2000 Highlights

AQUACULTURE DEPARTMENT
Southeast Asian Fisheries Development Center
Tigbauan, Iloilo, Philippines

The Department Chief reports

SEAFDEC/AQD in 2000

The year 2000 was another productive year for AQD. New research areas opened up for new species for culture.

Refinements of already developed technologies and industry practices were aimed at increasing aquaculture production and decreasing production cost through more innovative approaches like the application of biotechnology, particularly on growth acceleration.

Technologies were also verified in actual field conditions as to technical, environmental, and socioeconomic considerations. Those found viable were demonstrated in various sites in collaboration with the Philippine government agencies, local government units, and fishfarmers. On the regional level, and initially in collaboration with the Department of Fisheries of Thailand, AQD conducted verification and demonstration activities in Thailand and Vietnam.

While training courses were continued, AQD also served as the lead department for the regionalization of the Code of Conduct for Responsible Fisheries: Aquaculture Development, and organized workshops and seminars. Among these were the series of consultations in preparation for the ASEAN-SEAFDEC millennium conference.

Diversified information strategies were also adopted during the year. A much improved website continued to attract browsers interested in aquaculture as it consistently placed in the top ten sites searched for information on milkfish, grouper, tilapia, rabbitfish, mangrove-friendly aquaculture, and lake ecology while manuals on viable aquaculture technology were published.

The initial success shown by the ASEAN-SEAFDEC collaboration projects demonstrates the great potential for collaboration in common areas of interest among ASEAN countries. As more countries signify willingness to collaborate with AQD, sustainable aquaculture in the region is now within reach.

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Highlights 2000 of AQD Activities

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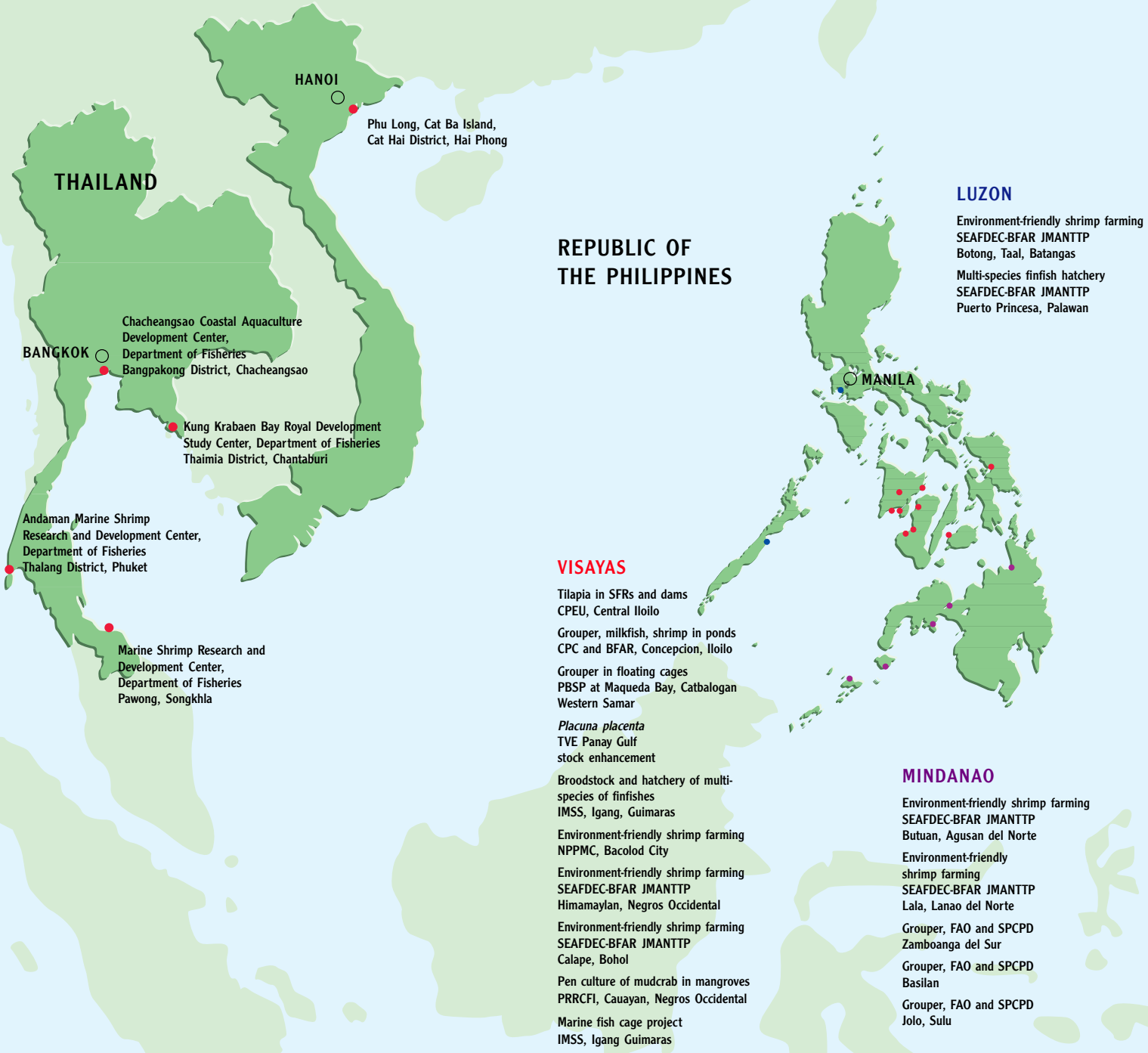
Response to industry needs

AQD showcased its technology demonstration and promotion projects in three countries: the Philippines, Thailand, and the Social ist Republic of Vietnam. Five techno-packages resulted in the publication of aquaculture manuals. This map and the table on page 5 show the farm sites, the technologies developed, and their corresponding management schemes.

On-farm technology demonstration and promotion projects of AQD



Environment-friendly scheme in intensive shrimp farming (low discharge system)

To promote sustainable aquaculture technologies and to support fish farmers who intend to invest in shrimp farming, AQD collaborated with the **Bureau of Fisheries and Aquatic Resources** through its Joint Mission for Accelerated Nationwide Technology Transfer Program. Field demonstration and training for fishfarmers and entrepreneurs were conducted. Using the now published shrimp farming technique that is being promoted by AQD, the technology included stocking at 25 shrimp per square meter in ponds equipped with long-arm paddlewheels for efficient aeration. A reservoir pond stocked with either tilapia or milkfish must be added. Daily feed computation are adjusted following a recommended feeding guide. Cost and return computations give a payback period of three croppings.

An encouraging harvest from Calape, Bohol, another TVES verification study

In Botong, Batangas, AQD Chief Dr. Rolando R. Platon (above, in dark blue vest), observes a nighttime shrimp stocking

In Dumangas Brackishwater Station, harvest from the low discharge scheme of the environment-friendly intensive shrimp farming attests to its viability. Right photo shows TVES Head Mr. Dan D. Baliao (left in checked shirt), and Mr. Susumo Ito (center, in white), Deputy Chief of AQD

Milkfish/grouper culture in ponds

The **Concepcion Polytechnic College** received technical assistance as AQD verified and demonstrated the economic viability of grouper/milkfish culture in ponds using hatchery bred fry.

High density milkfish culture in ponds is verified at DBS to promote use of substrates, additional feeding machine, and improved feed formulation

Grouper culture in net cages

Being a high cost fish in most countries in Asia, grouper culture can improve the income of small scale fisherfolk. Successful cage culture of grouper in coastal towns in the Philippines has shown that the grouper market is dynamic and added production is much needed for both local and export markets.

The **Philippine Business for Social Progress** and the **Food and Agriculture Organization-Southern Philippine Council for Peace and Development** were extended assistance regarding the livelihood enhancement component of their project in Cabucan Island, Jolo; Kigay, Malangas, Zamboanga del Sur; Alica, Zamboanga del Sur; and Isabela, Basilan. In collaboration with these agencies, AQD strengthened the project geared towards upliftment of the quality of life within the project area. AQD demonstrated the total culture procedure such as selection of site, construction of cages, sorting, packaging and transport, among others.

Grouper culture in net cages is verified in Kigay, Malangas, Zamboanga del Sur with the FAO-SPCPD

Technology verified, commercialized and promoted by AQD

Commodity	Technology developed	Management	Status	Promotions
Shrimp	Environment-friendly schemes in intensive shrimp farming a) Low discharge	25 shrimp per m², pumping, feeding, green water, treatment pond, reservoir, probiotics, substrates	On-going	Techno-demo in DBS and other BFAR sites nationwide; Manual published; Socialist Republic of Vietnam
	b) Closed-recycling system	60 shrimp per m², pumping, feeding, reservoir, greenwater, treatment pond, probiotics, water recycling, substrates	On-going	Demonstration in commercial scale in DBS and other BFAR-DTCS nationwide; Thailand (4 sites)
	c) Modified extensive	5 shrimp per m², green water, minimal pumping, supplemental feeding, bangus in cages as bio-manipulators, reservoir, substrates	On-going	For verification in DBS
Milkfish	Modified extensive milkfish culture (modular method)	Tidal, natural food, multiple cropping with whole year fingerling inventory	Completed	Demonstrated in commercial scale; Manual published
	High density culture in ponds	30 juveniles per m², pumping, tidal and natural food and supplemental feeding	On-going	Techno-demo in DBS; for further verification in DBS using substrates, additional feeding machine and improved feed formulation
	High density culture in cages	25-30 juveniles per m³, floater and slow-sinking pellet feeding	On-going	For further demonstration in Mariculture Park-IMSS
Grouper	Culture in brackishwater ponds	5 fingerlings per m², feeding, grading, and stand-by aeration	Completed	Commercialized Manual published
	Culture in cages	7 fingerlings per m³, feeding, grading		Commercialized Manual published
Mudcrab *Scylla* spp.	Production in brackishwater ponds	0.5 crablets per m², w/ and w/out feeding	Completed	Demonstrated in commercial scale; Manual published
	Pen culture in mangroves	0.5 crablets per meter², tidal, supplementary feeding, regular net inspection	Completed	Demonstrated in commercial scale; Manual published
Tilapia	Cage culture in dams and small farm reservoirs	feeding, regular inspection of cages, w/ integrated hatchery and nursery components	Completed	Demonstrated in commercial scale; Manual published

AQD charts a selective breeding program

Harnessing the principles of genetics for aquaculture can serve to fill the food security gap by improving techniques in fish farming and creating new and better products.

