

2002 Highlights



Aquaculture Department
Southeast Asian Fisheries Development Center
Tigbauan, Iloilo, Philippines



AQD Chief reports in 2002

The year 2002 was another productive year for AQD. Its research output in terms of number of scientific papers published in refereed journals is among the highest annual number of such publications of the department. AQD researchers also reaped all major awards in the annual Philippine Department of Agriculture - Bureau of Agricultural Research search for outstanding research papers. Significant advances were made in the development and standardization of diagnostic procedures for important viral diseases in shrimps and marine fish.




We have introduced innovations in the conduct of our training programs. For the first time, AQD has delivered two distance learning courses serving more participants at much lesser cost. The case studies in certain traditional courses have shifted from hypothetical cases to real life situations and also actively involving beneficiaries of such studies. We have also launched an aquafarmers forum where inquiries or discussion on certain problems may be held on-line.

We have further intensified the promotion and commercialization of aquaculture technologies with a broader range of collaborators. While initially, we concentrated our technology-transfer efforts in demonstration centers of government agencies, we are now working directly with the private sector. We have collaborated with the financial institutions to demonstrate economic viability of our technologies and to provide basis for such institutions to offer appropriate financial assistance packages to fishfarmers. We have linkage with NGO's, like the Meralco Foundation, Inc. to promote aquaculture as a strategy for country-side development.

Our regional verification projects conducted in collaboration with fisheries government agencies of certain SEAFDEC member countries have also produced record breaking results.

Thus for 2002, we have expanded further our linkages with our various stakeholders. These would not have been possible without the dedicated commitment of the Department's staff and the cooperation and support of our various collaborators.


Rolando R. Platon, Ph.D.
Chief

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Managing broodstock and improving seed quality

Broodstock management and genetic improvement

EGG QUALITY IMPROVEMENT THROUGH NUTRITIONAL MANIPULATION

To improve egg quality, broodstock of snapper, milkfish, and grouper are fed with nutritionally defined diets based on available information on their nutritional requirements.

The influence of Vitamin C supplementation in milkfish broodstock diet on egg production and quality of spawned eggs was assessed. Although milkfish broodstock fed diet without Vitamin C supplementation (control) had the highest number of spawns and egg production than those fed diets containing 1.0 and 0.1% vitamin C, broodstock fed diet containing 1.0% vitamin C had the highest egg viability, hatching rate, normal larvae developed, cumulative survival of eggs to normal larvae, and vitamin C levels in eggs.

Mangrove snapper broodstock fed a formulated diet containing squid meal, squid oil, vitamin C and E, and choline chloride and glutathione (diet 3) had the highest total egg production, and number of spawns compared to broodstock fed diet without squid meal but with vitamin C and E, choline chloride and glutathione (diet 2), and control (without all supplemented ingredients - diet 1). Broodstock fed diet 2 had the highest mean egg collection per spawn but had fewer numbers of spawning. Hatching rate, percent normal larvae, and cumulative survival of eggs to normal larvae were highest in spawns of broodstock fed diet 3.

Biochemical changes in the ovaries of wild- and pond-sourced mud crab (*Scylla serrata*) broodstock in relation to five ovarian stages were determined. Ovarian

The program addresses problem areas related to broodstock management, genetic improvement, and development of improved hatchery production technologies of major cultured species. Problem areas are:

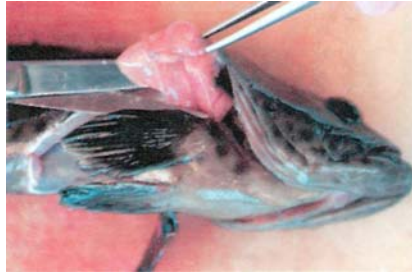
- poor or inconsistent quality of spawned eggs
- non-synchronous and unpredictable spawning of some species
- lack of information on the genetic diversity of cultured species
- lack of broodstock management and genetic selection methods for most of the important cultured species
- poor survival in the hatchery of fry and fingerlings for some species
- slow growth rates of juveniles
- economics of hatchery production



**Grouper
broodstock**



Mud crab broodstock



Collection of organ samples from grouper



Milkfish broodstock



Rabbitfish

crude protein, fat (including total lipid), and ash increased with maturation in wild mud crabs. Neutral lipid, phosphatidylcholine, total monoenoic and n-6 fatty acids, and vitamin C contents of ovaries increased with maturation, but only saturated and n-3 fatty acids continue to accumulate until stage V. Ovarian n-3 fatty acids were higher than n-6 fatty acids. These results together with information on other nutrients such as amino acids, and carotenoids will serve as basis in improving mud crab larval and broodstock diets.

ENVIRONMENTAL AND HORMONAL MANIPULATION FOR CONTROLLED BREEDING AND GROWTH ENHANCEMENT

Activities include collection of pituitary and liver samples from grouper, snapper and milkfish, and molecular cloning of growth hormone, other growth factors and gonadotropins of these species. Methods for recombinant rabbitfish GH and insulin-like growth factors (IGFs) production are being developed.

The full-length complementary deoxyribonucleic acids (cDNAs) of grouper and snapper GH, and grouper gonadotropins (GtH I and II) have been cloned. Work on grouper IGF-1 and rabbitfish GtH's are in progress.

The biological activity of recombinant rabbitfish GH (rrGH) has been tested on rabbitfish fry. Fry injected with the highest dose of rrGH (0.5µg/g body weight) were bigger than fry injected with lower dosages and in the control. Incorporation of recombinant rrGH into synthetic liposomes and its effectiveness as a medium for oral delivery of recombinant GH is being tested.

The influence of controlled temperature on milkfish breeding will be determined using a recirculating system. The system was designed to maintain a stable temperature throughout the year, particularly during months when temperature fluctuation is greatest.

Construction of two recirculating 200-m³ milkfish broodstock system consisting of a combination upflow and fluidized sand filter is completed and operational. Total ammonia nitrogen (TAN) and nitrite nitrogen levels in both systems are maintained at satisfactory levels.

GENETIC CHARACTERIZATION OF FARMED SPECIES

Genetic characterization of Nile tilapia, bighead carp, silvery therapon (*Leiopotherapon plumbeus*), kanduli (*Arius manilensis*), and native catfish (*Clarias macrocephalus*) is on-going. Silvery therapon specimens from Laguna de Bay, Sampaloc and Taal Lakes were analyzed for isozyme variation by starch gel electrophoresis. Of 12 enzymes analyzed from liver, heart, muscle, and eggs, only two enzymes, phosphoglucomutase (PGM) and alcohol dehydrogenase (ADH), were polymorphic.

Analysis of mitochondrial DNA-Restriction Fragment Length Polymorphism (DNA-RFLP) markers indicated the possibility that nine haplotypes may be present among Laguna de Bay kanduli populations.

DNA markers for the native catfish were also analyzed using Random Ampli-

fied Polymorphic DNA (RAPD), mitochondrial DNA-RFLP and microsatellites (found in some chromosomes). Eight potential RAPD markers were identified while microsatellite analysis using three primer pairs revealed no variation among the samples tested.

IMPROVEMENT OF BREEDING STRATEGIES AND STRAIN SELECTION FOR SELECTED SPECIES

To determine the influence of genetic traits and culture environment on growth, tilapia strains GIFT, NIFI, CLSU-selected, SEAFDEC-selected, and HL were grown in tanks and cages and their growth performance was correlated with selected molecular markers.

There were significant differences in specific growth rate (SGR) among the tank-reared Nile tilapia. After 12 weeks of rearing, GIFT and SEAFDEC-selected had the highest and lowest SGR, respectively, in both tank- and cage-reared tilapia. Highest genetic variation (heterozygosity or *Ho*) in the tank-reared tilapia was observed in NIFI followed by CLSU-selected, GIFT, and SEAFDEC-selected strains. In the cage-reared tilapia, GIFT had the highest *Ho* followed by CLSU-selected, NIFI, and SEAFDEC-selected strains.

Among red tilapia, tank-reared NIFI had highest SGR than HL and BFS. In cage-reared tilapia, HL had highest SGR than NIFI and BFS. Tank- and cage-reared HL had higher *Ho* than BFS and NIFI.



Nile tilapia

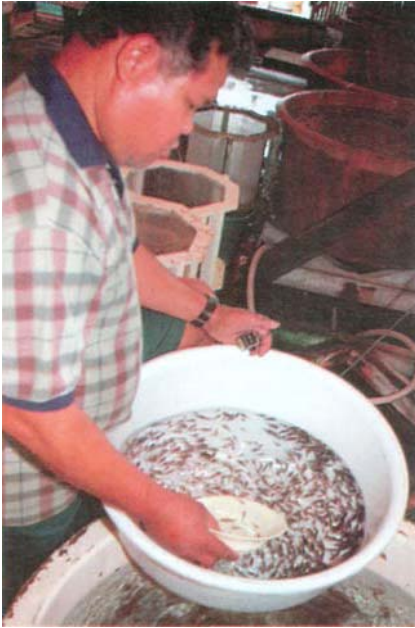


Determination of the influence of genetic traits and culture environment on growth of tilapia

Development of improved technologies for hatchery production

HATCHERY AND NURSERY HUSBANDRY TECHNIQUES

The semi-intensive seed production technique for grouper *Epinephelus coioides* was verified in 5-ton tanks. Newly hatched larvae were stocked at 10,000 to 40,000 per tank with 22 to 25 ppt seawater. Larvae were fed combination of copepod nauplii and enriched rotifers from day 2 to day 20. Copepods and *Artemia* of increasing sizes were given from day 20 until harvest, day 35. Average survival rate at harvest was 9.1%.



Grouper fingerlings



Cage culture of mud crab megalopa



The effect of continuous lighting on growth, survival and ingestion rates of red snapper, *Lutjanus argentimaculatus*, larvae was evaluated. Results showed that after two weeks of rearing, there was no difference in growth rates but larvae survived better under ambient light conditions.

To develop nursery rearing technique of snapper in illuminated floating net cages, hatchery-bred snappers (36 mm in size and 0.9 g in weight) were stocked at 75, 150, and 225 fry/m³-cage. Snappers fed mainly on light-attracted wild copepods. After 46 days of culture, the fish attained length of 60 to 66 mm and body weight of 3.6 to 4.5g. Survival ranged from 34 to 75%; average specific growth rate was 3.5% per day.

