and outside the mangrove pond. Those planted outside the pond served as the control of the study. They found that these newly planted mangrove seedlings grew vigorously inside the mangrove

In the SEAFDEC/AQD mangrove-friendly aquaculture project (below), fisherfolks engage in mudcrab culture to supplement their livelihood. They conserve their mangroves by not cutting down the trees when they construct the pens and ponds inside existing mangrove areas.



pond where the pond effluents were drained to, as compared to the seedlings outside the mangrove pond. They concluded that the nutrients in the effluent account for the higher growth rates.

The researchers noted that impounding of the mangrove area caused flooding of the roots of *Avicennia* and *Sonneratia* mangroves. They observed that *Rhizophora* is a mangrove tree species that can be integrated with shrimp ponds as it is not susceptible to flooding because of its elevated root system. However, they felt that more studies need to be done in fully understanding the integrated function of the mangrove ecosystem for aquaculture ventures.

Meanwhile, SEAFDEC/AQD is implementing a mangrove-friendly project in cooperation with local government officials in Ibabay, Aklan province in the Philippines.

The project aims to develop mangrove-friendly aquaculture technologies as a response to the call for conserving the country's mangrove, now suffering alarming rates of loss. A survey conducted by SEAFDEC/AQD last year



Dr. Jurgenne Primavera, SEAFDEC/AQD scientist: “Our research generates important information that can be used to develop a blueprint for sustainable and mangrove-friendly aquaculture.”

found that the overall state of coastal resources in the project area is in immediate need to be preserved and conserved, an important aspect of which is the recognition to address the conversion of mangroves for aquaculture beyond allowable limits.

The project provides opportunity for local fisherfolk to supplement their livelihood with mudcrab raising. In the project, mudcrab pens and ponds were constructed inside mangrove areas without cutting down mangrove trees, thus integrating a livelihood venture with the existing mangrove ecosystem.

The project has a 1,400-square meter pond constructed in an old *Avicennia* mangrove area. Natural depressions were deepened into canals with water and stocked with mudcrab. Young mudcrabs were stocked at

one crablet per two square meters. They were fed trash fish and golden apple snail mixed with rice bran, and harvested selectively. Production was 76 kilos of crabs for the first crop.

In the 300-square meter mudcrab pens made of slatted bamboos, crablets were stocked at 1-4 pieces per square meter. They were fed either trash fish or golden apple snail. A projected production is 2,425-13,600 kilograms per hectare per year. This means approximately US\$1,375 profit from a 4,000 square meter pen, a 60% return on investment (ROI), and 1.4-year payback period.

According to SEAFDEC/AQD researchers, the system of growing mudcrab in pens and ponds in the mangrove area, like any new farming technology, is yet to be refined. Certain issues need to be resolved. For instance, use of trash fish for feed deprives low-income people of accessible, cheap food. Thus, nutrition researchers are formulating low-cost moist pellets.

Further, construction of mangrove ponds and pens needs greater care to avoid damage to roots of mature mangrove (*Avicennia*, *Sonneratia*) unlike in the usual open water ponds where all vegetation is cleared.

We are refining abalone broodstock and hatchery technology



SEAFDEC/AQD researchers have successfully spawned the abalone (*Haliotis asinina*) in captivity, and have grown the hatchlings into broodstock in 12 months. This species is dubbed as the “cocktail abalone” because of its small size (maximum shell length at 10-11 centimeters). An Australian scientist called it “the fastest growing abalone in the world” since a marketable size of 5-6 centimeters can be attained within one year.

“Like other fisheries stocks, abalone suffer from heavy fishing pressure,” reports Mr. Armando Fermin, SEAFDEC/AQD scientist, “and we are refining existing breeding and hatchery techniques to produce sufficient seeds for restocking and help restore natural abalone populations. We’re also looking at the hatchery technology as a catalyst to the development of the abalone aquaculture industry in the Philippines. Our country is one of the major producers of abalone from capture fishery. In fact, the Philippine production of abalone from capture fishery is still in an upward trend, which is in contrast to other major producing countries like Australia, Japan, Mexico and New Zealand.”

Mr. Fermin relates that in Cebu in the Philippines, some processing plants are exporting canned abalone. The plants get supplies from fishers who collect abalone from nearby provinces of Samar, Negros and Surigao.

According to Mr. Fermin, abalone production from aquaculture can help alleviate the decreasing fishery catch in the world. He says that at present, Taiwan is the lead-



ing producer of abalone from aquaculture. However, Taiwan is producing another abalone species, the *Haliotis diversicolor*.

The focus of our abalone research

SEAFDEC/AQD's studies on refining broodstock and hatchery techniques are continuing to explore new research areas.

"Abalone spawn spontaneously throughout the year using only fresh seaweed (*Gracilariopsis bailinae*) as feed. In our hatchery, abalone juveniles attain sexual maturity in 8 months. From these stocks, we select the good ones for our breeding work. We also buy wild stocks from gatherers in Carles and Guimaras in Iloilo. One of the problems we are experiencing at present is the low rate of hatching and survival to postlarva or veliger stage which varies from 11-30%," Mr. Fermin recounts.

The low larval survival rate may be attributed to stress suffered by the eggs during collection and handling when eggs are transferred to other rearing facilities. The present problem may also be related to nutrition since the broodstock are fed only monospecific diet such as the seaweed.

In addressing these problem areas, SEAFDEC/AQD researchers have developed a broodstock diet (with 25% protein, 4% lipid) that can partially replace seaweed, the abalone's natural diet. Mr. Fermin adds: "Our studies show that this diet, given together with seaweed gave the highest number of spawning and egg fertilization rate. Higher amount of essential nutrients such as protein, lipid and the highly unsaturated fatty acids, e.g. 20:4 n-6, 20:5 n-3, 22:6 n-3 in the artificial diet may have been the reason for the better reproductive performance of abalone fed this diet."

Other areas that the researchers are presently looking into are improving larval settlement by artificial methods and refining techniques for grow-out culture of abalone in net cages in a nearby coastal community.

"When larvae start to settle, they exhibit a creeping behavior that characterizes their unique food grazing habit. At this time, they look for the most suitable food that are attached to the substrates where they settle," Mr. Fermin adds. The best food sources are epiphytic diatoms, preferably the groups *Navicula*, *Nitzschia*, *Cocconeis*, *Amphora*, that grow on the corrugated pvc panels as substrates through continuous inflow of sand filtered seawater. There are still other factors that control postlarval settlement, growth and survival. In our study, a 24-h pho-

toperiod and the presence of bio-films (combined diatoms and "mucus") on the artificial substrates can enhance larval settlement and metamorphosis. But these studies are still under verification in large hatchery tanks. It takes about 60 days to produce 1-cm shell length early abalone juveniles.

We have refined some nursery practices

Some nursery practices are now refined and can be recommended. According to Mr. Fermin, the smaller juveniles (5-8 mm) should be sorted and separated from the large (14-16 mm) ones before they are reared in the nursery. This is to prevent stunting the growth of the smaller ones.

In the nursery, juveniles measuring 11 millimeters and weighing less than half-a-gram can be stocked at 700 or even as high as 1500 individuals per square meter. It is also better to rear abalone juveniles in outdoor tanks as they get enough sunlight that helps enhance growth of microalgae that also serve as additional source of food aside from seaweeds. Though the survival rate is the same in both outdoor and indoor tanks, juveniles reared outdoors consumed more food, resulting in faster growth rate and shorter rearing period.

In terms of practical diet for juveniles, a diet with an optimal crude protein level at 27%, lipid at 5%, and carbohydrates at 40% supports abalone growth better than seaweed alone.



Mr. Armando Fermin, SEAFDEC/AQD scientist: "We are refining the broodstock and hatchery technology for abalone. We hope to be able to come up with a technology that will produce sufficient seed for restocking and aquaculture purposes."