Four invited scientists presented their experiences and lent their expertise to help AQD decide on approaches to a selective breeding program for priority aquaculture species in a workshop. The workshop titled Broodstock Management and Genetic Selection was held on 27-29 November in Iloilo City. Professor John Benzie of the University of New South Wales, Australia, presented techniques and their application for the genetic improvement of farmed aquatic fishes and crustaceans. Dr. Sirawut Klinbunga of BIOTEC, Thailand, described his government's recent efforts on selective breeding of the giant tiger shrimp. Dr. Roy Danzmann of the University of Guelph, Canada, talked about the application of molecular markers to pedigree analysis in aquaculture. Lastly, citing his experience in salmon farming and ranching, Dr. Noel Wilkins of the National University of Ireland discussed mechanisms to avoid the possible genetic pitfalls of an aquaranching program.

During the workshop that followed, matrices were formulated to assist in decision-making. One matrix listed AQD's candidate aquaculture species and their degree of domestication along with other attributes that can lend itself to an effective selective breeding program. Because of their relatively advanced degree of domestication, five farmed species – milkfish, sea bass, mudcrab, tilapia, and shrimp – were the focus of another matrix to identify breeding goals to assess the application of practical methodologies, with prime consideration on cost-efficiency. Breeding goals can include growth (e.g., milkfish) and/or disease resistance (e.g., shrimp).

The experts say that from their experiences, the decision to embark on a selective breeding program would start with the industry's clamor for better stocks. The degree of domestication of candidate species would also be a critical factor.

The workshop was attended by about 30 discussants from universities and research centers in the Philippines, including AQD researchers.

Regional fish disease project planning meeting

A Progress and Planning Meeting was convened at AQD, Iloilo, Philippines 11-12 December 2000. Twelve SEAFDEC staff, two scientists from the Philippines, three scientists from Thailand, and a reviewer from Japan participated in the Meeting.

The recommendations of the Meeting have been considered in the planning of the project: (a) research studies implemented in 2000 will be continued in 2001 with some revisions as deemed necessary; (b) research proposals from other SEAFDEC Member Countries (e.g., Thailand), as well as new proposals from AQD be considered; and (c) The Seminar/ Workshop on Disease Control in Fish and Shrimp Aquaculture in Southeast Asia-Diagnosis and Husbandry Technique will be held in December 2001 Iloilo, Philippines.

Broodstock management and genetic selection workshop held on November 2000 discussed approaches to a selective breeding program for priority aquaculture species. Discussants were researchers from AQD and other institutions, local and foreign

Mangrove-friendly shrimp culture planning workshop

AQD convened the Mangrove-Friendly Shrimp Culture Planning Workshop on 12-13 May 2000 in Iloilo City. This is a component of the project funded through the Japanese Trust Fund which aims to develop shrimp culture technology packages which are environment-friendly.

The planning workshop reviewed the status of environment-friendly shrimp culture technologies in Southeast Asia, and finalized the research, demonstration, and extension components of the SEAFDEC-ASEAN shrimp program. The project involves verification and pilot demonstration, research, and information dissemination. Technologies developed by the project would be promoted within the ASEAN Member Countries. Test sites for the semi-intensive system are the Philippines and Vietnam. The Vietnam site would verify the same set-up as in the Philippine sites except that mangroves and mud crab culture are integrated in the Vietnam farm.

The general framework and activities to be carried out under the Project were confirmed and adopted during the said workshop attended by thirty-seven participants from Thailand, Vietnam, Philippines, the SEAFDEC Secretariat, and SEAFDEC/AQD.

Some of the participants of the mangrove-friendly shrimp culture planning workshop. The conference focused discussions on technology packages for acceptable shrimp farming

A delegate from the Republic of Vietnam takes to the floor during the mangrove-friendly shrimp culture workshop

Regionalization of the Code of Conduct for Responsible Fisheries: Phase II – Aquaculture Development

AQD is the lead agency in the implementation of Phase II, Aquaculture Development of the SEAFDEC Program on the Regionalization of the Code of Conduct for Responsible Fisheries (RCCRF-AD). Phase II aims to develop regional guidelines for aquaculture development.

In 2000, AQD conducted two consultations. The first was the Pre-Technical Meeting of Core Experts held on 31 July - 2 August where 55 participants discussed the SEAFDEC Project on RCCRF and the scope of work for the preparation of the Regional Guidelines, and facilitated the identification of the Core Aquaculture Experts from the region. On 21-22 November, the Core Aquaculture Experts as well as experts from Japan and Philippines, FAO-RAP and AQD held a consultation where the participants adopted the Draft Regional Guidelines for Aquaculture Development for confirmation by their respective governments.

The participants in the said meetings also met in preparation for the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security in the New Millennium "Fish for the People." They finalized the guidelines for the conduct of national seminars by countries in the region. They also finalized the themes and sub-themes that will be discussed during the Conference.

All these consultations were held in Iloilo, Philippines.

Participants to the conference to develop regional guidelines for aquaculture development in the Regionalization of the Code of Conduct for Responsible Fisheries hold discussions in Iloilo City

Industry assessment

A nationwide survey to understand the input requirements of grow-out operators of shrimp, milkfish, tilapia, grouper, and mudcrab was conducted. The objective was to determine market development strategies that would guarantee efficient and sustainable sources of inputs (especially for feeds and substances, seeds/fry, skilled labor, technical assistance, land rental/lease) to complement commercially viable aquaculture technologies in the Philippines. Preliminary information of the survey conducted (180 aquaculture operators and 80 input suppliers) in places where tilapia is the major culture species show that inputs are available in the communities through enterprising local agents. However, capital/financial constraints limit access to these inputs. Consequently, implementation of the physical and operational improvements in aquafarms hinder productivity. Preliminary trends also show that tilapia growers continue to expect benefit from breeding and hatchery technology through extension and access to improved breeds. There is wide disparity in (1) access to technical assistance among aquaculture operators, and (2) the type of technology learned and applied by these operators.

A milkfish fry gatherer inspects his catch. Enterprising local agents liaise between fry gatherers and aquaculture producers

Community fishery resources management project (CFRM)

AQD continued to address coastal resources management concerns.

A pilot program to develop simple but reliable field protocols for monitoring the condition of coral reefs in Malalison Island, Antique, west central Philippines, was initiated by AQD researchers. This participatory monitoring approach was participated in by six local fisher-volunteers. With a researcher acting as reference, the volunteers each sampled the same 15m line transect laid at the 10m depth at two reef sites, each site having 2-3 transects. Overall, non specialist volunteers can provide semi-quantitative and qualitative information on the abundance of broad categories of reef benthos comparable with the assessment of an experienced researcher. Careful attention and more field trials are required to minimize sources of error, especially when volunteers with low educational attainment are involved.

Community participation is the first step in developing field protocols to monitor the condition of coral reefs

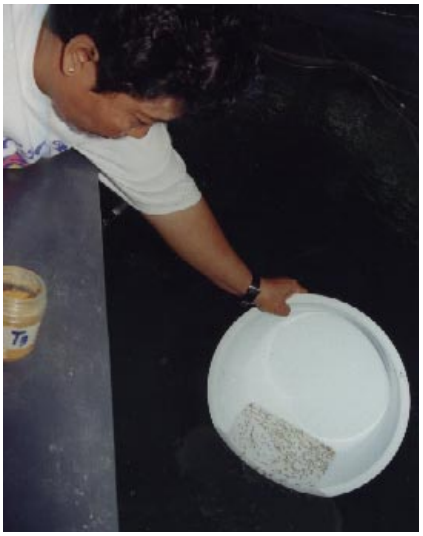
Milkfish *Chanos chanos*

Several milkfish production technologies have been developed at AQD and subsequently adopted by the industry but the fry availability problem still persists in the country. The recent intensification of milkfish production systems also pose environmental threats that need to be addressed. Studies to better understand growth regulation and factors that influence development of larvae and juveniles, nutrient dynamics in ponds, and ways to improve feed and waste management in intensive culture are the focus of AQD's research on milkfish.

Studies to address growth regulation in order to develop methods to enhance growth in juvenile milkfish involve the isolation, and characterization of growth hormone and insulin growth factors (IGF1 and IGF2). Milkfish growth hormone and insulin growth factors (IGF) have been cloned. Preliminary work to produce recombinant growth hormone is underway and studies to determine when GH and IGF genes are expressed in embryos and larvae is being done.

In the hatchery, the cost of producing milkfish fry has also been reduced through the development of larval feeds that can be fed to young larvae.