Mud crab (*Scylla serrata*) megalopa that have previously been reared for a month in hapa nets set in ponds were restocked in either hapa nets or earthen ponds at 1, 3 and 5 megalopa/m² to determine the optimum stocking density. Those grown in hapa nets had mean survival of 68%. Juveniles stocked in ponds had mean survival of 59%. Juveniles reared solely in hapa nets had body weights ranging from 3 to 7 g while those in ponds ranged from 10 to 16g.

Optimum salinity for mud crab culture was evaluated. Survival and molt intervals of juvenile *Scylla serrata* after the third molt (2.5 months after stocking) were similar among different salinities tested. *Scylla olivacea* juveniles had lower survival at 8 ppt compared to 16, 20, and 24 ppt. However, molt intervals and molt increments were not significantly different among salinities tested.

Larval stages of three species of mud crabs (*S. serrata*, *S. tranquebarica*, and *S. olivacea*) were collected to develop technical identification keys as a guide for wild seed collectors.

LARVAL REQUIREMENTS AND PHYSIOLOGY

The localization and changes in the activities of digestive enzymes (alkaline and acid phosphatases, non-specific esterase, aminopeptidase, trypsin, chemotrypsin, maltase, α -amylase, lipase, alkaline and acid proteases, and pepsin) during early development of grouper are being done.

Total lipid contents, lipid class composition, and lipid mobilization patterns of grouper eggs and larvae were determined. The total lipid content decreased from fertilized eggs to day 4 pre-fed larvae. Neutral lipid content was high in eggs and newly hatched larvae while polar lipid content was high in 2.5- and 4-day old larvae. Neutral lipid EPA was depleted at day 4, while polar lipid DHA remained abundant. In fed larvae, both neutral and polar lipid contents increased with age, with neutral lipids higher than polar lipids. Starved larvae showed the opposite trend: very low neutral and polar lipid contents with the latter having higher values. AA, EPA, and DHA were conserved more in polar than in neutral lipid. Wild grouper larvae starved for a week contained more polar than neutral lipid. DHA was lost after a week of starvation in both polar and neutral lipids while most other polar lipid fatty acids were conserved.

The efficacy of phosphorylated ascorbic acid (Rovimix Stay C-35) as a vitamin C source for milkfish larvae was tested. Larvae fed diets with vitamin C supplement showed significantly better growth and lower mortality compared to larvae fed the diet without vitamin C supplement. The minimum dietary vitamin C required for normal growth and survival of milkfish is about 200 to 250 mg ascorbic acid equivalents per kg diet.

VERIFICATION OF HATCHERY TECHNIQUES

Intensive seed production of rabbitfish was tested using the improved milkfish larval diet. Larvae fed live food were relatively bigger and had higher survival at day 21 than larvae fed the mixed diet of live food and artificial-diet. However, after seven weeks of rearing, survival was the same for the larvae fed live food, and larvae fed the mixed diet. First feeding larvae fed solely the diet had 100% mortality on day 7.

ALTERNATIVE LIVE FOOD

The suitability of the cladoceran *Ceriodaphnia cornuta* as a substitute for brine shrimp *Artemia* as feed in freshwater hatcheries was examined. *C. cornuta* can be mass produced in 1-ton tanks using the algae *Ankistrodesmus* as feed. Feeding trials using first-feeding Nile tilapia and native catfish larvae were conducted using live feed *Ceriodaphnia*, *Moina*, *Tubifex*, and *Artemia* given singly or in various combinations. After two weeks of rearing, best growth was observed in larvae fed a combination of *Tubifex*, *Moina*, and *Ceriodaphnia* (given at 70, 25, and 5%, respectively). However, highest survival was observed in groups fed *Artemia*.

Utilization of high DHA-producing thraustochytrids (*Schizochytrium mangrovei*) fungi as lipid source in marine fish larval nutrition was examined. Mass production trials using fermentors (20 ppt, 25°C, high glucose PYG enrichment medium, 5% inoculum) yielded 357.14 mg wet weight per 50 ml of culture after three days. Increasing the inoculum to 10% resulted in maximum yields ranging from 336.5-379.4 mg wet weight per 50 ml culture after one to two days.

The potential of some tropical Australian microalgae as live feed for rotifers, *Brachionus plicatilis*, and other mariculture species in the hatchery was evaluated. A cryptomonad alga from the culture collection of microalgae in Australia was successfully scaled-up under laboratory conditions. Scaled-up culture for the diatom *Nitzschia palacea* was also done. Average algal density of 2,300,000 cells per ml was obtained with the use of plant fertilizer (Manusol) given at 5 ppm.

TRAINING COURSES



Crab seed production

This training course provided 11 all-Filipino participants with technical knowledge and skills in crab seed production so they can establish or operate a crab hatchery. *Scylla serrata* was emphasized in the course. The training course was conducted from May 2 to 28.

The first international crab seed production training course was offered this year. The course ran from September 21 to October 23 with eight participants from India, Micronesia, and the Philippines.



Marine fish hatchery

Conducted from May 28 to June 26, this training course had 18 participants who came from SEAFDEC member countries. This course was developed by AQD to transfer technologies on the spawning and larval rearing of commercially important aquaculture species to its clientele. The species included were: milkfish, sea bass, grouper, snapper, and rabbitfish.

Developing responsible and sustainable aquaculture techniques



Milkfish



Feed-making

Environment-friendly aquaculture technologies

Objectives of the subprogram are to:

- Develop and promote efficient aquaculture systems and designs for maximum sustainable productivity
- Devise and determine appropriate design, equipment, and operation and management practices that optimize utilization of resources and inputs, minimize adverse impacts on the environment, and sustain biological/ecological diversity
- Demonstrate, verify, adopt, refine, and promote proven aquaculture technologies and practices
- Advance the social, economic, cultural, and policy importance of the aquaculture sector at the local, national, and regional level

NUTRIENT DYNAMICS OF AQUACULTURE SYSTEMS

Laboratory and pond experiments, and survey of the environmental condition of the receiving water (estuary in Punta Pulao, Dumangas, Iloilo) were conducted to determine the amount, forms, and flow of nitrogen (N) and phosphorous (P) from milkfish ponds to the receiving environment.

The total nutrients wastage from feces and excretion vary with the type of feed and size of fish. Using SEAFDEC formulated diet, about 28% of total N and 47% of total P consumed were lost through fecal production while 27% of total N and 42% of total P consumed were lost through excretion as total ammonia nitrogen (TAN) and phosphate (PO₄-P), respectively.

Fecal matter and uneaten feed entered the pond mostly as organic N (88 to 95%) and unavailable P (83 to 87%). Medium-scale production (semi-intensive system) has higher environmental losses of nutrients per fish production, but high-scale production (intensive system) had greater impact on the environment due to higher amount of nutrient loss. The N and P from fish waste and uneaten feed undergo nutrient transformation in the pond at biomass of 1,419 kg/ha and below, while nutrient buildup was apparent at higher biomass.

The holding capacity of unaerated, semi-intensive ponds was about 1,300 kg/ha or 50 kg feed/ha per day. The holding capacity of intensive pond supplied with aerators was about 5,000 kg/ha or 100 kg feed/ha per day. The N and P wastes were mostly transformed, discharged, and finally reached the estuary (receiving water) as dissolved inorganic N and P (DIN and DIP, respectively). Water discharge represented the major N and P output in semi-intensive pond (92.8% of N, 53% of P), and N output in intensive pond (62.8%).

In every culture period, N released to the environment represented 76% (106 kg N per ton fish) and 88% (192 kg N per ton fish) of total N in intensive and semi-intensive ponds, respectively. Phosphorus release were higher in semi-intensive pond (83% or 20 kg P per ton fish) than in intensive pond (73% or 12 kg P per ton

fish). The environmental condition of the estuary was assessed and its capacity was estimated based on the effluent discharge from milkfish ponds and water quality criteria. The estuary was characterized as net heterotrophic, and a nitrogen fixing or net denitrifying system depending upon the quality of river input. Nitrogen and phosphorus were abundant in the estuary at low tide, and the estuary was a source of DIN and DIP of fishponds around the area. At present, the environmental capacity of the estuary has been reached at low tide and occasionally at high tide. Based on N and P discharges from ponds, the capacity in terms of DIP input was about 2,200,000 mmole DIP per day.

FEED AND WASTE MANAGEMENT

The fate of uneaten milkfish and tilapia feeds was established through laboratory and tank experiments. Studies have been conducted to estimate the amount of uneaten feed and feces generated by milkfish and tilapia juveniles, and the rates of release of nutrients from feces. Preliminary results in experiment simulating intensive milkfish culture showed enrichment of inorganic nitrogen and phosphorus; higher chlorophyll *a* in tanks with milkfish culture than in tanks applied with an estimated amount of uneaten feed; and much lower but considerable fluctuations in tanks with no fish culture nor feed, generally observed during times of heavy rains and low light intensity.

CULTURE SYSTEMS AND BIOREMEDIATION STRATEGIES

The efficiency of seaweed (*Gracilariopsis bailinae*) as biofilter, as well as the growth and amenability of grouper (*Epinephelus coioides*) to intensive tank culture was evaluated in integrated recirculating tank culture systems. The system was equipped with upflow sand filters, primarily for solid removals. Changes in TAN through the *gracilaria* tanks were difficult to detect, although water quality was maintained. Measurable TAN reduction was observed in sand filtered water. About 3 kg *gracilaria* sufficiently absorbed ammonia nitrogen from 1.5 to 2 kg SEAFDEC-formulated grouper diet containing 43% protein. The grouper can thrive in properly designed and operated recirculating tank systems at high stocking densities of up to about 70 kg/m³.

Grouper density and required seaweed per kilogram of feed or grouper was verified in a recirculating system. Six kilogram of seaweed per 3 kg of SEAFDEC formulated diet efficiently maintained allowable level of total ammonia nitrogen



TRAINING COURSES

Freshwater Aquaculture

The training course was conducted at AQD's Binangonan Freshwater Station from April 2 to 30, with 11 participants from eight countries. The course included basic and advanced technologies in genetics, broodstock development, hatchery, nursery and grow-out operations of freshwater species like bighead carp, tilapia and catfish. The training session, for the first time, added a lecture topic on freshwater prawn *Macrobrachium rosenbergii*.