Trials for grow-out culture

Mr. Fermin conducted a trial for grow-out culture of abalone in flow-thru tanks. The abalone were stocked at an average density of 68 per square meter and fed the seaweed *Gracilariopsis* ad libitum. After 9-and-a-half months, the abalone reached market size (59 mm, 55 g). The researchers found that the use of seaweed is necessary because abalone at this phase of culture did not respond well to artificial feeding unlike in the nursery phase. While a diet containing 27% crude protein promoted a higher growth rate comparable to that of seaweed, the survival was low. Abalone fed a diet with 17% crude protein had slower growth rate but had a higher survival rate.

Grow-out of hatchery-produced juveniles in floating sea cages is currently being verified in one of the islands in northern Iloilo. The use of wild seaweeds that are endemic in the area as food for the caged abalone is being tested.

Mr. Fermin concludes that in the immediate fu-

ture, SEAFDEC/AQD's research results on abalone shall be able to provide hatchery seeds for aquaculture and sea-ranching purposes. A reseeding program to enhance natural populations shall also be developed in order to provide equal livelihood opportunities for small-scale fishers.

We have developed a better technique for handling and transporting milkfish broodstock and, soon, for seahorses and mudcrab



SEAFDEC/AQD researchers have developed a procedure for handling and transporting large milkfish broodstock that promises ease of operation and minimizes unnecessary injuries and death to fish.

Dr. Arnil Emata, SEAFDEC/AQD scientist, reveals that transport of live fish is commonly practiced, especially in the market for live fish as food.

The case of milkfish broodstock is however entirely different because fish need to be kept alive during and after handling and transport. Indeed, other workers have attempted this, although experimental evidence to support the effectiveness of such methods are lacking and at best anecdotal. In the mid-1970s, wild milkfish adults at SEAFDEC/AQD transported in canvas tanks installed in a wooden frame atop a truck also resulted in heavy mortalities.



The present procedure now followed at SEAFDEC/AQD was derived from the experimental work led by scientist Dr. Luis Maria Garcia starting in 1996. Fasted for a day, broodstock having sizes between 1 and 11 kg were loaded at various densities (40-60 kg/m³) in sealed oxygenated plastic bags or open canvas tanks containing chilled seawater (20-25 °C). Cool seawater was maintained during handling of fish and over 4-10 h transport by adding ice chunks or frozen gel packs. A pair of sealed plastic bags was each placed one atop each other in a reinforced styrofoam box. Fish remained calm when immersed in



chilled seawater, precluding the need for anaesthetic to immobilize fish. After transport, fish were allowed to fully recover in fresh seawater before transferring them to a rearing tank. Survival rates of up to 100% until a month after handling and transport in chilled seawater were not significantly different among groups of fish transported at various loading densities. In fact, spawnings were observed two weeks after sexually mature milkfish were handled and transported in these conditions, indicating that fish have overcome the physiological stress of handling and transport.

Recently, Dr. Emata verified this experimental procedure when 100 milkfish broodstock (4-13 year old, 2-7 kg each) were transported over 8 h, that is 2 h by boat and 6 h over land, without a single loss. Fish were starved 2-3 days before transport, but unlike the experimental protocol developed by Dr. Garcia, fish were immediately placed and handled in chilled seawater with a mild seda-



Dr. Arnil Emata and Dr. Luis Ma. Garcia:
 “Our studies led us to develop an efficient handling
 and transport technique for milkfish broodstock.”

tive. Sedation with 0.125 ml of 2-phenoxyethanol per liter seawater was maintained throughout transport. This slightly modified protocol was again applied with success when SEAFDEC/AQD assisted Alson Finfish Hatchery Incorporated, the country’s largest commercial milkfish hatchery, transport more than 200 broodstock from a sea

cage to a spawning pond 4 h away. Only two milkfish perished in the operation.

Although a cost and benefit analysis remains to be done, the milkfish industry stands to benefit from the handling and transport protocol developed by SEAFDEC/AQD. It opens a market for milkfish broodstock where entrepreneurs may simply purchase existing stocks elsewhere and transport these by air, sea, or land to their breeding and hatchery facilities. The technique may also be adopted when handling and transporting other large and excitable fishes.

The development of transport protocols for other cultured species have also been started in anticipation of transporting bulk quantities of hatchery seed to the farm. Two age groups of the seahorse *Hippocampus kuda* (12-15 day and 35-69 day old stocks) had survival rates of 90-100% after 48 h of simulated transport. Likewise, mudcrab zoea survived best at a loading density of 10,000 per liter compared with higher densities.

We have completed the life cycle of the red snapper and seahorse in captivity



The red snapper (*Lutjanus argentimaculatus*) and two species of seahorses (*Hippocampus kuda* and *H. barbouri*) are the latest additions to SEAFDEC/AQD’s roster of fish and shellfish whose life cycle has been completed in captivity.

A breeding program for the red snapper began in 1993 with the acquisition of wild stocks and rearing them in tanks. A year later, these stocks were hormonally manipulated to spawn, resulting in seeds that have also become sexually mature and spawned in 1999. These broodstock have produced sufficient volumes of eggs to support larviculture studies.

Meanwhile, a breeding program on marine ornamental fishes began in 1996. Seahorses were chosen for



this program in response to calls for its global conservation because of the increasing negative impacts of the seahorse trade on wild populations. So far, research has produced broodstock from hatchery seeds of these two species of seahorses, and second and third generation offspring for *H. barbouri* and *H. kuda*, respectively. Current research in progress includes manipulation of broodstock diets, stock density and feeding of young seahorses.

We've found that a strain of a Laguna Lake algae produces toxins that may cause fish kills



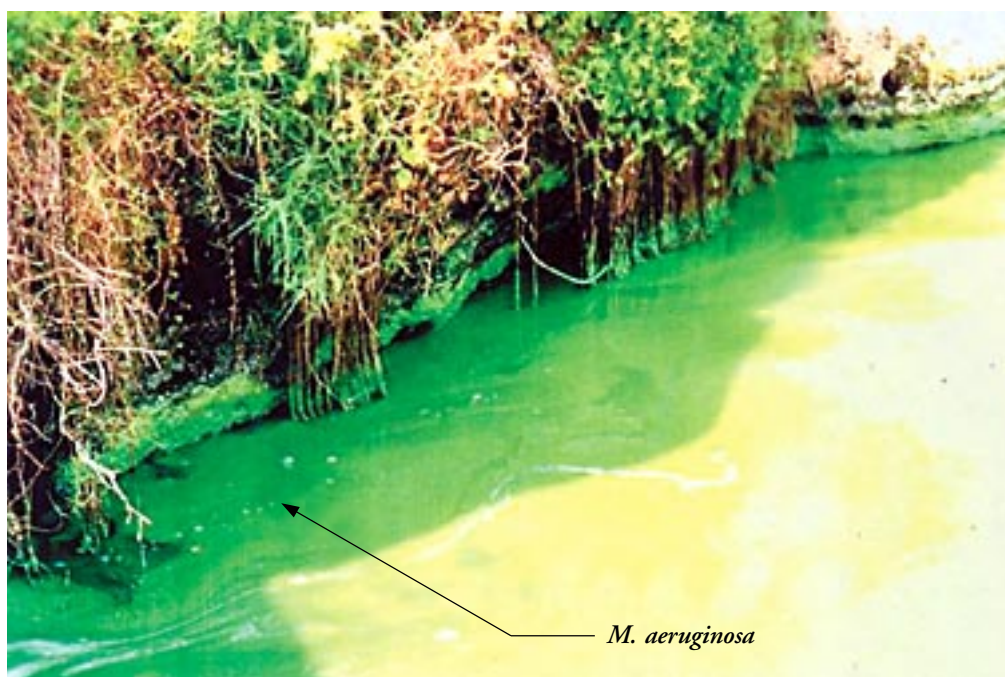
SEAFDEC/AQD scientists have determined the toxin concentration in populations of the blue-green algae *Microcystis aeruginosa*, a predominant algae found in Laguna de Bay, the Philippines' largest freshwater lake. The more than 90,000-hectare lake adjoins several towns in two provinces, Laguna and Rizal. It is a major source of livelihood for capture fishery and aquaculture with tilapia, milkfish and bighead carp as the dominant species. It is also used for navigation, agriculture irrigation, and is being eyed as a source of domestic water for Manila and surrounding areas.