For milkfish grow-out, nitrogen and phosphorous excretion rates of milkfish fed by dried natural food, commercial diet and SEAFDEC diet was determined to develop effective pond management techniques. Results show that nitrogen and phosphorus excretion rates of milkfish (ave. weight 38.8 g) fed dried natural food, commercial diet, and SEAFDEC diet were determined. Ammonia excretion (mg NH^3-N/kg fish/day) in three trials ranged from 262 to 438 in fish fed natural food, 244-574 for commercial diet, and 270-697 for SEAFDEC diet. Very low amount of nitrogen was excreted as urea (mg urea/kg fish/day): 0.0-8.8 for natural food, 0.0-24.5 for commercial diet, and 0.0-30 for SEAFDEC diet. Dried natural food contains 10.2% of ammonia while commercial and SEAFDEC diets contain 27.5%. Phosphorous excretion was minimal and very variable in all treatments (0-246 mg PO_4-P/kg/fish day).



Milkfish farming (above) remains a lucrative business in the Philippines

Water stability of various commercial feed for milkfish and tilapia is assessed (left)

Seed production (bottom) focused on the development of nursery rearing techniques

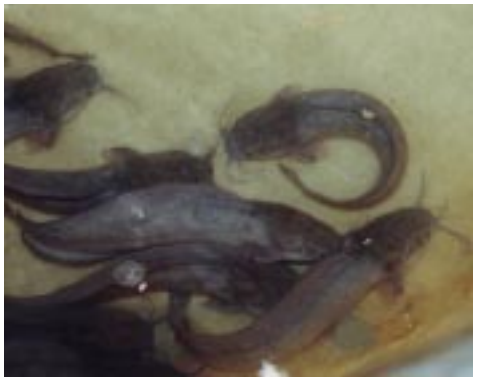
Uneaten feed is one of the contributors to water pollution. In a recent study, AQD researchers assessed the physical characteristics of commercial feeds for milkfish and tilapia namely: B-meg adult bangus BA, (28.05% crude protein, CP); B-meg juvenile bangus BJ, (29.38% CP); Excel bangus EB, (36.24% CP); Excel tilapia ET, (30.16% CP); Vitarich bangus VA, (31.1% CP); Tateh bangus TB, (27.58% CP); and Tateh tilapia TT, (28.86% CP). Water stability test showed that Tateh brand for milkfish and tilapia was the most water stable (mean range: 84.4% to 87.3%) after 30 minutes of submersion in seawater, brackishwater, and seawater. After one hour submersion, water stability ranged from 35 to 40% for all feed types.

Release of nutrients in water (ammonium and orthophosphate) from the above feeds was determined (at 25°C and pH 4, 7, and 10) to further boost water quality studies in ponds. Ammonium release was accelerated in neutral or alkaline (pH 7 and 10) media for all feed types. Orthophosphate release was rapid during the first 3 days for all seven types at all pH levels. The values started to lower afterwards.

Catfish

AQD research on the Philippine native catfish *(Clarias macrocephalus)* has progressed steadily. With catfish farmers now using AQD's fry and fingerling production method, other aspects of culture are presently being investigated to strengthen the industry.

A study to test the growth and survival of catfish fry from hatchery-bred and wild breeders stocked at densities of 400, 800, and 1200 fry/m² in net cages suspended in nursery tanks and ponds was conducted. Performance of catfish fingerlings from hatchery-bred and wild broodstock was comparable when reared in tanks and ponds. After 28 days, the



Growth and survival of catfish fingerlings from wild- and hatchery-bred broodstock are comparable when reared in tanks or ponds

Studies on catfish fingerlings in grow-out ponds would support industry growth

Tilapias

AQD continues to develop test procedures for evaluating the quality of tilapia fingerlings. A quality assessment method for Nile tilapia fingerlings based on data collected from 12 batches of commercial farm-bred fingerlings was completed. Performance of Nile tilapia fingerlings were ranked based on their biological index scores on growth and survival in tanks and cages.

Results showed that pond-bred stocks scored generally higher in both the biological index traits and survival index traits (= survival responses in all the stress tests) but when tested for growth and survival in cages, the cage-bred stocks outperformed the pond-bred fingerlings. Overall, even if an index can be established for screening tilapia stocks, growth and survival of tilapia would depend not solely on genetic but largely on environmental influences (e.g., hatchery management schemes and grow-out environment).

The reproductive efficiency of a fourth generation selected tilapia breeders was evaluated relative to a fourth generation control group and the parental generation. After 16 months of spawning in land-based concrete tanks, the control breeders had the most number of spawning and the highest seed production, followed by the select breeders. The parental population showed the lowest number of spawning and seed produced. For the breeders in cages, the control breeders gave the highest total spawning and number of fry and eggs. Mortality in the female parental breeders resulted in very low total spawning and seed production. Overall reproductive performance of fish was better in hatchery tanks than in hapa cages in the lake.

In a related study, AQD researchers further investigated the

Reproductive performance of tilapia breeders in land-based tanks and in cages is compared

Two different feeds for tilapia fingerlings is investigated

Lake-based studies of tilapia fingerlings and breeders are focused on reproductive performance and survival

tank- and pond-reared fingerlings from both hatchery-bred and wild broodstock attained similar sizes of 2.2-3.2 cm total length and 0.10-0.25 g body weight. But, survival rates were much lower among pond-reared stock (range: 4-13% in two runs) than those grown in tanks (44-80% in the first run, 26-57% in the second run) of the same batch.

The resulting fingerlings were grown further until a mean body weight (MBW) of 1.1 g and mean total length (MTL) of 5.2 cm were attained. Catfish juveniles from hatchery-bred and wild broodstock were then stocked in grow-out ponds at densities of 10-40 fish/m² and given SEAFDEC formulated feed of 34% crude protein. After 30 days of culture, catfish juveniles from hatchery-bred spawners had MBW of 8.5-10.8 g and MTL of 99.7-106.9 mm, while those from wild spawners had MBW of 7.0-7.99 g and MTL of 94.5-97.6 mm.

growth of a fourth generation select fish progeny which was communally grown with the progeny of the fourth generation control fish in three replicates for 9 weeks in polyethylene indoor tanks. Initial findings showed that the growth of the select offspring was significantly higher (4-9% higher in mean length) than the control offspring.

In another study, growth and survival of select and control fry were compared under two different feeds (artificially formulated diet and rice bran). Initial results show that growth of the select fry fed artificial formulated diet was higher than the growth of the control line.

No significant differences were found in the growth of select and control fingerlings when reared communally for six weeks in a cold room with water temperature ranging from 21 to 23°C. Growth of the two lines were also not significantly different when they were moved to outdoor tanks with water temperature ranging from 25 to 30°C.

Carp

BROODSTOCK MANAGEMENT

Bighead carp in cages in Laguna de Bay reach sexual maturity in 2-3 years. Rearing the fish to broodstock size in cages for a relatively long time is expensive and carries the risk of losing the fish during the typhoon season. Growth retardation of bighead carp as a tool for broodstock development and management was investigated. This involved rearing the fish in a crowded condition in tanks for some time.

Reproductive capacity of growth-retarded bighead carp breeders is investigated (above)

The carp hatchery (right) at Binangonan Freshwater Station

Bighead carp were stocked directly in cages (control) or reared in tanks for 6, 12, 18, and 24 months before stocking. A number of fish in the control group and those that have been reared in tanks for 6 and 12 months matured. Some of the mature fish were induced to spawn but reproductive performance did not indicate differences among treatments. Fish that had been reared in tanks for more than 12 months did not attain sexual maturity even after a total of 41 months of culture, suggesting that reproductive capacity was adversely affected by retardation of growth in tanks.

LARVAL REARING

Bighead carp larvae readily accept free-living nematodes as first food. The effect of various nematode densities (50, 75, 100, 125, and 150/ml per feeding time) was determined. Growth and survival of larvae were similar among treatments during the first 14 days. At day 21, survival rates were significantly high in fish given up to 100 nematodes/ml but body weight was highest in fish given 125 and 150 nematodes/ml.

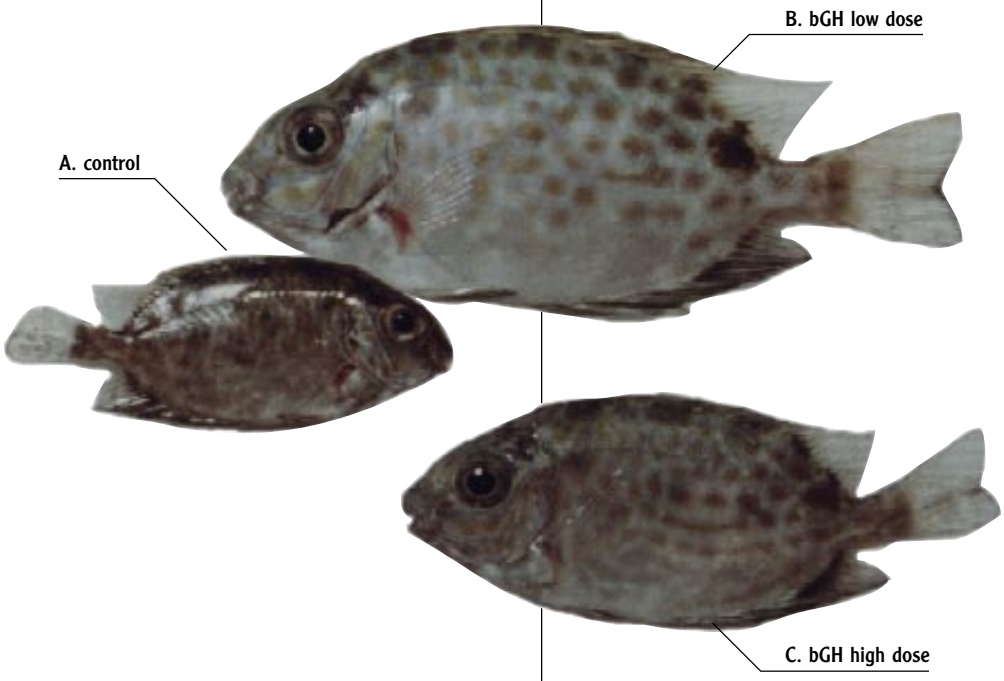
In a feeding trial using *Artemia* nauplii as control feed, bighead carp larvae were fed locally produced nematodes or nematodes cultured elsewhere and transported in sponge. Larvae fed *Artemia* nauplii had the highest growth followed by those fed locally produced nematodes. However, survival was highest in larvae fed locally produced nematodes. The low response of larvae on nematodes transported in sponge may be due to the relatively long transport time before nematodes can be used as feed.