Management of Sustainable Aquaculture Farming System

This training course was conducted from Jul 2 to 30, and was attended by 16 participants composing SEAFDEC member countries. The course dealt with sustainable farming techniques for milkfish, grouper, shrimp, mud crab, oyster, mussel, and seaweed.

TRAINING COURSE



Health Management in Aquaculture

Ten participants from eight countries attended this training course, which ran from April 14 to May 14. The course is aimed at enabling participants to apply the principles of health management into practice such that they can distinguish diseased from healthy fish/shrimp; identify disease agents and evaluate their effects on the host; and apply methods of disease diagnosis, prevention, and control.

and nitrite nitrogen. Seaweed growth averaged 80 g/day per kilogram fresh weight. Grouper survival was 99%; harvest was equivalent to 49 kg/m³.

The integrated, intensive recirculating pond culture of *Penaeus monodon* with seaweed and bivalves as biofilters and tilapia as biomanipulators was conducted at AQD's Dumangas Brackishwater Station. The nutrient dynamics of the system is being assessed by determining through mass balance budgets for nitrogen, phosphorous, and carbon from inputs and nutrient retention in pond components, as well as nutrient losses from uneaten feed, wastes and metabolites. Shrimp production ranged from 56.7 kg to 72.1 kg in 225-m² ponds, at 35.6% to 48.1% survival and 2.12 to 2.72 feed conversion ratio (FCR).

Tank experiments are being conducted to screen probiotics for biocontrol or bioremediation in recirculating and non-recirculating culture of *P. monodon*. Treatments include a control with no probiotics, with probiotics applied directly to the water, or with probiotics incorporated in the diet. Initial results showed that probiotics did not provide added benefits in terms of growth and survival of shrimps in non-recirculating tanks. However, in recirculating tanks, average body weight and survival rate was significantly higher when probiotic was added directly to water.

Pond culture techniques of the native, Asian catfish *Clarias macrocephalus* (Gunther) are being established using juveniles from hatchery-bred broodstock. The effects of stocking density on growth, survival, FCR, production, and economics are being evaluated this year in a private collaborator's farm. Medium and large-sized catfish fingerlings were stocked at 5 fingerlings/m² and 10 fish/m², respectively, in four units of 15-m² ponds. Medium-sized fingerlings had initial weight of 8g and mean total length (MTL) of 100mm; large-sized fingerlings had initial weight of 15g and MTL of 123mm. Fish were fed SEAFDEC-formulated diet containing 34% crude protein. After 90 days of culture, good survival (83% to 100%) and FCR (1.7 to 1.9) were observed.

SOCIO-ECONOMICS AND POLICY ISSUES IN AQUACULTURE

A study on the input-market development strategies and policy agenda for Philippine aquaculture is ongoing. The initial findings showed different characteristics of the aquaculture grow-out operators, while the interview with input suppliers suggested the growing need for inputs that will complement the required growth in the changing and continuously growing aquaculture sector in the Philippines. Eight categories of inputs were covered in the study so that the interactions and the relative importance of these inputs on the development of the aquaculture sector could be evaluated. Ownership, access and rent on land suitable for aquaculture, mainly in coastal areas, are regulated but inequities occur. Except for feeds and fertilizers where market channels are organized, the credit market that comprise organized banks and unorganized private lenders, and the other input markets are unregulated and unorganized. Market share and influence over prices ranged from nil in the labor, technology and credit markets, to average for the seedstock, and strong for feeds and fertilizers. The input suppliers largely perform distributive function more than product-assembly function. While 87% of the respondents did not report problems related to aquaculture inputs, they acknowledged that the lack of capital is the primary limiting factor. Other problem areas included the sea-



sonal availability, poor quality and high mortality of seedstock, and generally low and fluctuating output price. Setting standards for seedstock and feeds is suggested to improve efficiency of resource use and facilitate sustainable production. The input suppliers overall suggested that recent growout technologies, culture systems, and environmental concerns created corresponding changes in the need for inputs and support services.

New studies this year were: refinement of mangrove-mud crab pen systems and the evaluation of mud crab fisheries in Western Visayas; analysis of farm management and economic benefits of new sustainable fish production systems in brackish mangrove areas in Western Visayas; and evaluation of property regimes, resources and services in mangrove ecosystems and their implications for the adoption of mangrove-friendly aquaculture in the country.

Twelve units of 200-m² mangrove pens were constructed in an 8-ha mangrove area in Colong-colong, Zarraga, Iloilo to evaluate the effect of various feeding regimes [natural productivity (no feeding); natural productivity + supplementary feeds (slaughterhouse wastes); fish biomass; and low-cost pellets] on mud crab production. Each pen was stocked with wild juvenile *Scylla olivacea* at 0.8 crab/m². Although juveniles given fish showed consistent growth and the biggest size increase over nine weeks of culture, there were no significant differences among feeding treatments during the first three sampling periods. Significant differences were observed during the fourth sampling, with smallest crabs observed in pens relying on natural productivity.

Trends for mud crab fisheries of *Scylla* species in Kalibo and Ibajay, Aklan were observed for eight months, using four fishing or catching gears. Initial results showed that catch varied with fishing gear, with crab numbers and biomass generally declining from March to October in Kalibo and Ibajay. Mean crab sizes in Kalibo increased during the same period, while Ibajay crabs decreased in size from May, but increased towards October. The catching gear "bintol" was selective for smaller sizes, the "tunton" for bigger sizes, compared to the less selective "tapangan" that catches the highest numbers and biomass. The "bakikong" was deployed in Kalibo to monitor migration. While catch was higher in Kalibo, size of crab was bigger in Ibajay. The ratio of male to female crabs, female maturation stage, and crab species also varied with site, catching gear, and time of year.

Study visits to mangrove areas in Panay and Negros Occidental were conducted as part of the study about property regimes and valuation of resources and services in mangrove ecosystems. The visits revealed that there are many planting and reforestation activities being initiated at different levels. ➡ continued on page 15



INDIVIDUAL TRAINING (INTERNSHIP AND PRACTICUM

One hundred thirty persons underwent on-the-job training, while 27 had internships at the Department in 2002. They worked at various AQD offices and hatcheries in Tigbauan and Dumangas, Iloilo, and Binangonan, Rizal. These include: Breeding, Feed Development, Farming Systems and Ecology, Nursery, Fish Health, Training, and Technology Verification and Extension Sections; Supply, Medical Unit, Data Bank, Library, and FishWorld; Abalone, Crustacean, and Catfish hatcheries; and Integrated Broodstock/Hatchery Complex,

Schools/colleges/universities represented in the student training included: Negros Occidental School of Fisheries, Pangasinan State University, Northern Mindanao School of Fisheries, Central Luzon State University, Mindanao State University (in Naawan and Marawi) University of San Carlos, Philippine Science High School (in Iloilo and Davao City), Zamboanga State College of Marine Sciences and Technology, St. Paul College of Iloilo, Western Institute of Technology, AMA Computer College, Computer College of the Visayas, Iloilo State College of Fisheries, Sultan Kudarat Polytechnic State College, Cebu State College of Fisheries and Technology, University of the Philippines in the Visayas, and Polytechnic State College of Antique.

Left: catfish pond;
Opposite: stocking of
catfish fingerlings

DISTANCE-LEARNING COURSES

The first distance-learning course, *Principles of Health Management in Aquaculture* (AquaHealth online) ran from April 29 to August 16 with 25 international participants. The participants acquired knowledge and skills in health management, via the internet, at their own pace and time without leaving their respective places of work. The course provided knowledge on fish and crustacean diseases, the organisms causing the disease, and the disease prevention and control.

The second online course, the *Basic Principles of Aquaculture Nutrition* (AquaNutrition online) ran from August 19 to December 19 with 22 learners from various countries. The course equipped participants with knowledge on basic principles of nutrition and feeding, and development of cost-efficient diets for cultured species.

Nutritionally-efficient feeds using alternatives to fish meal and fish biomass

NUTRIENT REQUIREMENTS OF FISH

Grouper juveniles fed the control diet (fishmeal-based) had the highest specific growth rate or SGR (3.0%/day) followed by the juveniles fed lupin seed meal-based diet (2.7%/day). Juveniles fed poultry feather meal-based diet had the lowest SGR (2.4%/day). All juveniles fed the control diet survived, however 85% and 78% survived in juveniles fed lupin seed meal- and poultry feather meal-based diets, respectively.

The apparent dry matter digestibility (ADMD), and apparent protein digestibility (APD) values for the control diet (79.41% and 95.11%, respectively), and lupin seed meal-based diet (81.05% and 95.93%, respectively) were comparable, whereas values for poultry feather meal-based diet (77.47% and 88.80%) was low.

DEVELOPMENT OF ENVIRONMENT-FRIENDLY FEEDS WITH MINIMUM AMOUNT OF FISH MEAL

In evaluating the efficacy of lupin meal to replace fish meal in the diet for juvenile grouper, *Epinephelus coioides*, results showed that lupin meal could replace 50% of fish meal in grouper feeds with no adverse effects on growth, survival, and feed conversion ratio of grouper juveniles.

The use of green peas, *Pisum sativum*, meal as potential dietary protein source for juvenile milkfish, *Chanos chanos* Forsskal, was evaluated. Results indicated that green peas could be an alternative protein source and can replace up to 20% of the total dietary protein in milkfish diets.

The potential of green pea meal as an alternative protein source in practical diets for the juvenile tiger shrimp, *Penaeus monodon* was also assessed. Protein from green pea meal could substitute up to 80% of the protein from defatted soybean meal in the shrimp diet with no adverse effects on growth, survival, feed intake, body composition, and digestibility coefficients of dry matter and protein.

Green pea was similarly tested as alternative protein source in diets of Nile tilapia. Results indicated that green pea meal could substitute up to 50% of fish meal in the diet of male tilapia and could substitute up to 35% of plant protein in tilapia diet.



Tiger shrimp *Penaeus monodon*



Grouper fingerlings

FAIRS AND EXHIBITS

During the year, AQD participated in the following exhibits



- *Agri-Food Fair 2002* in March, Iloilo City. Exhibit was spearheaded by RAFC-VI, Western Visayas Foundation in cooperation with the Department of Agriculture
- *2nd International Conference on Stock Enhancement and Sea Ranching* in January at Kobe, Japan. It was hosted by the Fisheries Agency of Japan and the Japan Sea-Farming Association. SEAFDEC was one of the 12 co-sponsors.
- *Shrimp Congress 2002* in July, Bacolod City. The Congress was organized by the Philippine Shrimp Industry Association Inc. and Bureau of Fisheries and Aquatic Resources in cooperation with SEAFDEC/AQD, Department of Trade/Board of Investments, and Industry and Negros Prawn Producers Marketing Cooperative Inc.