"We're conducting a series of experiments in studying this toxin-producing algae as one of the possible causes of fish kills in the lake," say SEAFDEC/AQD researchers Dr. Susan Baldia and Ms. Malou Aralar.

The researchers claim that their initial tests on mice verified the toxic activity of the toxin extracted from *M. aeruginosa*. Their results showed that mice injected with a 10 and 15% dilution of the crude toxin extract died within 30-45 minutes after injection.

Ms. Aralar and Dr. Baldia report that fish kills in Laguna de Bay have been recorded and reports have pointed to the algal blooms as the cause. They say that Laguna de Bay experiences periodic algal blooms when it undergoes a high nutrient buildup brought in by effluents from its watershed, which drains water from agricultural, residential and industrial areas. The fish kills have been observed to coincide with these periodic algal blooms. The blooms, which may last for three months, usually occur between July and September but there have been occasions where they occur during other months.

The algal blooms have been generally perceived by fishers and residents in the lake area as responsible for the off-flavor, mud-like taste of the fish caught or cultured in pens in the lake. At this time, people refrain from



M. aeruginosa

eating the fish and produce from the lake are usually lower-priced than during normal times.

According to researchers, algal blooms have been observed to occur when lake water is clear and placid. This is brought about by the relatively calm condition of the lake and weak wind transport. It has been a general observation that water in the lake clears after saltwater enters. Saltwater flows into the lake through the nearby Pasig River. This river empties into Manila Bay. When the level of the lake water is lower than that of the Pasig River, saltwater intrusion into the lake happens. However, not all saltwater intrusion occurrence can lead to algal blooms. For example, in 1997 there was saltwater intrusion but there was no bloom of *Microcystis*. Blooms also occur when the water temperature in the lake ranged from 29-34°C.

Ms. Aralar explains that *M. aeruginosa* has been documented as a toxin-producing algae especially in temperate countries. She adds that in these countries, studies on



*SEAFDEC/AQD researchers Baldia (top) and Aralar: “We have identified populations of the toxin-producing algae *M. aeruginosa* in the Laguna de Bay. We’ll continue studies on the relationship of periodic blooms of this algae to fish kills in the lake and determine other factors such as lake conditions that may contribute to fish kills.”*

the toxic effects of ingesting toxin from this algae have been done on salmon and trout. The toxins affected the liver and the pancreas of these fishes. “There is an increasing number of studies reporting on the occurrence of the toxin in *Microcystis*. There are also scientific reports from temperate countries indicating that massive

fish deaths can be traced to ingestion of this toxic blue-green algae,” Ms. Aralar points out.

The SEAFDEC/AQD researchers further reveal that there had been reports from other countries that humans have died from use of water where the blue-green algae had been observed to thrive in. “We have also heard that our people drink the lake water with no side effects as they dilute the drinking water. However, we do not know the rate of dilution. While our primary concern is the effect of the toxin on fish kills and the related health hazards attendant to consumption of contaminated aquatic products, our research also generates data that can be useful for other uses of the lake. In the light of the plans to tap Laguna de Bay for domestic water, we feel that we should be armed with more scientific data about this *M. aeruginosa*,” the researchers conclude.

Thus, SEAFDEC/AQD researchers are investigating the relationship of other conditions in the lake with the occurrence of *M. aeruginosa* algal blooms. These include studies on water temperature, turbidity and the like.

The researchers are also determining the *M. aeruginosa* growth stage at which peak production of toxins occurs. Finally, they will conduct toxicity tests on fish by incorporating the algae in its several growth stages into the water where fish is raised.

We’re refining social technologies for sustainable coastal fisheries resources management



SEAFDEC/AQD researchers started implementing a community-based coastal fishery resources management and mangrove-friendly aquaculture project in collaboration with the local governments of Ibajay municipality and its adjacent Tangalan town, in Aklan province in the Philippines. Two non-government organizations, Process Foundation and USWAG are also helping SEAFDEC/AQD in the community organizing aspect of the project.

According to Mr. Renato Agbayani, SEAFDEC/AQD scientist, sustainable coastal fisheries resources management can be largely achieved when the local government officials and their coastal communities become empowered to care for and protect their coastal resources.

“In this project, we are applying the lessons that we

learned in a previous 8-year project in Malalison Island. These lessons became our social technologies that we are verifying in Aklan. Some of the major lessons we found were that enlightened fisherfolks could be effective managers and responsible users of fishery resources. We helped achieve this by providing scientific data on their resources, holding constant community consultations for livelihood project like the seaweed project we suggested to them, and influencing them to share the cost of development projects no matter how small their contribution is,” Mr. Agbayani reveals.

Lasting effect

The Malalison experience has provided some lasting effects on an empowered community. The people of Mala-

lison were able to organize themselves to assign and protect a marine reserve in their area. This was in answer to their desire to implement a territorial use rights ordinance that they worked out and passed by the local government and village councils. In addition, this move supported a previous deployment by



Mr. Renato Agbayani:
“SEAFDEC/AQD continues to exert efforts in understanding the socio-cultural and economic dynamics of coastal communities. We feel proud to contribute to the development of knowledge in refining social technologies for sustainable coastal fisheries resources management.”

SEAFDEC/AQD researchers of concrete artificial reef habitats in the area. To date, a total ban on fishing of any kind has been successfully enforced in the reserve.

In studying the biological impact of these developments on the reef biota, researchers observe that compared with Nablug reef, the island’s popular fishing ground, the marine reserve at Gui-ob exhibited dramatic increases in number and kinds of fish since its establishment in 1997. The evidence suggests that marine reserves can enhance fish stocks that may be a possible source of replenishing reef resources in areas open to fishing.

The fishers perceived improvements in the fishery resources today than 15 years ago. Greater positive changes were perceived in equity, particularly in the control of fishery resources, fair allocation of access rights, and participation and influence in fishery management.

The Aklan Coastal Fisheries Resources Management and Mangrove Friendly Aquaculture Project

In the Aklan project, SEAFDEC/AQD started the project by undertaking a rapid resource and socio-economic appraisal of the coastal communities. Results of

SEAFDEC/AQD researchers have demonstrated that mudcrab raised in mangrove areas (Right) can be a viable and sustainable enterprise with the use of environment-friendly technologies.

this showed that these two municipalities have a contiguous coastline that stretches approximately 20 kilometers facing Sibuyan Sea. Numerous streams and two major river systems drain part of the mountain range of North Panay, emptying effluvia that enhance the productivity of nearshore waters. Two major promontories (Apga Point and Sigat Point) provide protection to coastal villages against the northeastern monsoon.

The studies reveal that these neighboring municipalities share common fishing grounds in their extensive coral reefs. The open access nature of the reef fishery in municipal waters has resulted in overfishing and conflicts in the use of reef resources have been common over the years.

Generally, the coastal villages are not aware of the importance of seagrass and seaweeds beds as vital trophic links in coastal ecosystems. It was noted that these eco-



systems were neglected as a possible source of food and income for these resource-dependent communities.

Results also showed that governed by informal use rights, some areas of primary and secondary growth of mangroves, which are located mostly in Ibajay, have been exploited over the years. Consequently, the present state of coastal resources in these municipalities is reflected in dwindling catch from municipal waters and in the continuing impoverishment of coastal villages.