Clay is a possible medium for nematode storage and transport. The effect of various amounts of clay (0, 0.05, 0.1, 0.2, or 0.5 g/l) added to the rearing water was determined. Larvae in all treatments were fed *Artemia* nauplii. Mortality tended to increase with increasing clay concentration but did not differ significantly among treatments. Larvae without clay had both high growth and survival in rearing water without clay.

Rabbitfish *Siganus guttatus*

The rabbitfish culture industry has not seemed to pick up due to the very slow-growing nature of the fish. For farming considerations, rabbitfish is an ideal species because it breeds in captivity, spawns regularly, and eats algae. It is prized as much as other high value fish such as groupers and snappers while production input is low.

Three studies, mainly on growth, were conducted on rabbitfish – one on seed production and the other two on the application of biotechnology in aquaculture.



Four injections of bGH weekly results in faster growth compared to fish injected saline solution. Accelerated growth is still observed a month after the treatment is withdrawn

On seed production, feeding of larvae with (a) HUFA-enriched rotifer at 15-20 ind/ml, (b) HUFA-enriched rotifers supplemented with Nosan R-1 (0.5g/ton/day), or (c) Chlorella-fed rotifers supplemented with Nosan R-1, from day 1 to day 21 resulted in comparable growth and survival.

On rabbitfish growth hormone (GH), SEAFDEC/AQD researchers successfully cloned the cDNA of rabbitfish GH in 1999 and attempted to produce GH using recombinant DNA technology. Trials are still on-going on the production of recombinant GH and insulin-like growth factors (IGF-I and II) since the cDNAs for both IGFs were also successfully cloned in 2000. Specifically, experiments are being carried out to determine the conditions for optimal production of these proteins in bacterial cells.

The expression of GH, IGF-I and IGF-II mRNAs during early development in rabbitfish was also examined to determine when the so-called growth axis (GH-IGF axis) becomes active in the larvae. This information will provide important clues on whether or not rabbitfish larvae will respond to exogenous hormonal treatments aimed at growth promotion. GH mRNA was strongly expressed starting from day 2 and onwards. IGF II seems to be expressed more than IGF I during early development of rabbitfish. The cDNAs for rabbitfish glyceraldehyde phosphate dehydrogenase (GAPDH) and B-actin were also cloned and were used as internal standard for quantifying mRNA expression.

Experiments to accelerate growth using bovine growth hormone (bGH) were also conducted. Fry given weekly bGH injections for 4 weeks showed faster growth than the control fish. Moreover, fry treated with a low dose of the hormone (0.01 mg/g BW) showed faster growth than the group given the higher dose (0.1 mg/g BW). Experiments also showed that rabbitfish juveniles grow better in dilute seawater than in full-strength seawater.

Mangrove-friendly aquaculture

IMBAO MANGROVE CLAM *ANODONTIA EDENTULA*

AQD researchers have been investigating imbao as a potential species to be cultured in mangroves. It is abundant in Visayas and Mindanao.

A fishery survey of the mangrove clam *A. edentula* (local name *imbao*) in Panay Island, central Philippines showed that collectors were all male in Estancia, all female in Sapian, and mixed sexes in Nueva Valencia. Majority of them were married, 40-45 years old, and with 5-7 children. Their highest educational attainment was grade 2 to grade 6 of primary school. *Imbao* are collected inside mangrove forests or adjacent tidal flats with muddy or sandy-muddy substrates. Field samplings revealed that *imbao* can be collected at mean depths of 25-50 cm in sandy substrate, and 30-90 cm in muddy sites. Collection is year-round during daytime (2-6 hours) at low tide. Collecting methods include locating the clam through the opening of the exhalant siphon on the substrate and digging with a flat iron blade or bare hands. It can also be detected by poking an iron rod, or by walking barefoot on the substrate. Clams are either sold directly to the local markets or through middlemen at a retail price of P1.50-5.00. Collectors earn P80-250, P110-140, and P15-150 representing 10-90%, 10-90%, and 40-100% of daily income in Estancia, Sapian, and Nueva Valencia, respectively.

LARVAL REARING

Results of the two trials pointed to the importance of the following factors in larval rearing: 1) suitable size of adults (min. SL 70 mm females, 60 mm males), 2) biopsy of eggs (presence of stalk) and sperm, 3) ratio of eggs:sperm for fertilization (3 females: 1 male), 4) washing of fertilized eggs, 5) control of water quality through UV sterilization and antibiotic treatment, and 6) temperature control through use of water bath. At water temperature of 26-28 ºC and salinity of 28-32 ppt, the embryonic and larval stages were observed as follows: 1st polar body at 20-60 min from fertilization, 2-cell stage at 1.5-2.5 h, morula at 4-5 h, gastrula at 6-10 h, trocophore at 11-19 h, veliger at 1-1.5 d, D-veliger at 2-3 d and pediveliger at 4-5 d.

IMBAO AS SEDIMENT CLEANER.

AQD researchers are also studying the potential of *imbao* as sediment cleaner. *Imbao* harbors sulfur oxidizing symbiotic bacteria in its gills that provide its food by fixing CO_3 into organic compounds through aerobic oxidation of sulfide. In a tank culture of *imbao* completed in February 2000, researchers found decreasing sulfide, from 9.65±0.78 mM at the start of a culture period to undetectable values upon termination, implying the utilization of sulfide by the clams. This capability would make *imbao* useful if raised in polyculture with shrimp and fish.

Measuring imbao length before they are biopsied to determine sex. When sex is determined, the clams are injected serotonin to induce spawning

Mudcrab (*Scylla* spp.)

Scylla species, mud crab are being studied for reproductive performance: top, *S. serrata*; middle, *S. tranquebarica*; bottom, *S. olivacea*

BROODSTOCK MANAGEMENT

To develop a reliable criteria for egg and larval quality, a study was conducted to correlate biochemical components, free amino acids (FAA), major constituents of mudcrab eggs, with their viability. Samples of viable and non-viable eggs, day-old zoea, hepatopancreas and ovary taken from pond-reared mud crabs were analyzed for FAA content. FAA levels were higher in viable eggs than non-viable eggs.

Nets are very good substrate and shelters for crablets

Transfer of nutrients from mother to egg and catabolism of FAA as eggs undergo metamorphosis were also observed. These information would help identify specific amino acids needed by early feeding mud crab larvae and may be useful in formulating broodstock diets.

The reproductive performance of ablated and intact Scylla species *(S. serrata, S. tranquebarica, S. olivacea)* were compared using the same management techniques and best broodstock diet developed in previous experiments. After 120 days, all treatments had similar larval stages index except in ablated *S. tranquebarica* where no hatched larvae was obtained.

HEALTH MANAGEMENT

Twenty-five bacterial isolates from crustacean culture environments and natural food where *Vibrio harveyi* (VH) did not occur were isolated, characterized, and tested for inhibitory effects against *Vibrio harveyi* through one-on-one tests in mixed cultures. Only 6 out of the 25 isolates inhibited the growth of VH after 24-48 h in mixed cultures as seen after plating samples on nutrient agar. A common characteristic exhibited by the six VH-antagonistic isolates is fast growth on artificial medium.

Bacteria isolated from commercial probiotics were tested for survival at boiling temperature to assess their suitability for incorporation in pelleted feeds. The probiotic bacteria remained alive in boiling water for 3 minutes. After incorporating the probiotic in artificial feed, these diets were enumerated for bacteria. A potential problem with dietary incorporation of probiotics stood out because diets that had no probiotic bacteria also yielded colony-forming units similar to diets with probiotic. This means that much of the bacterial population that showed up in the test came from fish meal and other feed ingredients and these bacteria could mask the action of probiotics during the experimental runs.

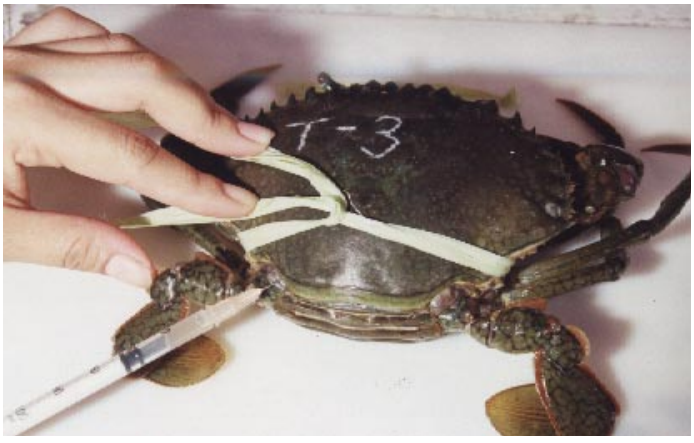
To increase survival of *S. serrata* from zoea to megalopa different water treatment schemes were tested. Results revealed best survival in rearing water treated with probiotics (3.6%), followed by antibiotics (2.4%), then activated charcoal (1.4%), and poorest in untreated control (0.0%).