NEWSLETTERS, MANUALS, REPORTS, CD-ROMS

The following information materials were released in 2002:



- "SEAFDEC Asian Aquaculture." Issues released include topics on environment-friendly shrimp culture, the talk on fish health, shrimp farming, and an emerging red snapper culture in the Philippines
- CD-ROM format of book, "Regional Guidelines for responsible fisheries in Southeast Asia: Responsible aquaculture," prepared by SEAFDEC Aquaculture Department, 94 p
- CD-ROM format of book, "Use of chemicals in aquaculture in Asia," edited by , JR Arthur, CR Lavilla-Pitogo and Subasinghe, 235 p
- "2001 Highlights," a 32-page report of SEAFDEC/AQD's priority programs and accomplishments in 2001
- "Nutrition in tropical aquaculture" textbook contains research-based information from several years of studies in fish nutrition and feed development at AQD. The textbook, edited by O Millamena, R Coloso, F Pascual, is the second title released from AQD's textbook writing program. 221 p

LIBRARY SERVICES

Current collection (2002) stands at 16,957 monographic volumes, 8,612 pamphlets, 3,635 SEAFDEC publications, and 6,687 journal volumes (bound). Additional materials this year were sourced from book purchases, subscriptions (journal titles and CD-ROMs), gifts, and publication exchanges.

The library was used by 17,379 readers for 1,922 hours of library service, making an average of nine readers per hour; 5,857 materials were borrowed, averaging 18 for 325 days of library service.

AQD library also served stakeholders by replying to queries: there were 142 queries re-

ceived from 43 countries. Requesters include researchers, farmers, farm technicians, students, and information workers. Commodities of interest include shrimps, mud crab, milkfish, tilapia, seaweeds, and groupers. There were 101 press releases about AQD and another 231 related news in different newspapers.

There were 446 requests received for searching on CD-ROMS: 1,578 pages (13,530 records) were generated from these searches.

Data inputting and editing of Library collection in Follet are ongoing. Total number of records in the Follet database as of December 31 is 26,303 titles and 41,123 volumes/copies.

AQD ONLINE

The AQD website www.seafdec.org.ph continued to attract more than a thousand browsers a month. The presentation of AQD's mandates on the home page of the website was improved. The Aquafarmers' Corner, a discussion board on aquaculture technology online was created on the homepage to serve as venue for exchanging and sharing ideas and issues by various stakeholders of the industry to further aquaculture development in the country.

The website of Fish Health Section of the Asian Fisheries Society (AFS-FHS) was linked to AQD website in 2002.



Screening new species aquaculture

The program aims to search for and screen candidate species of aquatic fishes, shellfishes, and plants suitable for culture.

REPRODUCTIVE BIOLOGY OF CANDIDATE AQUACULTURE SPECIES

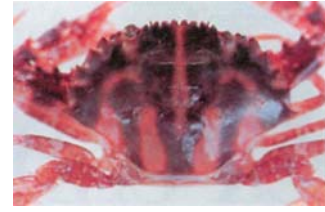
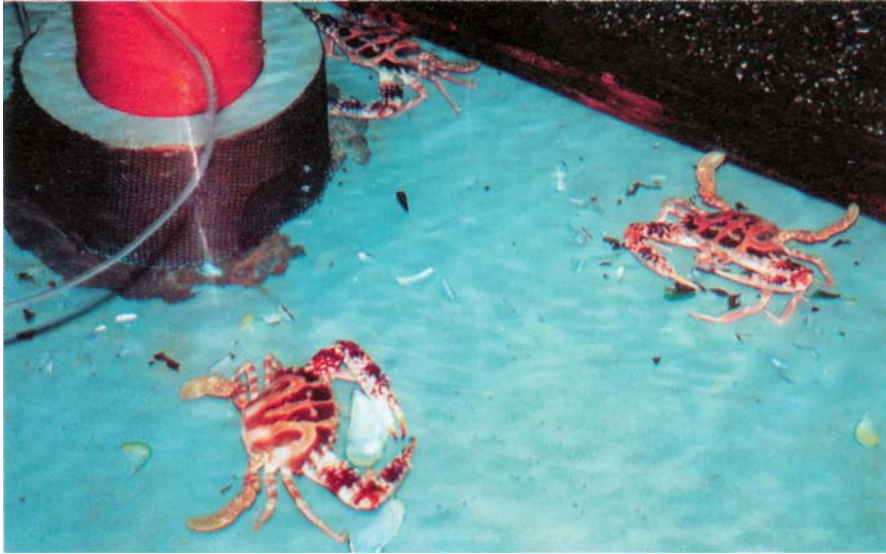
Several native species of fishes and shellfishes have been identified as possible aquaculture candidates either for food or for the marine ornamental fish trade.

Surgeonfish or blue tang (*Paracanthurus hepatus*) seed production from captive broodstock has been one of the focuses of research. The survival of blue tang larvae is correlated with food combination, salinity, and the frequency of water change. Five to six days after hatching was established to be a critical stage of larval development. Two batches of blue tang larvae survived until days 12 to 14 when reared in furazolidone- and oxytetracycline-treated water and fed combination of cryptomonad, oyster free-swimming larvae (trocophore), and marine ciliates.

Wild adult portunid crab *Charybdis feriatus* were collected in deep water (20 to 30 m) in Panay and Negros Islands. Crabs weighing 200 to 350 g were sexually mature. Wild-caught broodstock weighing 250 to 350 g held in tanks for a week and fed mussels and annelids may not require eyestalk ablation to spawn or remature. Wild-caught berried females produced more zoea per gram body weight than wild-caught females that matured in captivity. Repeated spawnings occurred until 14 days after the first spawning. Water depth tested in portunid crab broodstock tanks varied from 0.3 to 1.0 m, after adopting the mud crab broodstock rearing protocol. However, cannibalism and shell disease among broodstock held in shallow-water tanks were observed, resulting in low broodstock survival (29 to 40%).

Blue
tang





**Portunid
crabs**

More crabs spawned in covered tanks than those in tanks exposed to ambient light.

C. feriatus zoea molted to megalopa 18 to 20 days after spawning; megalopa molted to crab stage 25 to 30 days after spawning. Survival of megalopa fed live food in different combinations (*Tetraselmis*+*Brachionus*+*Artemia* and *Tetraselmis*+*Brachionus*) varied from 26 to 33%. No megalopa survived among larvae fed *Chaetoceros*+*Artemia*.

Survival until late megalopa and crab instar 1 was 4 to 5% in 1-ton tanks but reached 25 to 55% when reared in 3-liter containers. Immediately after and 24 to 48 post-simulated transport, megalopa had similar survival rates (15 to 30%) at loading densities of 50 to 150 megalopa/liter. The survival rate of crablets transported for six hours in oxygenated water was higher (63%) than those transported in moist paper only (18%). Survival of megalopa decreased from 47% to 25% when stocked in hapa nets at densities of 10 to 30 megalopa/m². Crab juveniles stocked in ponds had less than 1% survival rate.

Socio-economics and policy issues... ↩ Continued from page II

Two sites have already been selected for the case study: Carles in northern Iloilo and Escalante City in northern Negros Occidental. Coordination with local officials was made, and the questionnaire on resources, users, and rules of access has been prepared and pre-tested in the two sites. A listing of mangrove resource and services (MRS) in Carles was obtained during the structured interviews and focus group discussions. A set of MRS lists was completed for each of seven barangays. The resources identified by the respondents were mainly mangrove flora, shells, crustaceans, and fishes; while services included flood protection and fish juvenile habitat. The lists also included the corresponding prices (if marketable), effort to gather or catch (hours/day/month), and perception of abundance or scarcity of each MRS. Free-listing exercises were also started in Carles and Escalante City, and interviews are continuing.

Developing strategies for stock enhancement

This program aims to develop technologies for seed production and stock enhancement of mollusks and invertebrates, initially through the release of hatchery-produced juveniles into natural environments. Its current focus is on high value species that have high potentials for increasing livelihood opportunities in the coastal areas. To be developed by the program are strategies for the following activities:

- Mass seed production and tagging
- Release and monitoring
- Marine protected areas and artificial reefs
- Co-management of resources

SEED PRODUCTION AND TAGGING OF ABALONE AND TOP SHELL

Refinement of breeding and seed production techniques for abalone (*Haliotis asinina*) and top shell (*Trochus niloticus*) has been carried out to mass-produce juveniles for release into natural habitats, and for stock enhancement.

Increasing the number of abalone spawners from 50 to 100 individuals (1:4 male to female ratio) per 1-ton or 600-liter tanks doubled egg production, thus, optimizing tank capacity. Abalone broodstock (1 male and 1 female per 60-liter tanks) fed artificial diet or a combination of artificial diet and seaweeds produced more eggs and larvae than those fed seaweeds only. The use of ultraviolet-treated (UV-treated) seawater in incubating free-swimming (trochophore) larvae doubled or even tripled production of more developed larvae (veliger) than using sand-filtered seawater only. The optimum stocking density of abalone ranges from 200 to 250 larvae/liter. The use of grazed diatom plates and UV-treated seawater resulted in significantly higher larval settlement rate than un-grazed diatom plates and sand-filtered seawater only. To produce abalones with clear and distinct bluish-green shell band, 10 to 12 mm juveniles are stocked at 200 individuals per 50-liter tank and fed artificial diet for three to four weeks. Due to improved seed production techniques, abalone juvenile production was more than doubled from the 21,446 juveniles in 2001 to 47,600 juveniles in 2002.

Top shell seed production techniques developed in other countries were adopted and refined. Four induced spawnings produced 9,215 juveniles that developed from 1,750,333 larvae, which hatched from 14 million eggs. Some of the juveniles are now being fed artificial diet to produce the reddish-pink shell band that can be used as identifying mark when released for stock enhancement.