Benchmark information also revealed that nearshore resources are in distress and will require concerted attention by both resource users and local governments.

Based on these studies, the project has started two livelihood projects: culture of grouper in floating netcages in one village in Tangalan and culture of mudcrab in an existing mangrove area in another village in Ibajay.

Using SEAFDEC/AQD technologies, researchers are now introducing aquaculture livelihood project using sustainable and environment-friendly methods. In the mudcrab project, the pond is built in the mangrove area without cutting the mangrove trees, thus protecting them. This

sustainable, mangrove-friendly way of mudcrab culture is making local government officials and their constituents realize its potential benefit to their community – the use of mangroves as a nursery for the crablets, the educational opportunities provided to the youth by their wise use and conservation of their mangroves, and the ecotourism opportunities present in their community.

SEAFDEC/AQD's coastal fishery resources management project demonstrated the feasibility of raising grouper in floating netcages.

We're searching for cheaper substitutes for expensive larval feed



SEAFDEC/AQD researchers are proving that there are ways of producing cheaper and more effective larval feeds than the expensive *Artemia salina* and *Brachionus plicatilis*, the most commonly used natural food in larval rearing operations in fish hatcheries.

In one study, Mr. Joebert Toledo, SEAFDEC/AQD scientist, reveals that two to three day-old grouper larvae fed with the *Acartia tsuensis* copepod nauplii at their first feeding stage grew significantly faster and showed higher survival rate compared with those fed with rotifer only. The study indicated that the *Acartia* nauplii was highly preferred by the early stage larvae and was found to have superior nutritive value than rotifers.

“We found out that smaller-sized copepod nauplii were more appropriate to feed to grouper larvae at the

early rearing stage,” Mr. Toledo adds. Mr. Toledo explains that previous studies on the larval rearing of grouper involving rotifer as a sole feed resulted in low survival rates. This was because the size and the nutritional value of the rotifer were not appropriate for larvae that are feeding for the first time.

Mr. Toledo reports that the results of their study encourage more efforts in developing techniques in mass production of the copepods. They are now conducting fertilization studies using cow dung, chicken manure, and rice bran alone or in combination with chemical fertilizers. Mr. Toledo also adds that copepods can thrive well in fishponds if food supply such as phytoplankton is abundant and other predators are controlled.

In another study, Mr. Romeo Caturao, SEAFDEC/AQD

researcher, reveals that the copepod *Pseudodiaptomus annandalie* is another potential food substitute for *Artemia*. “This copepod is poorly known compared with other species,” Mr. Caturao says, “but we find that we can mass produce this organism.”

Mr. Caturao points out that their results indicated that *P. annandalie* produces the highest number of eggs, nauplii, and copepodite when reared at water salinity of 20-27 parts per thousand (ppt) and when fed with *Chaetoceros calcitrans* maintained at 100,000 cells per milliliter. Moreover, they hatch most efficiently at lower salinities of 15-25 ppt. When *P. annandalie* were fed to milkfish larvae, growth was better than those achieved with *Artemia* and *Brachionus* as feed.

This study also established that *P. annandalie* can be produced in large quantities within a five-day period in five- to ten-ton tanks. As much as 1,900 individual/liter of *P. annandalie* can grow in the 10-ton tanks. This means that this copepod species can be easily grown and made available as food for fish larvae in the hatchery.

Mr. Caturao concludes: “With all these basic information at hand, we are now able to develop mass production techniques for this little known copepod. We intend to conduct more studies especially on the costs and returns for such venture. We know now that *Acartia* and *P. annandalie* promote better growth in milkfish than *Brachionus* and are comparable with *Artemia*. However, if the economic studies would bear us out, we may be

able to completely replace the expensive *Artemia* through this mass production technology we are developing for *P. annandalie*.”

Meanwhile, a formulated milkfish larval diet can be used to reduce feed costs in hatchery operations. SEAFDEC/AQD researcher Ilda Borlongan reports that this diet, in combination with *Brachionus*, a natural larval food, can be fed effectively to milkfish larvae when they are two to eight days old. At 15 days old, the larvae can feed solely on the formulated diet and achieve good growth and survival rate.

Ms. Borlongan explains that in milkfish hatchery operations, the principal cost of producing *Brachionus*, is the production of its own food, the live algae like *Chlorella* sp. This mass production process is quite tedious, impractical and costly. Also, hatchery operators find extreme difficulty in producing the alga as they need bigger tank facilities to grow it.

“The limited success in completely replacing *Brachionus* with artificial diets is believed to be due to reduced digestive capacity of larvae at the onset of exogenous feeding. So we searched for a way where we can alleviate the situation,” Ms. Borlongan reveals.

“We modified a formulated larval diet by incorporating the needed enzymes. In another approach, we intend to use hydrolyzed ingredients like fish concentrates instead of enzymes to see if we can completely reduce dependence on natural foods costs,” Ms. Borlongan adds.



SEAFDEC/AQD researchers (left to right) Toledo, Borlongan and Caturao: “Our studies are paving the way for finding alternative ways to develop larval feed that can substitute for or replace the expensive *Artemia* and *Brachionus*.”

We're helping develop formulated diets for sustainable aquaculture



SEAFDEC/AQD researchers are breaking new grounds in developing cost-effective and environment-friendly aquaculture feeds.

Ms. Myrna Teruel, SEAFDEC/AQD scientist, says that their thrust in feed development continues to concentrate on refining practical feeds for cultured species through studies on digestibility of alternative feed ingredients and determination of nutrient budgets. At the same



SEAFDEC/AQD scientist Myrna Teruel: "Our mission is to help develop appropriate feed that can make a difference in bringing about sustainable aquaculture operations."

time, their studies aim to increase cost-effectiveness of feeds and to minimize the effects of feeds on the pond environment. "This way, we are able to develop feed for sustainable aquaculture," Ms. Teruel emphasizes.

She also points out that aquaculture feed is a big user of fish meal, the major source of protein in the feed. But the cost of fish meal is becoming

prohibitive and its availability is decreasing.

"Thus, our program is looking for fish meal substitutes. We are testing terrestrial sources of protein like cowpea, soybean, meat and bone, and blood meal as possible cheaper replacements for fish meal. We are investigating these replacements in our feeding studies for grouper, seabass and snapper," the researcher reports.

Studies in this direction

SEAFDEC/AQD research has achieved the following results:

1. As much as 40% of the fish meal ingredient in a diet for grouper juveniles can be replaced by processed



meat solubles. This modified diet achieves fish weight gain of 300-554 percent after 60 days of feeding. On the other hand, meat and bone meal can be used to replace 80% of fish meal in the diet.

2. A feed formulation for grow-out culture of the red snapper *Lutjanus argentimaculatus* using defatted soybean meal to replace as much as 30% of animal-based protein (fish meal, squid meal, etc.) has been developed.
3. A feed formulation containing 42.5% protein, 20% carbohydrate with lipid levels ranging from 6-18% is recommended for feeding juvenile sea bass, *Lates calcifer*.
4. The apparent protein digestibility (97%) of various formulated diets containing Chilean fish meal, defatted soybean meal and 40% Protamino Aqua was not significantly different in grouper juveniles weighing 30-90 grams.
5. A formulated diet containing 27% protein, 5% lipid and 40% carbohydrates enhanced better growth rate of juvenile abalone *Haliotis asinina* in terms of weight gain, increase in shell length, feed conversion ratio and protein efficiency ratio.
6. A modified SEAFDEC-formulated diet for shrimp containing plant-based protein that reduced the fish meal ingredient to 20% has a relatively lower nitrogen and phosphorous content in the pond effluent compared with the commercial feed.

We are developing a simplified, farmer-oriented selection procedure for tilapia broodstock



In the Philippines, a tilapia farmer cannot always get enough broodstock to meet the requirement in his farm. What he usually uses are the commonly sold fingerlings, not the broodstock size, that he grows as broodstock to produce fry and fingerlings. Thus, he ends up with a few good broodstock and becomes largely dependent on an outside source.