NURSERY AND GROW-OUT

Various strategies to minimize cannibalism in the culture of *S. serrata* juveniles were investigated. Nets as substrates and shelters for hatchery-reared juveniles were installed in cages in ponds. After 30 days of culture, survival of mud crab megalopae to juveniles were highest using net substrates (55%), followed by seaweeds (53.2%), then abaca (47.8%) and lowest at no substrate (38.9%). Culture of crab juveniles using net as shelters showed high body weight (0.51g) compared to seaweeds (0.48g), no substrate (0.44g) and abaca (0.41g).

Trimming of pincers or total cheliped loss is more effective in reducing cannibalism than feeding and providing shelters in tanks.

A guide to identify commercially important crab species as early as juvenile stage is necessary to aid farmers in stocking desired species in ponds. As a first step,



Sampling for ovary viability in *S. serrata* broodstock

Sampling of *Charybdis feriatus* reared in hapa nets in pond

morphometric characters were identified in hatchery-reared mud crab species. Of the 27 morphometric characters examined, nine can now be used to identify at least two of the species.

AQD researchers say that the popularly called christian crab *Charybdis feriatus* has a growing market. Two wild-caught berried *C. feriatus* (BW=200 and 230 g) were monitored and found to produce one million each of zoea 1 (Z1). Survival until megalopa stage after 18 days ranged from 2-22% (first spawn) and 25-55% (second spawn). However, survival until late megalopa and crab instar 1 stage (MC1) was only 4-5%. Late megalopa were stocked in hapa nets and had a survival of 47% when stocked at 10 ind/m². Morphological changes during larval development of *C. feriatus* were also documented. This species has six zoea and one megalopa stage. After 18-20 days, the zoea metamorphosed to megalopa, and after 7-10 days to crab instar stage.

Seaweed *Gracilaria, Gracilariopsis, Kappaphycus*

AQD research on seaweeds focused on *Gracilaria*, *Gracilariopsis*, and *Kappaphycus*. *Gracilariopsis bailinae* can sequester heavy metals cadmium, copper, lead, and zinc from the water. *G. bailinae* has the capability to filter and reduce excess levels of nitrogen and phosphorous in a recirculating water system with grouper and abalone.

In a survey of *Kappaphycus* culture in the Philippines, researchers found that deep sea farming of *K. alvarezii* using multiple raft long-line technique was more productive and profitable than either the traditional monoline technique or the popularly practiced hanging long-line technique.

AQD researchers also conducted a study of the life history of *Gracilaria* and *Gracilariopsis*. Preliminary results of this study showed that spores (carposporophyte) of *Gracilaria changii, G. firma* and *Gracilariopsis bailinae* grew to 3 cm under controlled conditions of 25°C and 300 µm/m²/sec after 3 months of culture.

Agars of *G. bailinae* tested by nuclear magnetic resonance spectroscopy revealed no distinct differences in the molecular structure between weak and strong gel strength agars. Differences in the molecular size of polymers composing the agar may be possible.

AQD researchers were also able to grow young plantlets from red and green *Eucheuma denticulatum* from protoplasts 75 days after UV treatment using a special media.

Kappaphycus **culture in tanks at AQD**

AQD researchers examine *Graciliariopsis bailinae* in tanks

Examination of *G. bailinae* for uptake of chemicals

Tiger shrimp

AQD studies on shrimp culture aim to remedy the industry's mistakes in the past – high density culture without due consideration to the environment. Hence, studies were conducted to formulate less polluting feeds and to combat diseases, primarily luminous vibriosis.

AQD formulated and tested a shrimp feed that would leave less ammonia, nitrite-nitrogen, nitrate-nitrogen, and phosphate in the water. With less of these nutrients, the growth of bacteria (and some putative disease-causing organisms) could be retarded. Trials in tanks have been completed, and the AQD feed fared better than the leading commercial shrimp feed in the Philippines (see chart).

The AQD feed formulation has the same proximate analysis as the commercial feed (e.g., 38% protein). However, the AQD feed contains partially substituted fish meal; the substitute is a biotechnologically processed soybean meal, incorporated at 6%.

In addition, researchers say that the daily variation in temperature, pH and dissolved oxygen in rearing ponds was minimal. Shrimp fed the AQD feed weighed an average of 2g more (27g) than shrimp fed the commercial feed (25g). Survival and feed conversion ratio were also better, 79% and 2.48 as against 75% and 2.88. Shrimp was stocked at 15 pieces/m² and reared for 17 weeks.

On health management, AQD conducted four studies, all funded by a trust fund from the Government of Japan.

		AQD feed	Commercial feed
Water	NH_3-N	0.003 - 0.01 ppm	0.04 - 0.10 ppm
	NO_2-N	0.001 - 0.02 ppm	0.02 - 0.13 ppm
	PO_4	0.2 - 0.6 ppm	0.3 - 0.9 ppm
	Total nitrogen	28%	28%
	Total phosphorus	80%	50%
Soil	Soil pH	7.42 - 8.15	7.5 - 8.18
	Organic matter	1.09 - 1.24%	1.25 - 2.0%
	Available phosphorus	107 - 143	133 - 152 ppm
	Total nitrogen	3.78%	14.42%
	Total phosphorus	12.95%	44.65%

The studies were:

- The use of polymerase chain reaction (PCR) technique to detect white spot syndrome virus (WSSV) infection in tiger shrimp is being refined. AQD researchers say they need to improve the quality of extracted shrimp DNA.
- There may be different serological strains of *Vibrio harveyi*, the bacteria associated with luminescent vibriosis in shrimp. The degree of virulence of these strains is being tested. Mean lethal dose (LD_{50}) of isolates identified as *V. harveyi* PN 9801, BS-9904, SW-9702 and PIZ-9809 was 10^6 colony forming units (CFU) per shrimp.
- The positive effect of "green water" in a shrimp farm may be attributed to the presence of tilapia. Researchers noted significantly nil amounts of luminous bacteria in the water of a tilapia pond and in a shrimp pond with tilapia compared to a shrimp pond without tilapia. Large tilapias do not seem to carry luminous bacteria while small tilapia have 102 CFU bacteria per ml in their mucus. When researchers screened for inhibitory metabolites against *V. harveyi*, they found several yeasts that did – *Hansensula* sp., *Rhodotorula* sp., *Candida* sp., and *Cryptococcus* sp. Tests on bacteria and algae are ongoing.
- Of the 25 bacterial isolates tested against *V. harveyi* in the laboratory, six were positive. These come from spawned crab eggs, *Brachionus*, and *Chlorella* cultures where no *V. harveyi* was found. Researchers say these potential probiotics all grow fast on artificial medium.

Processing penaeid shrimp specimens (left) taken from "green water" culture ponds

Probiotic studies at AQD are conducted in these shrimp ponds (right) at the Dumangas Brackishwater Station

Abalone

AQD is refining seed production techniques for abalone to produce sufficient seeds to restore natural abalone populations through restocking.

SEED PRODUCTION

The abalone hatchery had an average production of 21 million eggs/month from 10 spawning tanks each containing 30-40 females and 10 males. Egg production was higher in March, April and May with a total of 116 million eggs compared to 113 million eggs in the 9 non-peak months. However, the total number of competent larvae produced ranged only from 0.4 to 5 million/month corresponding to an average larval survival of approximately 10%. Total production of 2-month old early juveniles was about 10,000 individuals in 9 months.

Experiment results showed that larval settlement is improved by:

- Addition of diatom slurry to settlement tanks and provision of aeration 2 days after larval stocking
- Providing a single diatom species (i.e. *Navicula* sp.) than mixed diatoms on settlement substrates
- Growing the diatom *Nitzschia frustulum* or *Navicula* sp. on substrates such as rubberized canvas, corrugated plastic sheet or plexiglass
- Using chemicals such as GABA (0.3-0.5 mM) which is similar to those released by coralline algae, and KCl (5.0-7.0 mM) which is also effective in larval settlement of other invertebrates
- Providing abalone mucus on settlement plates and on diatoms grown on settlement plates.

Since the chemical substance in mucus and other settlement inducers is not yet known, research has been initiated to extract, purify and characterize the biochemical cues for larval settlement. Preliminary results showed that mucus and mucus-secreting foot muscle have proteins with molecular weights of about 60 and 110 kDa in both samples. The settlement-inducing protein complex in other invertebrates is also within this size range. Future work will include extracting, purifying and characterizing the chemical substance also in diatoms and abalone larvae along with mucus and mucus-secreting foot samples, and testing their effect on larval settlement through bioassays.

Further refinement of seed production techniques will continue in the next few years to come up with a technology ready for adoption by the industry.

ARTIFICIAL DIET DEVELOPMENT

AQD attempted to refine its juvenile diet formulation containing 27% protein and 5% lipid, which has been proven to give better growth of abalone juveniles (15 mm initial shell length) than seaweed diet until the 80th day of culture but without growth increase thereafter. Between the two new diets formulated for 21 mm SL abalone juveniles, the diet with high protein (27%) but low lipid (2%) resulted in higher daily growth rate than those given low protein (17%) but high lipid (5%). However, juveniles fed the seaweed *Graciliaria bailinae* had the highest daily growth rates and final body size than those given artificial diets after 180 days of culture.

Seaweed-feeding broodstock spawn spontaneously throughout the year

Results showed that abalone broodstock fed a combination of artificial diet and seaweeds produced more eggs and higher hatching rates compared to those given seaweeds only. Those given only seaweeds however had a higher survival rate of 89% versus 75% for those given the combination diet or artificial diet alone.

Future efforts will be aimed to develop cost-effective grow-out and broodstock diets that would give better results than seaweeds or the combination of seaweeds and artificial diet. The use of seaweeds alone as feeds for abalone may not be economically viable and sustainable in the future.