RELEASE AND MONITORING OF HATCHERY-PRODUCED ABALONE, TOP SHELL, AND GIANT CLAM

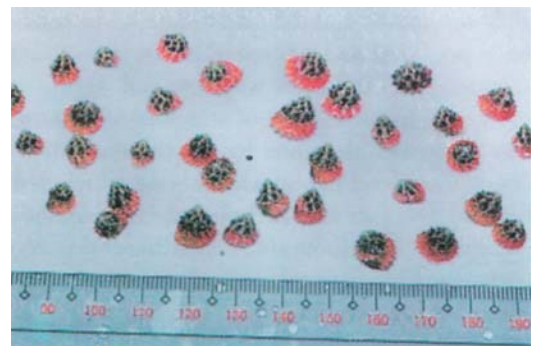
Sagay Marine Reserve was selected as a pilot site for the release of hatchery-produced abalones because the site has low density of the wild abalone, and is well-protected by an active *Bantay Dagat*. A seminar on resource management and stock enhancement was conducted in April for the Sagay Marine reserve staff



Giant clams



Diet-tagged abalone juveniles



Diet-tagged top shell juveniles



Monitoring released abalone

and other key people in preparation for the experimental release. In June, 1,800 hatchery-produced abalone juveniles of four different size-ranges (1.5-2, 2.5-3, 3.5-4 and 4.5-5 mm shell length) were released in Carbin Reef to determine the optimum size for release. Results indicated that the bigger ones (4.5-5 cm) had lower survival because they are more susceptible to predation by reef crabs. The smaller abalones were more cryptic and more difficult to find by predators, thus, survival was higher. Noting the results of the experimental release, another 2,500 (3 cm) abalone juveniles were released in October in another site in Carbin Reef.

Six and two months after the first and second releases, respectively, the abalones within 5 m from both sides of the release point were monitored by quadrat sampling so as not to destroy the corals. There was considerable growth of the released abalones and the recovery or recapture rates were 6.9% and 12.3% after two and six months, respectively.

An experimental release of 750 hatchery-produced top shell juveniles of three sizes (1, 1.5 and 2 cm shell height) was conducted in a coral reef in Igang Marine Substation to determine the optimum size for release.

The giant clam (*Tridacna gigas*) juveniles obtained from UP Marine Science Institute in October 2001 were reared in flow-through tanks. In February 2002, 300 giant clams were transferred to Igang Marine Substation for ocean nursery rearing. In September, giant clams more than 10 cm shell length were transferred from the ocean nursery cages to the coral reef for grow-out. Growth and survival of giant clams in tanks, cages, and on coral reefs are being monitored.

NURSERY AND GROW-OUT OF JUVENILE SEAHORSES IN ILLUMINATED SEA CAGES

In preparation for stock enhancement, one- to three-month old *Hippocampus barbouri* juveniles produced in the hatchery were reared in lighted, and un-lighted sea cages at AQD's Igang Marine Substation. Thawed *Acetes* were fed to a group of unlighted and lighted cage-reared seahorses; another lighted cage-reared group was not fed thawed *Acetes*.

Lighted cage-reared seahorses fed *Acetes* were significantly heavier (2.24 g) and longer (8.2 cm) after ten weeks of rearing. Mean body weight (1.49 g) and stretch height (7.25 cm) of seahorses in the control were not significantly different from those reared in un-lighted cages and fed *Acetes* (0.87 g, 6.3 cm, respectively).

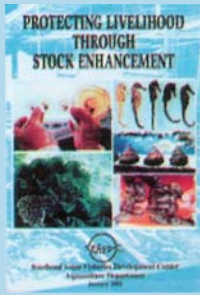


Giant clams reared in tanks



Monitoring of abalone released at Carbin Reef

PUBLICATION



"Protecting livelihood through stock enhancement," a two-page flyer on AQD's priority program

SEMINAR

A seminar on resource management and stock enhancement on April 24 was conducted for the Sagay Marine Reserve staff and other key people in preparation for the experimental release of abalone.

Seahorses grown in lighted cages and fed *Acetes* exhibited high mean specific growth rates (SGRs) based on body weight (3.6% g/day) and stretch height (1.14% cm/day). However, seahorses in lighted cages and fed *Acetes* exhibited lower survival (53.9%) than the other groups (78.9 and 79.8%), although survival rates among all groups were not significantly different.

MARINE PROTECTED AREAS AND ARTIFICIAL REEFS

The impact of marine protected areas and artificial reefs on coral reef fisheries in Malalison Island, Antique and Tangalan, Aklan were investigated. The mean size of commercially important fish groups were significantly higher in protected areas (Guiob and Pungtod reefs) than in fishing areas (Nablag, Kawit and Pangayawan reefs). Acanthurids comprised most of the catch in all sites (15.1% to 30.8%). Caesionids were caught mostly in Guiob (15.5%) and Kawit (15.1%) reefs compared to the other sites (1.9% to 6.1%). Chaetodontids and Pomacanthids were consistently high in all sites (15.5% to 18.5%) except in Kawit (4.5%). Holocentrids were caught more in Malalison sites (10% to 22%) than in Aldan sites (1.4% to 4.6%).

The study on the impacts of Sagay Marine Reserve showed that the level of rule compliance and resolution of conflict related to fishing had significantly improved, and there has been a significant reduction of threats (dynamite fishing and intrusion of commercial fishing) to the marine resources of Sagay Marine Reserve. However, fish and abalone abundance were still low. This has been attributed to problems and difficulties in the management of the 32,000-hectare marine reserve.

CO-MANAGEMENT OF RESOURCES

Five years after the establishment of LIPASECU Bay Management Council, Inc. (comprised of Libertad, Pandan, Sebaste, and Culasi), more than half of the problems in fisheries identified by the Council members are still related to law enforcement. These include the intrusion of commercial fishing vessels and outside fishers within municipal waters, and destructive fishing practices such as the use of dynamite and fine mesh. Among the problematic fishing gear identified are sinsoro (beach seine), pakpakan (ring net), lantsa (ring net), and panting kalabaw (tuna drift net).

LIPASECU is gaining strength despite changes in the composition of local government officials sitting in the Council (mayors and municipal councilors). Despite the difficulties it has encountered, it has caught the attention of other sectors and earned their accolade. It was awarded the "Best CRM Program" in 2001, and the Tingib Marine Sanctuary of Libertad was a recipient of the "Best Managed Reef Award" in 2001. In May 2002, it successfully presented a 10-year Integrated Coastal Resource Management Plan where many multi-sectoral groups attended and made commitments in support of the Plan.



Artificial reef



Stock assessment at LIPASECU Bay

Special programs

ASEAN-SEAFDEC FCG Programs

MANGROVE-FRIENDLY SHRIMP CULTURE TECHNOLOGY

Verification and pilot demonstration

To determine whether techniques known to be successful in a particular country or area can be adopted in other countries, four verification and pilot demonstration activities have been implemented:

Philippines Verification and refinement of intensive shrimp culture technique was conducted at AQD's Dumangas Brackishwater Station (DBS).

Verification of the closed recirculating system for shrimps at densities between 15 to 25 pcs/m² was conducted in 2002 following the same system used in 2001. The objective is to improve the quality and size at harvest. The verification ponds are six 1,000 m²-ponds that uses a common reservoir and sedimentation pond.

Thailand Verification and refinement of intensive shrimp culture technique was also conducted in Thailand. Three verification activities have been implemented in various centers: (1) Marine Shrimp Research and Development Center (MSRDC) of the Department of Fisheries (DOF) in Songkhla; (2) Andaman Marine Shrimp Research and Development Center (AMSRDC) of DOF in Phuket; and (3) the Kung Krabaen Royal Development Study Center (KKRDSC) in Chantaburi.

Vietnam One 8000 m²-pond was used for *P. monodon* culture and another 8000 m²-pond for *P. vanamei*, applying the semi-intensive culture systems. A big pond with mangroves is intended as water settlement and bio-filter pond in order to avoid the entrance of contagious diseases from outside.

Myanmar In order to demonstrate good pond management and to make sure that the protocols for environment-friendly shrimp farming are strictly car-

SEAFDEC AQD collaborates with various organizations and aquaculture research funding institutions to bring to fruition a number of special programs, which are grouped into: ASEAN-SEAFDEC Fisheries Consultative Group (FCG) Programs; BFAR-SEAFDEC Collaborative Programs; Bilateral Projects of the Philippine Government with AQD as Implementing Agency; SEAFDEC-JIRCAS Collaborative Program; ASEAN-SEAFDEC Special Five-Year Program on the Contribution of Sustainable Fisheries to Food Security in the ASEAN Region; and Other Collaborative Programs that are incorporated in the major programs implemented by AQD.



Water monitoring

Mangrove-friendly shrimp pond

TRAINING COURSES



Mangrove-friendly shrimp aquaculture

Conducted from July 7 to August 27, the course had ten participants from Malaysia, Vietnam, Cambodia, Thailand, Indonesia, Brunei, and Myanmar (one participant each); the other three came from the Philippines. The course was a component of the ASEAN-SEAFDEC program, and provided participants with a basic understanding of the mangrove ecosystem and technical skills on shrimp culture so that they can grow shrimp in a sustainable and mangrove-friendly manner.



Hands-on training on diagnosis of viral diseases of shrimps and marine fish

The "SEAFDEC hands-on training for detection of important viral diseases of shrimp and marine fish" ran from November 6 to 19 in Collaboration with Office International des Epizooties (OIE) and Networks of Aquaculture Centers in Asia-Pacific (NACA). The training aimed to train national trainers of SEAFDEC member countries. Of the 12 trainees, NACA funded two; Government of Japan funded the rest. Troubleshooting and supplemental training are planned for the same trainees in 2003.

ried out, AQD dispatched one of its technicians on detail to Yangon, Myanmar from February to May 2002. Together with the AQD technician, the Department of Fisheries-Myanmar also assigned its own technical staff to carry on with the activity after these two pilot verification runs.

Results of the two verification runs were very promising, considering that some ponds near the project site were devastated by the white spot syndrome virus (WSSV).

Nutrient cycles

Phase II of this study intends to evaluate the environmental impact of intensive shrimp culture, based on actual conditions with the integration of green water technique and seaweed, with bivalves as biofilters in a closed recirculating pond system. *Penaeus monodon* juveniles, tilapia and oysters were stocked at 30, 15, and 10 individuals/m², respectively. Seaweed (*Gracilaria* sp.) was stocked at 90 kg/canal.

Stock sampling was done every 20 days. The average body weight of shrimps in all treatments did not differ.