In response to this problem, SEAFDEC/AQD scientists have developed a simplified selection procedure that a farmer can follow to produce his own good quality broodstock.

Dr. Zubaida Basiao, SEAFDEC/AQD scientist, says that their selective breeding technique produces small but steady gains in tilapia growth in the long term. She reports that their research in Laguna Lake-raised tilapia showed a 3% gain in growth in the fish after one generation of offspring. On the other hand, their farmer-participatory research conducted in farmer's earthen ponds showed as much as 7-9% gain in growth after one generation. "Our computations indicate that a farmer can obtain as much as a significant 34% increase in income after five years with a 3% growth gain from two generations of selected broodstock. In addition, this selection procedure can be conducted easily with a few facilities and without disrupting production operations. Furthermore, a farmer would have more control over his choice of good quality spawners and reduce his cost for purchase of breeders. From the genetics point of view, we are promoting on-farm gene banking and a socio-economically sustaining genetic conservation of tilapia," Dr. Basiao points out.

Dr. Basiao avers that this simplified selection procedure can be employed by a tilapia fish farmer, whether he buys breeders or fry to grow them into breeders. She advises however: "A farmer should get his breeders or fry from a reputable source like the Munoz, Nueva Ecija-based GIFT Foundation, the Bureau of Fisheries and Aquatic Resources National Tilapia Breeding Center, the Central Luzon State University, or from private tilapia hatcheries known for quality broodstock. He should also purchase uniformly-sized fry, about 12 millimeters long and no longer than 14 millimeters."



The selective breeding technique

Dr. Basiao describes the procedure as follows:

At the start, a farmer needs at least 150 male and 150 female tilapias to spawn. This number will ensure less inbreeding in the tilapias, resulting in a genetically healthy stock. The offspring of these original parents will then be grown and later used as the broodstock.

Then the farmer selects the fry that he will grow into spawners. As soon as the fry produced by the parent tilapias start swimming, he scoops the fry with an appropriate scoop net. He does this operation in a day or two and the collected fry can be pooled in a holding net from three to four days and fed with natural food. At the end of this holding period, the farmer passes the fry through an A-sized mesh net sorter. All fry that pass through the A-net sorter should be stocked in an appropriate nursery and grown as fingerlings. This almost uniformly sized group of fry will be grown into spawners. On the other hand, the culled fry may be grown as food fish for sale.

After 6-8 weeks of rearing the fry or until they reach at least 40 mm long, the selection for length is done in two stages. At this time, each fingerling would be, on the average, about 39 millimeters long and would weigh about two grams. The first selection for length involves getting the average length of the fingerlings by measuring a random sample of 100-200 fingerlings. Then the farmer sets aside another random sample of fish that measures close to the mean length, say 200 fingerlings. This will be the unselected control group that can be used for testing the

growth performance of the succeeding tilapia progenies.

The longest 50% of the fingerlings are then saved for further rearing. If the sexes of these selected fish can already be differentiated, the males and the females should be grown separately. If not, they are grown 4 weeks further or until they reach the size when the sexes can be determined.

The second stage of selection is conducted when all the fish are mature and are ready to spawn. Only the largest 10% of both the male and female are chosen as the select spawners. They should be stocked together in a separate breeding pond, cage or tank, taking special measure that no other fish except the select spawners are in the facility. They should then be allowed to mate among themselves randomly. These fish will now be the select broodstock that will be used to produce the first select generation of fish as well as the production fish for sale.

Determining response to selection

How does a farmer know that his selected broodstock perform well? Dr. Basiao suggests the following:

- The best way to do this is to compare the growth rate of the progenies of the selected broodstock with those of the unselected broodstock control group. This unselected broodstock comprises the other group earlier separated during the first selection for length.
- This control group should be reared under the same conditions as the select broodstock, that is, they should be provided the same husbandry and management schemes as those of the select group. This is the only way where a farmer can determine whether the growth rate of his fish is due to selective breeding.
- A farmer can also evaluate the fish response to his selective breeding process. He should grow together

in the same environment the offspring of both the select broodstock and the unselected, or control fish. The fingerlings are matched in size and should be fin-clipped. The size of the fingerlings (20 from the selected group and 20 from the unselected) should be the same to within one millimeter and should be reared in at least three small cages. Then he takes length measurements of all the fish monthly until some data are ready for evaluation.

- While statistical analysis of data for significant differences is not normally within the farmer's realm, he can already see some good trends in the fish growth rate from the raw averages of the fish length he had recorded.
- This selective breeding program while simple and inexpensive requires facilities, labor, dedication and serious record keeping on the part of the farmer.

Plans for the future

According to Dr. Basiao, SEAFDEC/AQD expects to refine both the laboratory and on-farm procedure by conducting more farmer-participatory research. It also hopes to spread the selective breeding technique to more farmers by conducting short-term training courses. Lastly, SEAFDEC/AQD will expand or modify the use of this procedure to apply to other fish species.



Dr. Zubaida Basiao, SEAFDEC/AQD scientist: "Our simplified farmer-friendly procedure for selecting tilapia broodstock will surely enhance a more productive tilapia industry."

Our collaborators



- Australian Center for International Agricultural Research (ACIAR)
- Canada-ASEAN Centre
- Department of Agriculture – Bureau of Fisheries and Aquatic Resources, Philippines
- European Union (EU)
- Food and Agriculture Organization of the United Nations (FAO)
- Japan International Cooperation Agency (JICA)
- Network of Aquaculture Centers in Asia (NACA)
- Research Institute of Marine Products, Ministry of Fisheries, Vietnam

We're opening more doors for verifying and demonstrating aquaculture technologies



Since its inception in 1996, SEAFDEC/AQD's technology verification and extension program (TVE) has taken big strides in the field testing of culture systems and determining their economic as well as commercial viability. In addition, the program has packaged aquaculture technologies in the form of extension manuals for dissemination to a larger clientele within the country and in the region.

"One of our major achievements in 1998 and 1999 was our entry into the Southeast Asian regional scene," relates Mr. Dan Baliao, SEAFDEC/AQD researcher.

Mr. Baliao reveals that previously, the TVE program conducted its activities in the Philippines. This time, a technology verification and demonstration project on mangrove-friendly shrimp culture is being conducted in a site in Phu Long, Vietnam. The Research Institute for Marine Products (RIMP) of Vietnam's Ministry of Fisheries is collaborating with SEAFDEC/AQD through the Management of Sustainable Coastal Fisheries (MSCF) project being coordinated by the SEAFDEC Secretariat. The project will demonstrate the semi-intensive technology for shrimp culture in a mangrove-forested area. To get more shrimp farmers to see the demonstration of the technology, RIMP specialists are accommodating 5-10 persons of their people's communities every two weeks to visit the site. The project will offer a hands-on training course for shrimp growers.

Mr. Baliao adds that SEAFDEC/AQD, in cooperation with the Department of Fisheries of Thailand, is implementing the ASEAN-SEAFDEC collaborative project on Mangrove-friendly Shrimp Culture. This project involves verification and demonstration activities in Thailand and in the Philippines.

In Thailand, the project will focus on mangrove-friendly intensive shrimp culture technology, using a recirculating water and pond effluent treatment system. In the Philippines, the counterpart project activity is on the mangrove-friendly shrimp culture in a semi-intensive system. It is being conducted at SEAFDEC/AQD's Dumangas Brackishwater Station in Iloilo. Other TVE



projects are planned to be conducted in Myanmar and Cambodia.

"We have also started a technology acceleration and enhancement program with the Philippines' Bureau of Fisheries and Aquatic Resources (BFAR). Our technologies will be demonstrated in BFAR's 11 regional stations. This means that our TVE program will have a nationwide presence in the Philippines," Mr. Baliao explains.