There is now a growing public interest in the aquaculture of local abalone species

An early juvenile feeding on epiphytic diatoms. Juvenile can be subsequently fed formulated diets during secondary nursery

Experimental set-up for the study of the effects of diatom density on settlement of abalone larvae

Marine ornamental fishes

AQD studies on breeding and seed production of marine ornamental fishes continue. Procedures for producing seahorse juveniles in the hatchery are being improved. The following studies were conducted:

- a short term study to examine the acceptability of previously frozen *Artemia* feed showed that frozen HUFA-enriched *Artemia* adults with beta-carotene were totally consumed by seahorses within 3 h (in 3 of 4 replicates with 3 seahorses each) while previously frozen *Artemia* without beta-carotene were not totally consumed in all replicate tanks.
- attempts to establish mating pairs by manipulating sex ratios and age differences resulted in only two pairs of hatchery-bred *Hippocampus kuda* (1-3 years old) having successfully mated. The male was two years older than the female in one pair while the other pair was of the same age. In both cases, fish were stocked at a ratio of one male:one female and mating occurred 20-23 days after pairing. Mating pairs of *H. kuda* and *H. barbouri* offered either DHA Selco-enriched *Artemia* adults, mysids or their combination had comparable frequencies of parturition and produced similar broodsizes and stretched height of newly-born juveniles. Survival of the young at day 10 was similar.

Seahorse is popular worldwide as both a medicinal and ornamental fish

AQD studies now focus on breeding and production of seahorse juveniles in the hatchery

Mangrove red snapper *(Lutjanus argentimaculatus)*

BROODSTOCK MANAGEMENT

Following successful completion of its life cycle in captivity last year, formulation of a broodstock diet to ensure egg and larval quality and minimize use of trash fish, was undertaken. Broodstock fed formulated diet had similar mean egg production per spawn (1.24 million), percent egg viability (68.36%) and hatching (64.85%) as those fed trash fish (1.20 million, 67.10% and 68.32%, respectively). However, total egg production of fish fed formulated diet (53.39 million in 43 spawns) was lower than those fed trash fish (67.88 million from 53 spawns). Natural spawning in both groups occurred mostly between the last quarter and new moon phases. Chemical analysis of egg and larvae in each treatment to determine levels of essential fatty and amino acids are on going.

SEED PRODUCTION

AQD concentrated on the improvement of hatchery technology to ensure fry availability. Newly hatched larvae had higher survival in 3 ton tanks when stocked at 15,000 (12.9%) than at 30,000 (4.0%) or 45,000 (5.0%) larvae/ton. In another study, treatment with thyroxine either through encapsulation with *Artemia* or by immersion of 25-day old larvae did not improve survival in comparison with the control groups (96.5-98.4%).

In feeding experiments, growth and survival of 30-day old larvae fed solely on *Artemia* were relatively higher than those given a mixed diet of *Artemia* and artificial diet (1:1) and artificial diet alone. Feeding incidence for newly hatched larvae was equally higher under ambient light rearing than under 24 or 16 light period conditions.

GROW-OUT

Cage-reared juveniles fed diets containing vitamin C developed normal eyes and bodies than those fed diets without Vitamin C which had opaque eyes and soft bodies. Vitamin C levels in the brain, liver and kidney as well as histological analysis of these tissues are in progress.

A mangrove red snapper breeder is weighed

Floating cages for red snapper broodstock at Igang Marine Substation

Red snapper fed diets containing Vitamin C; inset shows opaque eyes of juveniles without dietary Vitamin C supplementation

- captive *H. kuda* juveniles were fed either rotifers alone, copepods alone, or their combination to assess the food selection trait and appropriateness of food. Gut content analysis showed that seahorses started feeding at birth (day 0) on all food types offered. Selective feeding appeared to develop as they grow, preferring larger prey to smaller ones (i.e., copepod adults over nauplii). Seahorses preferred copepods to rotifers. Growth rate was highest and mortality rate lowest in seahorses fed a combination diet; slowest growth and highest mortality rate were observed in seahorses fed rotifer diet alone.
- juvenile *H. kuda* (mean body weight [BW], 172 mg) exposed to freshwater (0 salinity) showed a mean survival time (MST) of 12 h while those (BW, 289 mg) exposed to 55 salinity had MST of 20 h. It can tolerate salinities as low as 5 and as high as 50 for at least 18 days. Significant growth in terms of increase in dry weight was observed only among those exposed to 15 to 50 salinity.

AQD researchers conducted field surveys at two locations in Iloilo to assess wild seahorse population and to provide baseline information for evaluating local impact of unintentional releases that may occur during nursery and grow-out of hatchery seahorse stocks in cages. Three seahorses *(Hippocampus comes)* and 95 synganthids *(Corythoichthys, Syngathoides, Doryrhampus)* were recorded from Igang in Guimaras Island on 4-5 May 2000 to translate to about 1 seahorse and 31 synganthids per 10 hr effort per person. At Gigantes Island on 24-26 July 2000, the survey yielded 20 wild seahorses, which were subsequently transported and reared in Tigbauan. The yield of seahorses from shallow seagrass beds and coral reefs in deep water (20m) varied from 2-6 seahorses per 10 h of effort per person.

AQD research on the development of captive broodstock and seed production of the blue tang *Paracanthurus hepatus* was conducted. Naturally spawned eggs were collected for 15-20 days monthly from June until November from captive broodstock. Spawned eggs and newly hatched larvae were characterized; growth of larvae from day 1-7 was recorded. Larvae survived until 8 days from hatching. Improvement of water management and feeding schemes would be made to increase larval survival.

Grouper (*Epinephelus* spp.)

Groupers are high value fish in local and international markets. But, production is limited due to dependence on wild fry supply, trash fish as feed, and parasitic infestations and other diseases. AQD continues to address these problems.

SEED PRODUCTION

AQD is refining grouper's hatchery technology to make it viable and sustainable. A study on the microflora of naturally spawned eggs showed that the best stage to disinfect with iodine at 75 ppm for 10 minutes is when the embryo starts "twitching."

The effects of environmental factors on egg development, hatching and survival were also examined. Mild (100 ml/min) aeration levels decrease the percentage of hatching, survival and occurrence of normal larvae. Grouper eggs at early cleavage stage have high embryonic survival and hatching rates at 32 to 40 ppt. Embryonic development and hatching were generally higher at 28°C at 32 ppt. Among test salinities (8-40 ppt), newly hatched larvae consistently had higher survival at 16 and 24 ppt up to 5 days from hatching.

The use of natural food like free-living nematodes and copepods (*Acartia* spp.) were found to be feasible for early stage grouper larvae. Inorganic fertilizers in combination with cow dung showed highest production of copepods in ponds.

NURSERY AND GROW-OUT

Presently grouper culturists rely heavily on trash fish for feeds. A study showed that animal by-product (meat and bone) meals can replace up to 80% of fish meal in the diet of juvenile grouper *(Epinephelus coioides)* without affecting growth, survival and feed conversion. In an apparent protein digestibility experiment, grouper fed meat and bone meal-based diet had comparative growth rates to those fed the fish meal-based reference diet and had significantly higher survival rate.

Studies on the monogenean *Pseudorhabdosynochus*, the most abundant parasite recovered in the gills of pond-reared grouper, were conducted. Preliminary results indicated that its eggs hatch and develop in a wide range of salinities (6-42 ppt). The life cycle of this monogenean from egg to larval stage to a fully mature parasite is completed in 13-20 days. However, without a host, the life span of the larvae (oncomiracidium) is only 4-8 hours. Parasites in pond and cage reared grouper can be treated effectively in a bath with 250 ppm formalin for 1 hour with no adverse effect on the fish.

Newly harvested grouper (inset) fed low fish meal-based diets in experimental cages at Igang Marine Substation

Grouper fingerling harvest is monitored at AQD to address industry needs

Different treatments for AQD studies on grouper parasite disinfection and control is monitored

Larval food project

AQD studies on larval food project were on the copepod *Pseudodiaptomus annandalie*, local *Navicula* sp. and the fungus Thraustochytrid.

Total abundance, egg, nauplii, and copepodid productions of *P. annandalie* was significantly higher when fed with *Chaetoceros calcitrans* (100,000 cells/ml throughout the culture period) over other microalgal species: *Tetraselmis chuii, Chlorella vulgaris, Skeletonema costatum,* at lower salinities (20-25 ppt). Average hatching rate of eggs was consistently highest at 20 ppt during the first run. Results of scale-up production of *P. annandalie* after five days of culture in 4 l, 250 l and 1 t tanks were 253.33, 591.66 and 1096.9 ind/l, respectively. When it was cultured in 10 t outdoor tanks, total abundance was 1900 ind/l. Physico-chemical parameters did not vary throughout the culture period.

Propagation of *P. annandalie* in 40 t tanks showed that mass production is possible in big tanks.

Another experiment tested the acceptability of *P. annandalie* by milkfish larvae. After 24 days of culture, milkfish larvae fed *P. annandalie* had faster growth (4.86 mm) compared with those fed other feeds such as *Artemia* sp. (11.56 mm), *Brachionus* sp. (9.39 mm), and frozen *P. annandalie* (9.38 mm). Survival rates were low in all treatments (10.53 to 18.96%) but milkfish fed live *P. annandalie* had better survival (18.96%) than milkfish fed frozen *P. annandalie* (10.53%). The second run of the experiment showed the same trend where the treatment of live *P. annandalie* had the highest mean length (mm) and survival rate (%) after 24 days of culture over other feeds.

An experiment using different species of microalgae showed that *C. calcitrans* were grazed more by *P. annandalie* compared with other microalgal species *(Tetraselmis, Skeletonema,* and *Chrorella)*. Grazing on *C. calcitrans* was also more pronounced at 20-25 ppt.