Capacity of mangrove to absorb effluents

The capacity of mangroves to process shrimp (*Penaeus monodon*) pond effluents was determined in an impounded natural mangrove area. Twenty four-hour monitoring of effluents showed that removal of suspended solids by the mangrove system was similar day and night, whereas there was net removal of ammonia and nitrate in the day and net production at night. Based on a rate of 115.3 mg total nitrogen (N) removed/m² mangrove per day from this study and published values of N loss in culture ponds, and N composition of feeds and feeding rates, 1 ha of natural mangroves was calculated to process excess N produced by 2,750 kg of shrimp. This means that 0.7 to 1.1 ha, 1.4 to 2.2 ha, and 2.2 to 3.3 ha of mangroves are needed to support stocking densities of 10, 20 and 30 shrimp/m², respectively.

AQUACULTURE DISEASE MANAGEMENT

Establishment and standardization of diagnostic methods

Development of sensitive diagnostic methods of hepatopancreatic parvo-like virus (HPV) and monodon baculovirus (MBV) was undertaken. Experiments showed that *Penaeus monodon* postlarvae with hepatopancreatic parvovirus (HPV) infected other *P. monodon* postlarvae in the same aquaria (horizontal transmission). Experimental infection of HPV produced enough viruses for monoclonal antibody (MAb) production; hybridoma were produced.

Identifying populations of wild shrimp *P. monodon* broodstock that are free of important viruses is important in order to secure virus-free broodstock; nationwide sampling was done. Optimization of Polymerase Chain Reaction (PCR) for detection for White Spot Syndrome Virus (WSSV) and MBV was undertaken. Sample analysis using refined PCR technique is ongoing. Adjustments of PCR technique for Yellow Head Virus (YHV), HPV, and Taura Syndrome Virus (TSV) are ongoing.

Tissue filtrates from grouper, milkfish, sea bass, and rabbitfish were assayed for viruses using E-11 cell lines. Results showed that 5 out of 15, 2 out of 36, and 5 out of 8 of unexplained grouper disease cases from 2000 to 2002 were related to viable viruses, predominantly Viral Nervous Necrosis (VNN). The viruses isolated from rabbitfish and red snapper were



Detection of viral pathogens

not VNN and needs to be identified.

The pathogenicity of nodavirus from orange-spotted grouper from the Philippines was tested for orange-spotted grouper, seabass, mangrove red snapper and milkfish. The results showed that all fishes tested were susceptible to the virus, indicating the danger of the disease to cultured fishes other than grouper.

To establish a model of preventive measures for VNN in the hatchery, grouper broodstock in AQD hatchery were screened for VNN. Broodstock were separated into *VNN-negative* and *VNN-positive*; eggs are being monitored for VNN. *VNN-positive* broodstock spawned *VNN-negative* eggs until sixth to seventh day of spawning. However, the eggs from succeeding spawning were *VNN-positive*, indicating the importance of monitoring eggs.

Biology and pathogenesis of disease agents

Parasites of cultured red snapper include protozoan ciliates, skin fluke, gill fluke, and copepod, with the gill fluke (*Haliotrema*) as the most prevalent. Rabbitfish harbored protozoan ciliates, gill fluke, copepod and nematode, with protozoan (*Trichodina*) as the most prevalent parasite. Digenean (*Gauhatiiana*) was the most prevalent parasite of catfish; other parasites include protozoan ciliate, gill fluke, digenean, and nematodes.

Monogenean infection in grouper showed higher mortality with increasing infection rate; 500 adult monogeneans per ten fish resulted in mortality of all fish in 72 hours. Higher infection rate in fish showed lower hematocrit value, indicating that the parasite decreased red blood cells. Experiment on the effect of temperature on hatching rate of monogenean egg showed hatching rate of 67 to 85% from 25 to 35°C. Thus, monogenean had a wide range of temperature adaptation.

Hydrogen peroxide (H₂O₂) application to control marine leech was not effective because the experiment showed that leech was resistant to H₂O₂.

Disease prevention and control

Candidate probiotic bacterium (strain C1) was found not pathogenic to crab larvae. The bacterium was successfully bio-encapsulated into larval food, *Artemia* nauplii, with no significant effect on nauplii survival. Colonization of the probiotic bacterium on *Artemia* cysts showed lower *Vibrio* population associated with nauplii compared to that of control. Probiotic bacterium introduced to rearing environment through surfaces of artificial material (corrugated plastic sheets), and natural material (window-pane shell, *Placuna sella*) indicated higher efficiency in the surface of natural material. Therefore, bacterial flora of rearing water can be influenced either through colonized surfaces or through bio-filtration system.

Screening of probiotics as biocontrol or bioremediation in the rearing of *P. monodon* was investigated using 250-liter tanks; recirculating system was found to be more efficient and appropriate than non-recirculating system. Probiotic A was effective when added in the culture water but not in the food.

Antibacterial metabolites in the microbial and phytoplankton flora of the green water cultured *P. monodon* was assessed. Algal isolates associated with the green water culture were further screened for inhibitory metabolites against disease-

PUBLICATIONS



"Regional Guidelines for Responsible Fisheries in Southeast Asia: Responsible Aquaculture" was published in 2001 thru the efforts of FAO and NACA as well as other agencies. It is now being translated into national languages in the region.

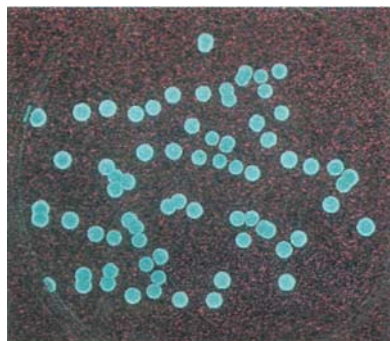


Proceedings of fish and shrimp disease workshop

"Disease Control in Fish and Shrimp Aquaculture in Southeast Asia - Diagnosis and Husbandry Techniques," 215 pages, edited by Y Inui and ER Cruz-Lacierda. This volume contains the 14 papers presented at a seminar-workshop held December 4 to 6, 2001 that was organized by SEAFDEC and Office International des Epizooties.



Isolation of hepatopancreas for viral detection and identification



Pure culture of *Vibrio harveyi*



Tiger shrimp broodstock

TRAINING COURSE



Mariculture

Five participants coming from their respective municipality (Nueva Valencia, Jordan, Buenavista, San Lorenzo and Sibunag, Guimaras) participated in this special hands-on training course. The course ran from August 5, 2002 to January 16, 2003. Through lecture and practical sessions, the training provided participants with knowledge and skills in cage culture and broodstock development of economically important fishes.

causing luminous bacteria, *Vibrio harveyi*. *Chaetoceros*, *Nitzschia*, *Leptolyngbia*, *Skeletonema* consistently inhibited *V. harveyi* while *Chlorella's* inhibitory effects were inconsistent. Mucus from rabbitfish, tilapia, seabass, red snapper, and milkfish inhibited *V. harveyi*.

Bacteria that were found to inhibit *V. harveyi* were combined to develop probiotics. Experiment showed that developed probiotics effectively reduced *V. harveyi* in the pond soil.

The mechanism of tilapia-integrated water in controlling *V. harveyi* in shrimp culture was determined. Stocking tilapia higher than 300 g/ton shrimp or stocking milkfish and grouper with tilapia was effective in controlling *V. harveyi*.

Establishment of evaluation methods for residual chemicals in aquaculture products

Detection of pesticide residues in aquaculture products was conducted to validate, standardize and develop analytical methods for sampling, extraction and quantification of pesticides in aquaculture products. The recovery and efficiency, detection limits and reproducibility of the methods for 26 pesticide residues have been established. No significant detectable concentration of the pesticides, of which detection methods had already been standardized, was detected in sampled and analyzed aquaculture products (shrimp, milkfish, grouper, seabass, siganid, catfish, tilapia, and seaweed).

BFAR-SEAFDEC collaborative program

SEAFDEC-AQD has continued to strengthen its linkage with various agencies and institutions in the Philippines, its host government, especially with the Bureau of Fisheries and Aquatic resources (BFAR) for the development of aquaculture technologies for use of lakes; commercialization and promotion of developed aquaculture technologies; and strain improvement of commercially important seaweeds. The experience of AQD in disseminating aquaculture technologies in the country will be duplicated in other SEAFDEC member countries.

DEVELOPMENT OF APPROPRIATE TECHNOLOGIES FOR USE OF LAKES

This subprogram aims to determine the carrying capacity of major lakes currently used for aquaculture activities, conduct studies on pollutants in Laguna de Bay, and investigate toxic algal blooms in the lakes.



Laguna de Bay



Shrimp harvest at Dumagas Brackishwater Station



Shrimp harvest at Lanao del Norte

Toxins in algae

The possible stimulation of *Microcystis aeruginosa* bloom by different aquaculture wastes was investigated. Results showed that the treatment with the combination of ground pellet feed and lake water had high *Microcystis* count at 2.42×10^5 cells/ml on the fourth day of the experiment. This treatment also had the highest inorganic nitrogen concentration of 3.2 mg/L. Eight species of blue-greens, 25 species of greens, 12 species of diatoms, and 1 species of flagellate were found in the different treatments.

The effect of purified microcystin-LR (MC-LR) on red tilapia (*Oreochromis* sp.) given intraperitoneal injections at concentrations of 0.1 to 10,000 $\mu\text{g}/\text{kg}$ to red tilapia (*Oreochromis* sp.) was also determined. An LD₅₀ of 1,300 $\mu\text{g}/\text{kg}$ MC-LR in this fish was obtained.

COMMERCIALIZATION AND PROMOTION OF DEVELOPED TECHNOLOGIES

The Joint Mission for Accelerated Nationwide Technology Transfer Program (JMANITP) is a program conceived by AQD and BFAR in 1999 to undertake essential techno-transfer activities jointly utilizing their respective technical, financial, physical and manpower resources.

Environment-friendly schemes in shrimp farming

The semi-intensive and modified extensive culture systems employing environment-friendly schemes in shrimp farming was conducted at AQD's Dumangas Brackishwater Station (DBS).

The stocking density used for the semi-intensive and modified extensive culture systems was 15, and 5 pcs/m², respectively. One pond with an area of 8,782 m² was utilized for the semi-intensive culture system while another 8,931 m² pond was used for the modified extensive culture system. These two systems required the use of a treatment pond with baffles, seaweeds and biomanipulators and the other schemes employed in the closed-recirculating and low-discharge intensive run. The semi-intensive pond yielded 4,696.8 kg while the modified extensive pond yielded 1,749.5 kg. The pond stocked at a lower density attained an average body weight (ABW) of 34 g after 118 days of culture (DOC) while the pond with a higher stocking density had an ABW of 31 g after 121 DOC.