Mr. Dan Baliao, SEAFDEC/AQD researcher: "Our technology verification program has expanded into the Southeast Asian region. We are now in Vietnam and Thailand. Soon we shall conduct projects in Myanmar and Cambodia."



TVE projects completed

Within the reporting period, SEAFDEC/AQD's TVE program has completed or nearing completion twelve technology verification projects involving 26 cooperators.

TITLE OF PROJECT	COOPERATOR
Grouper culture in brackishwater ponds	Concepcion Polytechnic College, Concepcion, Iloilo Sanson Farm, Bacolod City
Nursery and grow-out culture of milkfish derived from hatchery seeds	Jalandoni Farms, E.B. Magalona, Negros Occidental Naranjo Farms, Carles, Iloilo Arches Farm, Roxas City Capiz Institute of Technology, Roxas City Iloilo State College of Fisheries, Barotac Nuevo, Iloilo Department of Agriculture, Iloilo City
Cage culture of tilapia in small farm reservoirs	Bingawan Multi-purpose Coop, Bingawan, Iloilo Local Government of Tapaz, Capiz
Environment-friendly schemes for disease prevention in tiger shrimp farms	Santa Clara Farms, Talisay Negros Occidental Golden Prawn Farm, E.B. Magalona, Negros Occidental Sanson Farm, Bacolod City
Culture of mudcrab in brackishwater ponds	Jalandoni Farm, E.B. Magalona, Negros Occidental Montelibano Farm, E.B. Magalona, Negros Occidental Gargarita Farm, Himamaylan, Negros Occidental
Biculture of seaweeds and milkfish in brackishwater ponds	Iloilo State College of Fisheries, Barotac Nuevo, Iloilo
Mudcrab culture in tidal flats with existing mangroves	Manalo Multi-Purpose Cooperative, Puerto Princesa, Palawan Philippine Reef and Rainforest Conservation Foundation (PRRCFI), Cauyan, Negros Occidental Gigantes Island Fisherman Cooperative, Carles, Iloilo
Accelerated transfer of milkfish hatchery technology	Luis Roxas, Batan, Aklan Aquaspec, Guimbal, Iloilo
Hanging raft-method of oyster and mussel production	Local government of Ivisan, Capiz
Grouper, snapper culture in floating cages	PBSP, Samar (Maqueda Bay)
Grouper culture in cages	Southern Philippines Council for Peace and Development, (SPCPD) and Food and Agriculture Organization (FAO) of the United Nations, Basilan, Zamboanga Sur and Jolo
Hatchery-bred snapper culture in ponds	Iloilo State College of Fisheries, Barotac Nuevo, Iloilo

Ongoing projects

TITLE OF PROJECT	COOPERATOR
Seed production of mudcrab	Western Samar Agricultural Research Development Program (WESAMAR), Western Samar
Environment-friendly schemes for disease prevention in tiger shrimp farms	Bureau of Fisheries and Aquatic Resources (BFAR), Lanao del Norte OPLAN Sagip Sugpo, Negros Prawn Producers and Marketing Cooperative (NPPMC), Negros Occidental Calape, Bohol
Pen culture of mudcrab in mangroves	Bureau of Fisheries and Aquatic Resources (BFAR), Lanao del Norte
Mudcrab culture in mangroves	PRRCFI, Negros Occidental
Seed production of window-pane shells	Local governments of Tigbauan and Oton, Iloilo
Catfish culture	Technology and Livelihood Development Center (TLDC), Local government of San Joaquin, Iloilo
Tilapia culture in small farm reservoirs	Local governments of Tubungan and Miagao, Iloilo
Grouper culture in netcages	SPCPD-FAO-UNDP, Basilan, Jolo and Lanao del Norte
Grouper and snapper culture in net cages	Shell Philippines, Subic, Zambales Philippine Business for Social Progress, Maqueda Bay, Samar
Marine fish hatchery	Department of Agriculture Sea-ranching Station, Puerto Princesa, Palawan

Other collaborators

Panay Gulf Development Program in collaboration with Department of Environment and Natural Resources (DENR), Department of Agriculture (DA), Department of Science and Technology (DOST), University of the Philippines in the Visayas (UPV), Land Bank of the Philippines (LBP)
Central Panay Economic Unification, Inc. (CPEU)
Technology Promotion Center (TPC) of LBP
Bureau of Fisheries and Aquatic Resources (BFAR), DA
Center for Renewable Resources and Energy Efficiency (CREE), Shell Philippines

We continue fine-tuning our training courses to address current needs



Training activities at SEAFDEC/AQD underwent significant changes in the curriculum. Courses were also designed and oriented to the bigger picture of aquaculture within the context of sustainability.

According to Mr. Renato Agbayani, SEAFDEC/AQD scientist, training courses are anchored on the framework of responsible aquaculture development. “This orientation aims to propagate aquaculture technologies that are economically viable, environment-friendly. It involves approaches to coastal resource management that protect and conserve the resources as well as ensure equitable sharing of resource benefits by all stakeholders,” he expounds.

Mr. Agbayani says that an example is the change in the nomenclature of the Third Country Training Programme sponsored by both the Governments of the Philippines and Japan through the Japan International Cooperation Agency (JICA). Previously, the training course was titled as “Coastal Aquaculture Management.” It is now offered as “Responsible Aquaculture Development” to reflect its global orientation concern.

Another change in the SEAFDEC/AQD training activities is its active stance in bringing the training activities on site. An example of this were the training sessions held in Vietnam in the last two years wherein a large number of Vietnamese participants attended the training. The second session was attended by participants from Kampuchea aside from the trainees from Vietnam. This reflects a regional sensitivity to the present needs of SEAFDEC member countries.

From the learning experience and insights gained from an eight-year

project on coastal community resources development in Malalison Island, Antique, Philippines, SEAFDEC/AQD launched its “Sustainable Aquaculture and Coastal Resource Management (SACRM)” training course. This course is tailored to the needs of the Local Government Units (LGUs) in the Philippines. These LGUs are implementing the country’s Local Government Code and the Philippine Fisheries Act of 1998 in their various communities. At present, many LGUs are actively asserting their role in promoting sustainable management and use of coastal resources in the country.

In the SACRM training course, SEAFDEC/AQD scientists assist LGU officials and representatives in identifying appropriate sustainable aquaculture activities, coastal resource management action, policy reforms and in the strengthening of community organizations. The training course participants are also provided opportunity to develop and present their localized action plans that are practical, viable and doable.

Mr. Agbayani concludes: “We continue to refine our training courses to suit the needs of our clientele. In short, we try to be *au courant*.”



Number of people trained

Six hundred and one (601) people underwent SEAFDEC/AQD training; 197 trained in regular training courses, 270 took special training courses, 134 attended internship and on-the-job training.