Results of the study on local *Navicula* sp. showed that the formulation of Renaud et al. (1991)* can sustain cell growth of up to 32 days in indoor and outdoor culture conditions compared with other fertilization schemes. There were no significant differences in cell biomass of *Navicula* sp. exposed to both culture conditions except for the presence of contamination (blue-green algae) in cultures located outside. For practical application, the culture of *Navicula* sp. in semi-continuous system (renewal of culture every 4 days) located outdoor, exposed to one fluorescent tube during night time is recommended. Four trial tests were attempted for *H. asinina* settlement using a single kind of diatom but no larvae settled. Biomass (cell dry weight/chlorophyll a) determination were completed.

AQD also identified and determined the abundance of Thraustochytrid isolates from fallen mangrove leaves. *Schizochytrium mangrovei* was the most abundant species observed with frequencies of occurrence ranging from 40 to 100%. Physiological studies on the combined effects of salinity and temperature on biomass production was undertaken on selected thraustochytrid isolates (two *S. mangrovei*, two *Schizochytrium*, one *Thraustochytrium* sp.). Results showed that optimum growth for *S. mangrovei* was 20-30°C in 100% artificial seawater (ASW). *Schizochytrium* sp. grew best at 20°C in 50-100% ASW, while Thraustochytrium sp. at 25°C in 75-100% ASW. Highest biomass obtained ranged from 300 to 350 mg freeze dry weight (FDW) per 50 ml broth medium (equivalent to 6-7 g FDW/L). Freeze-dried cells of selected isolates (two *S. magrovei*, two *Schizochytrium* sp., and *Thraustochytrium* sp.) were used for bioencapsulation study using *Artemia* nauplii. Live cells of *S. mangrovei* and *Thraustochytrium* sp. were also used. After a 10 h enrichment, *Artemia* were harvested, freeze-dried, and stored at -70°C for fatty acid analysis.

Culture of natural food in tanks

A researcher examines larval food species in the laboratory

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Collaborative Programs

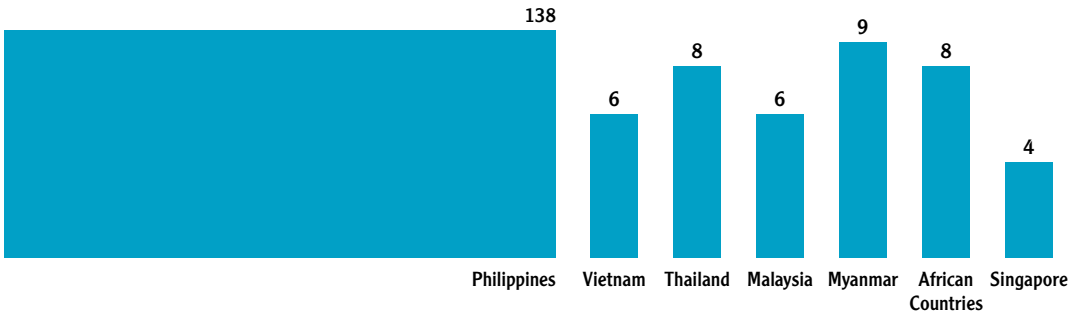
Research

- Australian Centre for International Agricultural Research (ACIAR) – for grouper *(Epinephelus coioides)* research on broodstock and seed production, nursery and growout culture, and development of practical diets for fingerlings.
- European Union (EU) – for a collaborative project on ecosystem studies in Laguna de Bay and on larval food production.
- International Centre for Living Aquatic Resources Management (ICLARM) and the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) – for the project on institutional arrangements in fisheries co-management.
- ASEAN, SEAFDEC Departments and Member Countries – through the ASEAN SEAFDEC Fisheries Consultative Group for participation in the projects Management for Sustainable Coastal Fisheries in Southeast Asia (MSCF), Promotion of Mangrove-Friendly Aquaculture in Southeast Asia, and the Development of Fish Disease Diagnostic Inspection Methodologies for Artificial-Bred Seeds.

Training

- Japan International Cooperation Agency (JICA) – for implementation of the Third-Country Training Programme on Responsible Aquaculture - Phase II.
- Department of Agriculture, Bureau of Fisheries and Aquatic Resources – for adoption of six technology verification activities: (1) environment-friendly shrimp culture in Lanao del Norte, Surigao del Norte, Bohol, Batangas, Quezon, and Negros Occidental; (2) multi-species hatchery operation and management for Pangasinan, Palawan, Samar; (3) pond and pen culture of economically important species in Quezon; (4) pond, pen, and cage culture of economically important fishes, crustaceans, molluscs, and seaweeds for Lanao del Norte, Bohol, Palawan, Surigao del Norte; (5) milkfish broodstock development and seed production in Bohol; and (6) integrated marine fish hatchery, seed production and broodstock development in Palawan.
- NGOs, fishery universities and schools, people's organizations, and financing institutions – for implementing technology verification projects in the Philippines, and for training on sustainable aquaculture and coastal resource management for LGUs and NGOs.

Attendance in Training by Country



Training Program

AQD continues to develop human resources for the region's aquaculture industry. It has three kinds of training programs: regular (classroom and laboratory), special (customized to the needs of the requesting party), and individual (for fishery students and aquaculturists).

For the year 2000, over 207 from the industry, academic, government, and non-government personnel were trained. Most came from the Philippines.

Multinational trainees during the Third Country Training for Responsible Aquaculture

In training courses, classroom lectures are the basis for hands-on practice

A training for local government units on sustainable coastal resource management is one of the special trainings conducted in 2000

Regular training Course	Duration	No. of Participants
Fish Health Management	Mar 8 - Apr 12	11
Freshwater Aquaculture	Apr 4 - May 3	17
Management of Sustainable Aquafarming Systems	May 30 - Jul 6	21
Marine Fish Hatchery	Jun 6 - Jul 14	17
	Total	66

Special Training Program	Duration	No. of Participants
3rd Country Training Program for responsible aquaculture development (TCTP-RAD)[1]	Jan 18 - Mar 17	16
Freshwater Aquaculture[2]	Mar 6 - Apr 4	3
Seaweed Farming[3]	Feb 7 - 18	1
Sustainable Aquaculture and Coastal Resources Management (SACRM) 2nd session[4]	Apr 10 - 15	20
Sustainable Aquaculture and Coastal Resources Management for Northern Negros Aquatic Resources Management – Advisory Council (NNRMAC), 3rd session[5]	May 29 - Jun 3	10
Sustainable Aquaculture and Coastal Resource Management for LGUs and NGOs (4th session)[6]	Jul 24 - 29	25
3rd Country Training for Responsible Aquaculture Development (TCTP-RAD) 2nd session[7]	Sep 5 - Nov 3	14
	Total	89

Individualized Training Program	No. of Participants
On-the-job	34
Internship	18
Total	52

Outreach Programs	Duration	No. of Participants
Seaweed farming and utilization Ajuy, Iloilo	Feb 18	42
Prawn disease prevention and treatment Gubat, Sorsogon	Jul 25 - 26	28
Coastal resources management Pontevedra, Capiz	Sep 4 - 5	80
Sustainable and responsible aquaculture practices and fishery product development Pasacao, Camarines Sur	Nov. 27 - 30	34
	Total	184

[1] Funded by the Government of Japan thru JICA TCTP – 1st session

[2] Sponsored by FAO

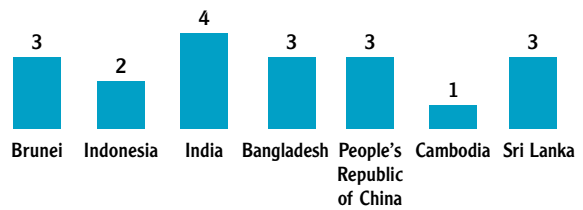
[3] Specialized course for lone Sinagapore national funded by a private company

[4] In collaboration with the Northern Iloilo Alliance for Coastal Development and PROCESS Foundation Panay

[5] In collaboration with Northern Negros Aquatic Resources Management Advisory Council (NNARMAC)

[6] 4th session of SACRM for LGUs and NGOs namely: Pipuli Foundation, Inc., Pilar Bay Management Council and BFAR Carraga Region

[7] Funded by the Government of Japan

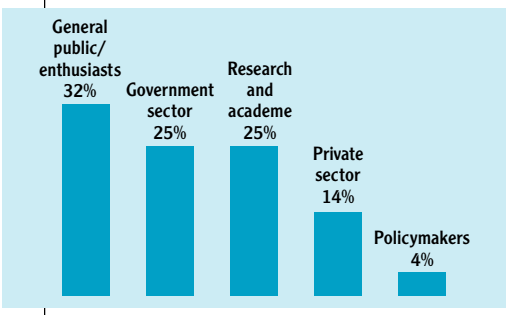


Extension materials

SEAFDEC/AQD Information Kiosk CD. A compact disc on AQD programs has been produced with the help of a private production company, UniMatrix IT. The CD presentation has two parts: institutional and the commodities part. Video clips are also included

SEAFDEC Asian Aquaculture (SAA). Six issues of this 32-page newsletter were produced and circulated by the end of 2000. The issues carried special features on LGUs and aquaculture, catfish culture, beginner's guide to aquaculture, exotic aquaculture, molluscs, and fish marketing.

The reader profile is as follows (2,500 copies of each issue is circulated):



1999 Highlights. This is a 28-page report of AQD's R&D accomplishments in 1999.

Advances in aquaculture research and development: biennial report 1998 and 1999. This is a 31-page report of AQD's accomplishments in the period indicated.