In Botong, Taal, Batangas, the modified extensive and the semi-intensive culture system was also implemented using two 2,000 m² ponds. After 108 DOC, the modified extensive pond (stocking density of 5 pcs/m²) yielded 332.8 kg of shrimps, which is equivalent to a production rate of 1,664 kg/ha. In the semi-intensive pond (stocking density of 15 pcs/m²), the yield was 912.6 kg after 109 DOC, which is equivalent to a production rate of 4,563 kg/ha.

In Lala, Lanao del Norte, the semi-intensive culture system was utilized in two 4,000 m² ponds stocked at 15 pcs/m². Another two 4,000 m² ponds were utilized as treatment ponds and reservoir ponds at the same time to meet the water requirement of the grow-out ponds. Harvest from the two ponds yielded 870.9, and 954.3 kg of shrimps with an ABW of 27.05, and 26.58 g, respectively.

These environment-friendly schemes in shrimp farming were also implemented in two private shrimp farms namely, the Siochi shrimp farm in Nasugbo, Batangas and the Karen shrimp farm in Banate, Iloilo. Impressive results were obtained in both farms. Impressed with the success of the first runs, the owner of the Siochi shrimp farm requested the AQD's Technology Verification Section through the JMANITP to manage his farm. Technical assistance was also extended to other private shrimp farms like the Eric Ledesma in Silay, Negros Occidental; Cordero in Balasan, Iloilo; and the Rovira in Oton, Iloilo. The JMANITP is currently helping in the management of these private shrimp farms.

TECHNOLOGY CARAVAN



Lecture-demonstrations of developed aquaculture technologies were conducted in the Provinces of Southern Luzon from July 22 to August 10, 2002. Extension of these aquaculture technologies offered alternative livelihood to coastal communities of Lucena City; Calauan, Quezon; Ragay, Camarines Sur; Mercedes, Camarines Norte; and Sorsogon City. The Bureau of Fisheries and Aquatic Resources (BFAR) regional offices together with AQD, BFAR Central Office, Bureau of Post Harvest Research and Extension and QUEDAN Corporation facilitated this activity.

PUBLICATION



"Proceedings of the (Philippine) National Planning Workshop," a 100-page volume on a conference held August 2 to 3, 2001. Edited by AQ Hurtado, NG Guanzon Jr, TR de Castro-Mallare, Ma RJ Luhan

Mariculture Park

SEAFDEC AQD is promoting the concept of a Mariculture Park as a way of rationalizing the development of seacages. Together with the BEAR, it is operating a Mariculture Park training and demonstration facility in Igang, Guimaras.

Milkfish, snapper and grouper are still being grown in cages at AQD's Igang Marine Sub-station.

Sibunag was the first municipality in Guimaras to adopt the mariculture park concept. The on-site transfer of technology on cage based aquaculture projects is now on its fourth month of operation in Sibunag, Guimaras. A total of 36 bamboo-floating cages (3x3x3 m) were constructed. It is currently stocked with grouper and snapper at various densities ranging from 7 to 15 pcs/m³.

BFAR in collaboration with SEAFDEC AQD and the local government of the Island Garden City of Samal has established the Samal Island Mariculture Park in the Davao Gulf, southern Philippines. As of December 31, 2002, four companies/individuals, and four cooperatives with a total aggregate membership of 176 have put up cages in the commercial-scale Mariculture Park. Each locator has put up from one to four cages mostly milkfish monoculture, with one engaged in polyculture of milkfish and rabbitfish.

In addition, within the shallow coastal areas of the Mariculture Park, 11 bamboo cages have been set up by fisherfolk, all stocked with siganids.

STRAIN IMPROVEMENT OF COMMERCIALY IMPORTANT SEAWEEDS

Studies were mainly focused on strain improvement of commercially important seaweeds, and development of culture systems for marine and brackishwater species.

Improved strains of *Kappaphycus* and *Eucheuma* were developed through tissue culture and mutagenesis. Callus induction and plantlet regeneration were obtained using different concentrations of plant growth hormones (PGRs), carbon

Cage culture of *Eucheuma denticulatum*

compounds and 'Boston recipe' (pAA+zeatin). The 'Boston recipe' showed highest regeneration, and 100% callus induction compared with the PGRs and carbon compounds. Green *K. striatum* plantlets can tolerate salinity of 23. However, the plants were healthiest and attained 100% survival at 32 and 35 ppt, respectively. Several plantlets of red and green *K. striatum* treated with nitro-3-methyl guanidine (NTG) are under hatchery conditions for possible outplanting in the future.

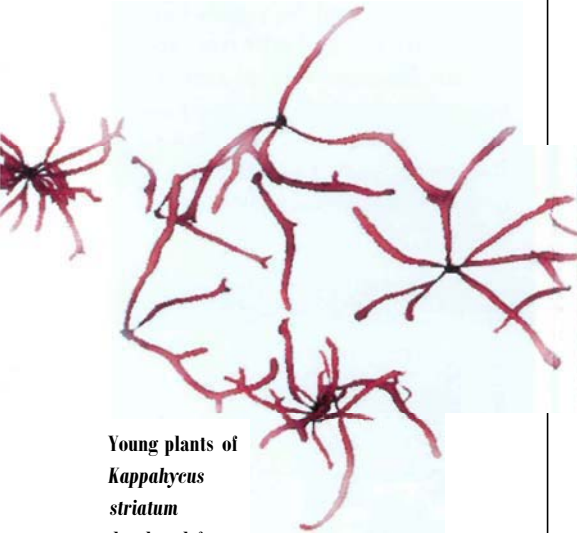
Based in Random Amplified Polymorphic DNA (RAPD) analysis, *E. denticulatum* regenerants appeared to be genetically stable.

Successful release of spores from carposporophyte and tetrasporophyte was observed in *Gracilaria firma* and *Gracilariopsis heteroclada*. The spores, under favorable conditions, grew and developed at a rate of 10% per day.

Several samples of *Gracilaria*, *Kappaphycus* and *Eucheuma* were collected from different places of Panay for DNA polymorphism analysis; samples were pulverized in liquid nitrogen and stored at -20°C.

AQUACULTURE-BASED COUNTRYSIDE DEVELOPMENT

In pursuance of the special project on the promotion and commercialization of developed technologies in collaboration with BFAR, AQD was offered to operate the freshwater fish hatchery and farm school of Meralco Foundation, Inc. (MFI) in



Young plants of *Kappaphycus striatum* developed from tissue culture



Jalajala, Rizal located along the shores of Laguna de Bay about 74 km southeast of Manila and 44 km southeast of AQD Binangonan Freshwater Station. Known as the Aquaculture-Based Countryside Development (ABCD), the Project being implemented at the MFI facilities includes production of SEAFDEC strain tilapia fingerlings. The hatchery shall also be producing bighead carp fingerlings and catfish fingerlings depending on market demand. The farm school shall be used as a venue for training in freshwater aquaculture.

Bilateral Projects

THIRD-COUNTRY TRAINING PROGRAM

The third-country training program on responsible aquaculture development (TCTP-RAD) aims to intensify dissemination of responsible and sustainable aquaculture technology for rural development. Already on its second phase, this program is for five-year period from 1999 with one training course conducted annually.



Quadrat sampling of seagrass

GROUPEL RESEARCH NETWORK

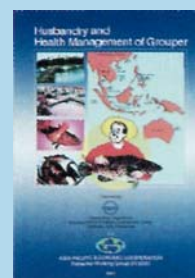
Established by APEC and ACIAR and coordinated by NACA, AQD'S participation is on the conduct of research on larval morphology and nutrition focusing on the species *Epinephelus coioides*.

LABORATORY FOR ADVANCED AQUACULTURE TECHNOLOGIES

AQD serves as the host for the Laboratory for Advanced Aquaculture Technologies or Biotechnology Laboratory, a grant aid of the Government of Japan through JICA to the Government of the Philippines. Construction of the Enclosed Wet Laboratory started in early 2002, and is expected for completion in early 2003.



PUBLICATION



AQD was designated by APEC to serve as coordinator for the publication of the manual, "Husbandry and Health Management of Grouper", which has been translated into major languages in the Asia-Pacific region with the cooperation of NACA.

TRAINING COURSE



Responsible aquaculture development

The RAD training course offered from October 1 to November 28, 2002 aimed to intensify dissemination of responsible and sustainable aquaculture technology for rural development.

Ten countries from Asia and Africa were invited to participate. The 17 accepted participants came from China (1), Nigeria (1), East Timor (1), Kenya (1), Cambodia (2), Pakistan (2), the Philippines (2), Sri Lanka (2), Myanmar (2), and Indonesia (3).

Cornerstone laying for the Enclosed Wet Laboratory by Philippine Senate President Franklin Drilon, Ambassador of Japan to the Philippines Yoshihisa Ara, DA Undersecretary Cesar Drilon, Jr., and AQD Chief Dr. Rolando Platon

SEMINAR-WORKSHOP

As one of the activities under IRAP, AQD convened the seminar-workshop on IRAP in Bangkok, Thailand from September 17 to 19 to discuss aquaculture development the region. IRAP will be implemented and monitored by the national and technical coordinators of each member country. AQD Chief serves as the project manager of IRAP.

The seminar-workshop was participated in by representatives from the ASEAN member countries as well as from the SEAFDEC Secretariat and AQD, and from the NACA and the Food and Agriculture Organization (FAO) Regional Office for Asia and the Pacific (FAO/RAP).



Food security and poverty alleviation in the region were discussed during the seminar-workshop on ASEAN-SEAFDEC IRAP



Representatives of regional donor organizations with organizers of Regional Donor Consultation Meeting

SEAFDEC-JIRCAS Collaborative Program

Five studies were implemented at AQD starting 2002. These are: (1) Development of viral disease control on high commercial value species in brackishwater mangrove areas; (2) Egg and larval quality of the mangrove red snapper fed improved broodstock diet; (3) Valuation of mangrove resources and services: Implication for the adoption of mangrove-friendly aquaculture in Western Visayas, Philippines; (4) Property regimes in mangrove ecosystems: Implication for the adoption of mangrove-friendly aquaculture in the Philippines; (5) Analysis of farm management and economic benefits of new sustainable fish production system in brackish mangrove areas in Western Visayas, Philippines.