Regular training courses offered

TITLE OF TRAINING COURSE	NUMBER OF PARTICIPANTS		TOTAL
	1998	1999	
Aquaculture management	26	21	47
Fish health management	15	16	31
Marine fish hatchery	19	14	31
Freshwater aquaculture	11	16	27
Shrimp hatchery operation	12	*	12
Fish nutrition	14	18	32
Management of sustainable aquafarming systems	*	15	15
			197

* not offered

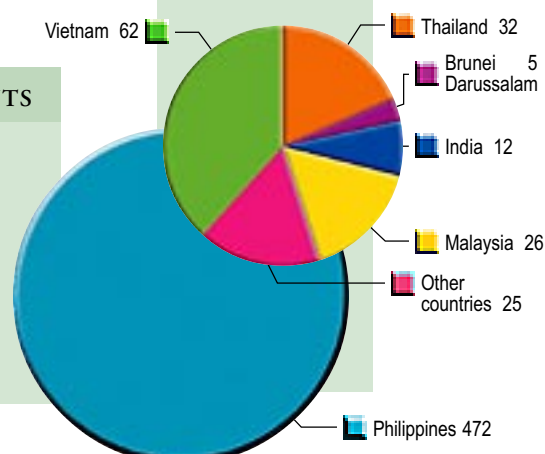
Special training courses, 1998

TITLE	PARTICIPANTS
Sustainable aquaculture and coastal resource management	20
Coastal aquaculture resource management (Third Country Training)	27
Mangrove-friendly aquaculture and coastal resource management	27
Oyster and mussel culture	27
Biology and culture of molluscs	22
Total	123

Where our training participants come from

Special training courses, 1999

TITLE	PARTICIPANTS
Seaweeds, grouper and cage farming	28
Mangrove-friendly aquaculture (on-site training, Vietnam)	25
Shrimp hatchery operation	1
Grouper culture in cage and ponds	38
Seed production of native catfish	9
Sustainable aquaculture and coastal resource management	30
Mollusc health management	16
Total	147



Our collaborators

- Technical Education and Skills Development Authority (TESDA) Region V, Bicol, Philippines
- Japan International Cooperation Agency (JICA) Third Country Training Programme (TCTP)
- Local government units (LGUs), Philippines
- Land Bank of the Philippines
- Danish International Development Agency (DANIDA)
- SEAFDEC Secretariat
- Tropical Marine Mollusc Programme, Bangkok, Thailand
- FAO-UNDP
- Research Institute of Marine Products, Ministry of Fisheries, Vietnam
- ASEAN-Canada
- Bureau of Fisheries and Aquaculture Resources (BFAR)
- Process Foundation Inc.

We have started a college textbook production program



S EAFDEC/AQD has initiated a program that will produce college-level textbooks on aquaculture. The program aims to fill the gap in the lack of aquaculture textbooks that feature South-east Asian conditions.

“The data generated by our researchers had been used as basis for producing training materials for our training courses. The training syllabi will be our kick-off point for producing aquaculture textbooks,” says Ms. Milagros Castaños, head of the development communication unit, SEAFDEC/AQD’s office in charge of producing information materials based on research.

Ms. Castaños explains that eight textbooks are in the pipeline. The proposed titles are the following: Aquatic Animal Health, Fish Nutrition, Aquatic Ecology in the Philippine Setting, Farming Systems, Hatchery Systems, Fish Physiology, and Genetics and Breeding of Aquatic Animals. The authors of these books

are mainly the SEAFDEC/AQD scientists who will write articles based on their completed research.

At present, SEAFDEC/AQD is collaborating with the Iloilo State College of Fisheries in pre-testing the textbooks in its collegiate courses on aquaculture.

“We will produce two textbooks initially, in time for next year’s school opening classes in June, 2000. These are the ones on Aquatic Animal Health and Fish Nutrition,” Ms. Castaños reveals.

SEAFDEC/AQD plans to institutionalize this textbook production program in an effort to contribute to better aquaculture education in Southeast Asia.

Our other activities

Activities in 1998 and 1999 continued production of extension materials, maintaining the SEAFDEC/AQD website in the Internet, instituting an aquaculture news service, and maintaining an aquaculture library.



Milagros Castaños: “We are producing textbooks for college students. These books will feature aquaculture information from research conducted under Southeast Asian conditions.”

Our publications

PUBLICATION	DESCRIPTION
Newsletter	
SEAFDEC Asian Aquaculture	Bimonthly newsletter, 12 issues, each issue with special feature. Featured topics on integrated farming, seaweed culture, tilapia culture, sustainable aquaculture, mussel and oyster culture, pen and cage culture, The Malalison story, grouper culture and mangrove-friendly aquaculture, marine ornamental fishes, milkfish culture, milkfish, tiger shrimp, and bighead carp and ADSEA '99; 2,500 copies are circulated
Extension manuals	
Grouper culture in brackishwater ponds	based on SEAFDEC/AQD’s technology verification efforts, authored by D Baliao et al
Seabass hatchery operations	update of the manual first published in 1992, written by MM Parazo et al

Our publications (continued)

PUBLICATION	DESCRIPTION
Manuals	
The modular method: milkfish pond culture	18 pages, describes a better way of raising milkfish in brackishwater ponds, written by DD Baliao et al
Pen culture of mudcrab in mangroves	10 pages, details the operation of net enclosures in mangroves for mudcrab culture, by DD Baliao et al
Mudcrab	32 pages, gives a general overview of mudcrab species of commercial value and their grow-out monoculture in ponds; polyculture with milkfish; and fattening in ponds, mangroves, and cages. By DD Baliao et al
Mudcrab <i>Scylla</i> spp. production in brackishwater ponds	14 pages, covers the specifics of grow-out operation, including cost-benefit analysis and a list of useful references. By DD Baliao et al
Monograph	
Biology and culture of siganids	an update of the monograph by MN Duray
Ecology and farming of milkfish	117 pages, discusses the life history and ecology and various aspects of the farming industry in the Philippines, authored by T Bagarinao
Institutional Reports	
1997 Highlights	summarizes SEAFDEC/AQD's 1997 activities
1998 Highlights	31-page report of SEAFDEC/AQD's research and development activities for 1998
1996-1997 SEAFDEC/AQD Biennial report	a detailed report of accomplishments of SEAFDEC/AQD for the period covered
Promoting appropriate aquaculture technology for more fish in Southeast Asia	a 24-page report that discusses the commercial trial runs of SEAFDEC/AQD-developed technologies on (1) milkfish hatchery, pond culture using hatchery-raised fry, and polyculture of milkfish and seaweeds; (2) the use of environment-friendly schemes in tiger shrimp culture; (3) mudcrab culture in ponds and net enclosures in mangroves; (4) cage culture of hybrid tilapia; (5) catfish hatchery technology; and (6) oyster and mussel culture in rafts
Flyers and Leaflets	
Milkfish breeding and hatchery technology at SEAFDEC/AQD	describes the techniques already adopted by the private sector: broodstock management and artificial diet, commercial fry production, live transport, and larval diet
Milkfish breeding and hatchery fry production	a reprint of the 2-page flyer that summarizes the integrated milkfish broodstock and hatchery operation technology developed by SEAFDEC/AQD
The commercialization of SEAFDEC/AQD's milkfish fry production technology	illustrates SEAFDEC/AQD's newest hatchery facility – the Integrated Fish Broodstock and Hatchery Demonstration – and the extension program that goes with it – Accelerated Transfer of Milkfish Fry Production Technology
Mudcrab culture	summarizes the available technologies on mudcrab grow-out, monoculture in ponds and in tidal flats with existing mangroves, polyculture with milkfish in ponds, and mudcrab fattening
Seed production of native catfish <i>Clarias macrocephalus</i>	describes SEAFDEC/AQD's work on artificially propagating the catfish
The farming of <i>Kappaphycus</i>	introduces the red seaweed with notes on the types of culture systems, the environmental factors required, initial investment needed, and crop management
Binangonan Freshwater Station	illustrates SEAFDEC/AQD's research and development activities in freshwater aquaculture and lake ecology, primarily for Laguna de Bay

Our publications (continued)

PUBLICATION	DESCRIPTION
Flyers and Leaflets	
Reaching out through technology verification and extension	presents the efforts of SEAFDEC/AQD to fast-track commercialization of aquaculture technologies developed
Aquaculture training program	a 20-page brochure that introduces SEAFDEC/AQD's short-term regular courses
Training module on sustainable aquaculture and coastal resource management	describes the new SEAFDEC/AQD's training courses, including course content, qualification of participants, and enrollment process