Diseases of penaeid shrimps in the Philippines (2nd edition). The 83-page manual by CR Lavilla et al. covers viral, bacterial, fungal, protozoan, and nutritional/toxic and environmental diseases. The manual has full color photographs of diseases on shrimps.

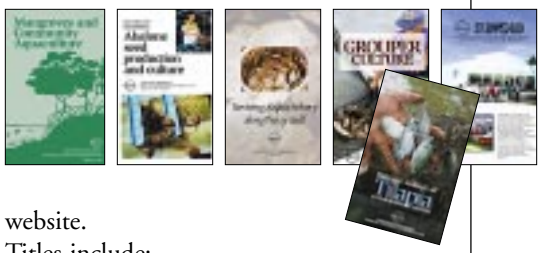
Mangrove-friendly aquaculture. This is a 217-page proceedings of the conference held January 1999, and is edited by JH Primavera et al.

Grouper culture in floating cages. This is a 10-page manual authored by DD Baliao et al, describing grouper grow-out culture activities from net cage construction to post-harvest. Economic analysis of the business venture is also included.

Net cage culture of tilapia in dams and small farm reservoirs. This is a 14-page manual by DD Baliao et al. Tilapia production in dams and small farm reservoirs is described including site selection, design of net cages, management, and profitability analysis.

Environment-friendly schemes in intensive shrimp farming. This is a 24-page manual by Dan Baliao.

Flyers. Five two-spread flyers have been published and are now included in the AQD Information Kit for visitors. These can also be downloaded from the AQD



website.

Titles include:

- Mangroves and community aquaculture
- R&D: abalone seed production and culture
- Reviving *kapis* fishery along Panay Gulf
- Grouper culture
- Netcage culture of tilapia in freshwater reservoirs
- FishWorld

Library services

At the end of 2000, AQD's library collection stands at 15,404 monographic volumes, 8,008 pamphlets, 3,226 SEAFDEC publications, and 4,800 journal volumes (bound). The Library continued with its Gifts and Exchanges program, received book donations from Dr. F. Brian Davy of IDRC Canada, Marine Biological Association of the United Kingdom Satellite Library, and Asia Foundation. The Library also received funding from the Government of Japan for journal subscription and equipment.

About 21,098 readers were recorded for 2,054 hours of library service, making an average of 10 readers per hour. Around 6,600 materials were borrowed, averaging 26 for 248 days of library service. External users were mostly students of fisheries schools.

The AQD Library also continued to computerize its systems. After a short training in March, the Library launched its Online Public Access Catalog (OPAC/Follet software) in July 6. Editing and barcoding (or electronic tagging) of all collections and databases continued.

Mass media service

To keep the general public informed of AQD activities, various news stories and features have been regularly released to the mass media in the Philippines. AQD also contributes articles regularly to the newsletter of the SEAFDEC Secretariat in Bangkok. This newsletter is circulated in SEAFDEC Member-Countries.

AQD appeared in 79 articles in the Philippine mass media this year. Of these, 67 were sourced from AQD and 12 were written by non-AQD writers. In addition, AQD stories numbered 33 in SEAFDEC Newsletter's December 1999 issue, and the March, June, and September 2000 issues.

AQD Chief Dr. Rolando R. Platon is interviewed by radio and TV anchors and reporters from local news

AQD also attended to requests by the Iloilo media to feature/interview top AQD officials in radio-TV programs. The Iloilo media were invited to two international conferences organized by AQD. Also, on August 25, the AQD Chief, the Heads of Training-Information and Administration-Finance, and the AQD Museum Curator went live on IBC TV-12 and Radyo Budyong for a 1-hr and 30 min. panel discussion. The topics included AQD programs on technology commercialization, training-extension, and environment education (FishWorld).

Visitors and inquiries

A total of 2,521 visitors were accommodated for the whole year (excluding student visitors to FishWorld). The visitors were government personnel (94.1%), foreign visitors (4.4%), and private entities (1.5%). They were briefed on AQD activities and given a tour of AQD facilities. Consultations with RD staff were also facilitated.

AQD received and responded to inquiries about its programs and activities: (1) 86 inquiries on training courses being offered by AQD; of the 86 queries, 51 are from foreign countries and 35 from the different places in the country. (2) 260 inquiries or requests for AQD publications and videos. (3) 332 written and phone queries and requests for library materials from 43 countries.

Visitors to AQD are varied. This group is a team from the Standard Chartered Bank

FishWorld

The FishWorld was opened and inaugurated in 2000 during AQD's anniversary celebration. It is an education center which aims to provide education relative to responsible aquaculture and fisheries, environmental protection, and sustainable development. It also aims to show the inter-connectedness of all life and ecosystems on earth through various exhibits.

FishWorld features a 50-seat room for lectures and video showings, oceanarium and ecosystems exhibit, children's activity room, marine science hall, culture and arts gallery, and an aquaculture room. FishWorld also holds an annual competition on the arts, science, writing, song, and dance.

The AQD environment education center was inaugurated on July 2000 during the anniversary celebration

At the FishWorld inauguration, school children view the mangrove friendly aquaculture model, including the various mangrove species that may be replanted to regain lost mangroves

AQD on-line

www.seafdec.org.ph

The AQD website continued to attract browsers interested in aquaculture. The AQD website averaged 193 visitors a week, and was in the top 20% of about one million websites that was most linked to other domains. It also consistently placed within the top ten sites searched for information on milkfish, grouper, tilapia, rabbitfish, mangrove-friendly aquaculture and lake ecology. The ranking was made by Yahoo and AltaVista, two of the most popular search engines in the internet.

Textbook project

AQD has undertaken a textbook project upon the request of the Iloilo State College of Fisheries (ISCOF). ISCOF has been using AQD's training materials, such as lecture notes for teaching fisheries courses. Six textbooks were planned to be produced. For 2000, two were in production.

Health management in aquaculture. The prototype was launched during ISCOF's August foundation day at Barotac Nuevo, Iloilo with Speaker Manny Villar receiving the draft layout and prototype cover from the AQD Chief. The book written by Lio-Po et al. covers various diseases of fish and penaeid shrimps, diagnosis, methods of prevention, immunity and biological methods of prevention, and molecular biology techniques in disease diagnosis, among others.

Fish nutrition. Also launched at ISCOF, the book is undergoing editing.

Former Philippines House of Representatives Speaker Manuel Villar receives the prototype cover of an AQD textbook from AQD Chief Dr. R. Platon

Four manuals are launched during the year. Dr. Herminio Rabanal, foremost Filipino scientist and aquaculture researcher, receives a complimentary copy of one of the manuals from AQD Chief Dr. R. R. Platon

Fairs and exhibits

AQD participated in seven agriculture fairs and exhibits organized by the Philippine government. These were in Iloilo City last March, in Quezon City in May, in Cebu City in June, in Pasay City in July, again in Quezon City and in Manila in October, and in Roxas City in December.

AQD exhibit booths welcome inquiries regarding aquaculture from the general public

AQD exhibit booth in Nasugbu, Batangas. At the closing ceremony of the nationwide Techno-caravan Program of the Bureau of Fisheries and Aquatic Resources and SEAFDEC, Department of Agriculture Secretary Edgardo Angara and AQD Chief Dr. R. Platon view the AQD presentation

Videos

Milkfish hatchery operations. This is a 12-minute video program that describes SEAFDEC/AQD's recommended mode of operations for a milkfish hatchery.

TCTP 2000. This is an 18-minute video documentary about the Third Country Training Programme (TCTP) on Responsible Development conducted January to March 2000 by SEAFDEC/AQD and JICA. The video highlights the experiences of the 16 trainees in resource and ecological assessments of seagrasses, corals, mangroves, and the rural community. The video is exclusively distributed to TCTP trainees and program coordinators

The AQD Story. An updated version of the video briefing for AQD guests and visitors. This was first shown during AQD's 27th Anniversary in July.

At the 27th anniversary celebration, the Dean Domiciano K. Villaluz Lecture series is delivered by Leocadio S. Sebastian, Ph.D. of PhilRice Institute. Dr. Sebastian, right, receives a Plaque of Appreciation from AQD Chief Dr. R. R. Platon, third from right, after the lecture

Ms. Didi Baticados (with trophy) and Dr. Jurgenne H. Primavera are both Best Published Paper awardees of the 14th Elvira Tan Memorial Awards for marine fisheries and aquaculture categories

Visitors to the 27th anniversary Philippines Department of Agriculture Undersecretary Mr. Cesar Drilon and the Honorable Mayor of the Municipality of Tigbauan Mrs. Myrna Torres inspect the aquarium stocks on display at FishWorld, an education center for responsible aquaculture and fisheries

A forum for Local Government Unit personnel of coastal towns of the municipality of Tigbauan is held with the town mayor and DA undersecretary regarding stock enhancement of the fast disappearing lampirong (capiz shell, *Placuna placenta*)

Personnel and management

As of 31 December 2000 the total number of AQD personnel staff totalled 308 with 142 in Research, 35 in Training and Information, 92 in Administration, 21 in Finance, and 18 in the Office of the Chief. Seven AQD employees were separated from the service due to retirements and resignations.

Top officials of AQD include:

Rolando Platon, Ph.D.
Chief

Susumu Ito
Deputy Chief

Clarissa Marte, Ph.D.
Head, Research Division

Dan Baliao
Head, Administration and Finance

Renato Agbayani
Head, Training and Information
(retired December 15)

Pastor Torres, Jr.
Head, Training and Information
(starting December 18)

New Ph.Ds. returned for duty

Wenresti Gallardo, Ph.D. Marine Science, Nagasaki University, Japan, March 31, 2000

Susana Siar, Ph.D. Geography, University of Hawaii at Manoa, August 13, 2000

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

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) in 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 Station

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March 2001