ASEAN-SEAFDEC Special Five-Year Program

ASEAN and SEAFDEC recognizing the need to increase fish production in a sustainable manner, agreed to jointly implement the ASEAN-SEAFDEC special five-year program.

The implementation of the program includes an aquaculture component, the Integrated Regional Aquaculture Program (IRAP), comprising two projects, namely: (1) Aquaculture for Rural Development, and (2) Supply of Good Quality Seeds. IRAP is being coordinated by AQD and funded by the Government of Japan through the ASEAN Foundation.

AQD conducted the Seminar-Workshop on IRAP and co-organized the Regional Donor Consultation on the Role of Aquaculture and Living Aquatic Resources: Priorities for Support and Networking with FAO, NACA, WorldFish Center, and MRC. AQD also planned the site visitation and survey of the proposed project sites for IRAP in the ASEAN countries.

REGIONAL DONOR CONSULTATION MEETING

The Regional Donor Consultation on the Role of Aquaculture and Living Aquatic Resources: Priorities for Support and Networking was convened in Metro Manila and Iloilo, Philippines from November 27 to 29.

The purpose of the consultation was to orient institutions and donors as to the role, needs and potentials of the sub-sector on aquaculture development and living aquatic resources management for the Asia-Pacific region, noting that more recently, there has been a shift in emphasis towards the role of aquaculture and aquatic resource management in rural development.

The consultation was attended by representatives from its collaborating partners, namely, the FAO of the United Nations, AQD, NACA, the Mekong River Commission (MRC), and The WorldFish Center (formerly ICLARM).

Representatives from donor organizations and agencies such as the Australian Centre for International Agricultural Research (ACIAR); the Australian Agency for International Development (AUSAID); the Directorate General for International Cooperation (DGCI) of Belgium; the European Union (EU); Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and the German Development Service (DED); Japan International Cooperation Agency (JICA); the Norwegian Trade Council of the Royal Norwegian Embassy; the US Agency for International Development (USAID), and the United Nations Development Program (UNDP), also attended the Consultation.

Other Collaborative Programs/Research Grants

Food and Agriculture Organization of the United Nations

AQD has been collaborating with FAO through the FAO Regional Office in Asia and the Pacific (FAO/RAP) on various instances specifically on co-organization and/or representation in conferences, seminars, workshops, training, etc. More particularly, FAO co-organized the conduct of the Regional Donor Consultation on the Role of Aquaculture and Living Aquatic Resources: Priorities for Support and Networking, Metro Manila and Iloilo, Philippines, 27 to 29 November 2002. FAO also participated in the development of the Regional Guidelines for Responsible Aquaculture under the SEAFDEC Program on the Regionalization of the Code of Conduct for Responsible Fisheries. FAO also provided inputs during the IRAP Seminar-Workshop in Bangkok, Thailand in September 2002.

European Union (EC-CAMS)

The following four projects were implemented by AQD starting February 2002 and are ongoing:

- Culture and management of *Scylla* sp.: Broodstock and larval quality
- Culture and management of *Scylla* sp.: Nursery and culture of *Scylla* sp.
- Culture and management of *Scylla* sp.: Fisheries of *Scylla* sp. in Western Visayas
- Culture and management of *Scylla* sp.: Refinement of mangrove-mud crab pen systems

The WorldFish Center (formerly ICLARM)

The following project was implemented by AQD: Scale question on co-management: Malalison island and LIPASECU Bay Management Council, Inc.

In addition, WorldFish Center collaborated with FAO, NACA, AQD and MRC in the conduct of the Regional Donor Consultation on the Role of Aquaculture and Living Aquatic Resources: Priorities for Support and Networking in Metro Manila and Iloilo, Philippines, 27-29 November 2002.

Network of Aquaculture Centres in Asia-Pacific (NACA)

- Regionalization of the Code of Conduct for Responsible Fisheries: Aquaculture Development
- Grouper Research Network
- Manual on Husbandry and Health Management of Grouper
- SEAFDEC Hands-on Training for the Detection of Important Viral Diseases of Shrimp and Marine Fishes

Asian Institute of Technology (AIT) DANIDA, Thailand

A study on institutional arrangements, perceptions, and impacts of marine protected area (MPA) in Sagay, Negros Occidental: its implications for abalone (*H. asinina*) stock enhancement

Degussa Texturant Systems, France

A study on the effect of epiphytes on the productivity of *Kappaphycus*

International Foundation Science (IFS), Sweden

A study on the aquaculture and coastal resource management: impacts of marine protected areas and artificial reefs on coral reef fisheries

Japan International Cooperation Agency (JICA), Japan

A study on collection of microalgae as potential food for cultured species and for remediation activity

Rovithai Limited, Bangkok, Thailand

Studies on Vitamin C requirement of milkfish larvae, and the influence of Vitamin C diet supplementation on reproductive performance of milkfish broodstock

United States of America Agency for International Development (USAID), USA

A study on the improvement of growth and survival in cultured rabbitfish (*Siganus guttatus*)

United States of America Dry Pea and Lentil Council (USADPLC), USA

Studies on the utilization of feed peas (*Pisum sativum*) in milkfish diets, and as alternative protein source in the shrimp (*Penaeus monodon*) and tilapia diets

AQD/ Fishworld visitors



One hundred fifty-three groups or 10,962 individuals visited SEAFDEC/AQD and FishWorld in 2002. The visitors included students, teachers, and parents from 46 elementary schools and 66 high schools and colleges.

Among the notable visitors were Ambassador Yoshihisa Ara (Ambassador of Japan to the Philippines) and Senate President Franklin Drilon who came for the cornerstone laying of the Biotech Wet Lab, Dr. I-Chin Liao and Dr. Hiroshi Motoh who came to see old friends at AQD, and John Silva of the National Museum who came for the conference of science centers in the Philippines.

Personnel and management

AQD staff totaled 283: 133, Research; 23, Training and Information; 9, Technology Verification and Commercialization; 102, Administration and Finance Division; 16, Office of the Chief.

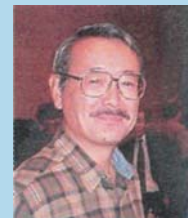
Ten employees were separated from the service due to retirement (7), resignation (2), and death (1).

Top officials of AQD include Rolando Platon, Ph.D. as Chief; Susumu Ito, Deputy Chief (until August only); Clarissa Marte, Ph.D., Research Division Head; Wilfredo Yap, Technology Verification and Commercialization Division (TVCD) Head; Pastor Torres, Jr., Training and Information Head; and Dan Baliao, Administration and Finance Head.

During the Year, the Technology Commercialization/Technical Assistance Section of TVCD was created.



Platon



Marte



Yap



Torres



Baliao

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SEAFDEC/AQD'S response to industry needs

AQD assists the Mariculture Livelihood project in Sibunag, Guimaras



AQD assists in the extension of aquaculture technologies during the Fisheries Technology Caravan in Southern Luzon, organized by DA-BFAR



Graduates of a four-month mariculture skills development sessions are trained to practice sustainable mariculture



AQD staff member lectures on modified extensive shrimp farming in Butuan City, Agusan del Norte



BFAR collaborated with AQD in the establishment and operation of commercial-scale Samal Island Mariculture Park



Shrimp farms assisted by AQD result in bountiful harvests

The Southeast Asian Fisheries Development Center

(SEAFDEC), a regional treaty organization based in Bangkok, Thailand was established in December 1967 to promote 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, Indonesia and Cambodia. The council of Directors who represents SEAFDEC Member Countries is the policy-making body of the organization.



SEAFDEC does research on appropriate fisheries technologies, trains fisheries and aquaculture technicians, and disseminates fisheries and aquaculture technologies. Four departments were established to pursue these objectives

- The **Training Department (TD)** in Samut Prakan, Thailand (1967) for marine capture fisheries training
- The **Marine Fisheries Research Department (MFRD)** in Singapore (1967) for fishery post harvest technology
- The **Aquaculture Department (AQD)** in Tigbauan, Iloilo, Philippines (1973) for aquaculture research and development
- The **Marine Fishery Resources Development and Management Department (MFRDMD)** in Kuala Terengganu, Malaysia (1992) for the development and management of 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

The Aquaculture Department in the Philippines maintains four stations: in Iloilo Province, the Tigbauan Main Station and the Dumangas Brackishwater Station; in Guimaras, the Igang marine Substation; and in Rizal, the Binangonan Freshwater Substation.



Tigbauan Main Station



Dumangas Brackishwater Station



Igang marine Substation



Binangonan Freshwater Substation

Aquaculture Department (AQD)

5021 Tigbauan, Iloilo
Philippines
PO Box 256, 5000 Iloilo City
Philippines
Tel: (63 33) 511 9171; 336 2891;
336 2937; 336 2965
Cable: SEAFDEC ILOILO
Fax: (63 33) 335 1008; 511 8709
E-Mail: aqdchief@aqd.seafdec.org.ph
<http://www.seafdec.org.ph>

Training Department (TD)

PO Box 97
Phrasamutchedi
Samut Prakan 10290
Thailand
Tel: (66 2) 425 8040 to 5
Fax: (66 2) 425 8561
E-Mail: td@seafdec.org
<http://www.seafdec.org>

Marine Fisheries Research Department (MFRD)

2 Perahu Road off Limchukang Road
Singapore 718915
Tel: (65) 790 7973
Fax: (65) 790 7963, 861 3196
E-Mail: mfrdlibr@pacific.net.sg
<http://www.asean.fishnet.gov.sg/mfrd.html>

Marine Fishery Resources Development and Management Department (MFRDMD)

Fisheries Garden, Chendering
21080 Kuala Terengganu
Malaysia
Tel: (609) 617 5135
Fax: (609) 617 5136
E-Mail: seafdec@po.jaring.my
<http://www.agrolink.moa.my/dof/seafdec.html>

SEAFDEC Secretariat

Suraswadi Building
Department of Fisheries Compound
Kasetsart University Campus
Chatukchak, Bangkok 10900
Thailand
Tel: (66 2) 940 6326 to 940 6329
Fax: (66 2) 940 6336
E-Mail: secretariat@seafdec.org
<http://www.seafdec.org>