Educational videos

TITLE	DESCRIPTION
Conserving our mangrove resources	12 minutes, describes the plight of mangroves and efforts to sustain them in the wake of the aquafarming boom; suited for science and environment class viewing and in awareness seminars on coastal resource conservation
Mussel and oyster culture	9 minutes; depicts the SEAFDEC/AQD-favored method of using the environment-friendly hanging raft for oyster and mussel culture; shows construction of the raft, the site selection process, the two farming phases (spat collection and grow-out), and harvest; Shots mostly taken at SEAFDEC/AQD's technology and extension project in Capiz and Aklan, two provinces in west central Philippines
Grouper culture in brackishwater ponds	8.5-minutes; based on SEAFDEC/AQD's extension manual of the same title; shows the different stages of grouper culture: grow-out, harvest, and post-harvest, as well as site selection and pond preparation; also describes the economics of grouper production and provides tips for marketing and transport of the product
The year that was	7 minutes, describes SEAFDEC/AQD's major activities in 1999
Grouper cage culture	16 minutes, a documentary describing site selection, cage construction and grow-out culture of grouper
A CFRM experience: the Malalison story	30 minutes, documentary highlighting processes and lessons gained in SEAFDEC/AQD's 7-year project in Antique
Milkfish hatchery operations	12 minutes, describes SEAFDEC/AQD's recommended mode of operations for a milkfish hatchery used at its Integrated Fish Broodstock and Hatchery Demonstration Complex
Ang palaabuton sang kapagangan	12-minute video documentary on coral reefs

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Visit our website and learn more about aquaculture. Order books, publications and educational videos. Get to know more about our research, training and information dissemination activities. Click on <http://www.seafdec.org.ph>



New MS and PhD additions to our pool of expertise



Six research and training staff earned their advanced degrees: Gilda L. Po, PhD (Biological Science); Luis Ma. B. Garcia, Doctorate in Fisheries Science; Oseni M. Millamena, PhD, Fisheries

Science; Fe Dolores P. Estepa, Doctorate in Fisheries Science; Ruel V. Eguia, MS Aquaculture; and Febe Lou C. Gapasin, M Aquaculture.

New facilities and infrastructure



SEAFDEC/AQD has a new brackishwater pond research facility, known as the Dumangas Brackishwater Station (right). This is a 16-hectare brackishwater farm in Punta Pulao, Dumangas, Iloilo, donated by the Philippines' Department of Agriculture on October 27, 1998.

In 1998, the Abalone Hatchery (right) was completed.

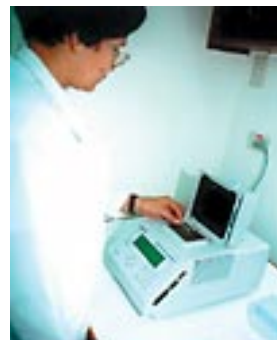


The Integrated Fish Broodstock and



Hatchery Demonstration Complex (above) was completed and inaugurated on July 9, 1998, SEAFDEC/AQD's 25th anniversary.

Equipment for a high-tech laboratory for Advanced Aquaculture Technologies are being set-up and tested. The lab is equipped to analyze DNA samples for studies on genetic improvement of cultured species (right, middle).



The construction of Fish World (below), an eco-park dedicated to the environment education of the general public, is nearly complete. It is to be inaugurated on July 9, 2000, SEAFDEC/AQD's 27th anniversary.



SEAFDEC/AQD IN THE THIRD MILLENNIUM

Globalization is fast spreading in the Southeast Asian region. It is bringing in new implications on how research and development activities in the region will be refocused.

For its part, SEAFDEC/AQD opens the third millennium with a bold step to address regional issues and concerns of the aquaculture industry. Based on the new strategic plan, SEAFDEC/AQD will strengthen its programs to highlight its regional character as a treaty organization of Southeast Asian countries.

Firstly, it is intensifying its efforts of collaboration with the Association of Southeast Asian Nations (ASEAN). Through the ASEAN framework, SEAFDEC/AQD hopes that more countries in the region can benefit from its generated technologies in aquaculture.

“We have to chart new paths for our technologies. We need to ensure that our technologies are integrated in the mainstream of national aquaculture development pro-

grams,” stresses Dr. Rolando Platon, SEAFDEC/AQD Chief.

Dr. Platon laments the fact that while aquaculture is a fast growing industry and a large contributor of fish products in the world trade, nary a government program in the region has a strong aquaculture component. He adds that this is reflected in lack of adequate support for the aquaculture industry and inadequate budgets for research and development.

Dr. Platon believes that with a formal collaboration with ASEAN, more SEAFDEC/AQD technologies can be incorporated in the formulation of the ASEAN countries’ national development programs. He explains that SEAFDEC/AQD will be working closely with the ASEAN Fisheries Working Group, the ASEAN member countries’ institutional forum for fishery concerns in the region.

Dr. Platon continues: “We have actually an ongoing collaboration. Our researchers are working with experts from Thailand’s Department of Fisheries in verifying





Dr. Rolando Platon, Chief, SEAFDEC/AQD: "We have to address the implications for our R&D activities with increasing globalization around us. We will strive to be the regional center of excellence for aquaculture research, training and information dissemination activities."



mangrove-friendly shrimp culture technologies in Vietnam. We started this verification program mainly in the Philippines and at this time, we feel we have enough experience to spread this effort in the region. We're starting with Vietnam and soon, we shall be doing the same in the other ASEAN countries."

At the same time, SEAFDEC/AQD is coordinating the SEAFDEC Aquaculture Collaborative Network, a project of SEAFDEC and its member countries. This network provides regional collaboration through the region's existing institutions working in aquaculture R&D. The network hopes that an open research system will facilitate intraregional exchange of expertise and information. Thus, aquaculture technology development in the region will be hastened.

Secondly, SEAFDEC/AQD will expand its collaboration with the aquaculture industry. Dr. Platon feels that while SEAFDEC/AQD has generated a vast amount of information on aquaculture, it seems that the private sector has not taken much advantage of this information.

Dr. Platon suggests the development of appropriately packaged

programs that are geared to the problems of the industry. "This will be our prime strategy. We will collaborate more with the industry in developing R&D program packages. These packages will feature a relevant problem being addressed by a working interdisciplinary team of our scientists within a given time frame, let's say 4-5 years. This way, results will be more relevant and can be applied immediately."

"In this connection," Dr. Platon adds, "we need to determine the impact of our training program. We need to follow up on our trainees. We must find out how they have used the knowledge they gained from this training and how they have influenced the industry in their respective countries."

SEAFDEC/AQD is also into the biotechnology area of research. Dr. Platon reports that SEAFDEC/AQD is now installing a biotechnology laboratory. "This is a complete laboratory that will enable us to go into the cutting edge of technology. We are preparing for this important area of research with staff development. We are sending some of our staff for advanced studies in biotechnology. We are utilizing advanced techniques in biotechnology research. This way, we can contribute to generating relevant information on diseases, feed development, and breeding."

As donor funds continue to dwindle, SEAFDEC/AQD plans to tap non-traditional sources of funds to augment its financial requirements. Dr. Platon explains that SEAFDEC/AQD will pursue cost-recovery measures that will boost its R&D funds.

"Of course, we shall not go commercial in its true sense, since we are more in public service," Dr. Platon points out, "but we shall offer consulting services of our staff to sectors who are able and willing to pay. We can accept contracts for research, training and information-dissemination projects that are funded by regional or international agencies. In the long run, this arrangement is more efficient. Private industry need not put up their own R&D departments since they can come to us to conduct research on their problem. We will also generate added funds through sale of our products of research, our patents and royalties, and our aquaculture textbooks, publications and videos."

With all these activities, Dr. Platon further envisions SEAFDEC/AQD as the center for aquaculture research, training and information-dissemination activities in the Southeast Asian region. Summing up, Dr. Platon expresses confidence, that "with our expertise in aquaculture, our experiences in the industry and a working mechanism within the ASEAN framework, I feel we should be able to comfortably achieve this goal in the not distant future."

Advances in aquaculture research and development

**BIENNIAL REPORT
1998 AND 1999**



**Aquaculture
Department**

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