

2001 Highlights



AQUACULTURE DEPARTMENT
Southeast Asian Fisheries Development Center
Tigbauan Iloilo, Philippines

SEAFDEC AQD in 2001

The Aquaculture Department has restructured its programs for the years 2001-2005 along problem areas of concentration, which integrate its research, technology verification-demonstration, and training and information dissemination thrusts.

Many projects were implemented in 2001: final approval of the Y895 million (P431 million) Laboratory for Advanced Aquaculture Technologies, the first-ever training in crab seed production, and the successful implementation of various verification projects within the Philippines in collaboration with the Bureau of Fisheries and Aquatic Resources.

Region-wide, it was a spotlight year for AQD, whose reach was extended through the *Mangrove-friendly shrimp aquaculture* verification and training activities in the shores of Vietnam and Myanmar in cooperation with Thailand's Department of Fisheries. Mangroveweb.net, the project's website was launched in December. Two SEAFDEC regional events involved AQD in year-long preparations: the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security in the New Millennium, and preparation and publication of the *Regional guidelines for responsible aquaculture*. Finally, the December seminar-workshop on Disease Control in Fish and Shrimp Aquaculture in Southeast Asia supported by the Japanese Trust Fund and organized by the Department and the Office International des Epizooties capped this busy year.

In behalf of the SEAFDEC Aquaculture Department, I would like to thank our collaborators, friends, promoters, clientele, stakeholders and staff for their support. To effectively respond to the industry's needs, let us continue to foster this spirit and mission of innovation strengthened by unity of purpose and goodwill, through the challenging years ahead.



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MANAGING BROODSTOCK AND IMPROVING SEED QUALITY

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

- Poor or inconsistent quality of spawned eggs
- Non-synchronous, unpredicted and highly seasonal spawnings 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 hatchery of fry and fingerlings for some species
- Slow growth rates of juveniles
- Economics of hatchery production

BROODSTOCK MANAGEMENT AND GENETIC IMPROVEMENT



Egg quality improvement through nutritional manipulation

Nutrition of fish broodstock is one of the major factors affecting egg and larval quality; thus, practical diets for farmed fish species have to be developed to include dietary components that boost their reproductive performance.

Milkfish and snapper broodstock were fed nutritionally defined diets based on available information on their nutritional requirements.

Supplementation of the milkfish diet with vitamin C at 0.1% resulted in better reproductive performance. Mean percent egg viability, hatching, normal larvae and cumulative survival from eggs to normal larvae were higher for milkfish fed diets containing 0.1% vitamin C than those given diets containing 1.0% vitamin C

and the control (no vitamin C supplementation).

Red snapper broodstock fed a formulated diet had higher total egg production and mean egg production per spawning than broodstock fed fish biomass alone. Though egg viability and normal larvae count of both groups were about the same, hatching and cumulative survival rates of eggs to normal larvae were higher for the broodstock fed the formulated diet.

Free amino acids (FAAs), which are major constituents of crustacean eggs were higher in viable than in non-viable eggs. The amino acids, arginine, histidine, methionine, threonine and tryptophan decreased during embryogenesis, implying that these are the major FAA catabolized by crab eggs. This information may help identify the amino acid needs of mud crab larvae, as well as indicate good quality eggs.

Environmental and hormonal manipulation for controlled breeding and growth enhancement

Hormonal manipulation is one way to control reproduction and improve growth and survival in fish. Towards this end, production of recombinant rabbitfish and milkfish growth hormones (GHs) and the

insulin-like growth factors (IGFs) was initiated. The biological activity of two preparations of recombinant rabbitfish GH (rrGH) was tested in rabbitfish fry. Cloning of grouper and snapper GH, as well as gonadotropins of grouper was also done.

Genetic characterization of farmed species

Genetic characterization was done for Nile tilapia, bighead carp, and selected indigenous species such as silvery therapon (*ayungin*), *kanduli* (*Arius* sp.) and native catfish. The Nile tilapia *Oreochromis niloticus* and bighead carp *Aristichthys nobilis* from private hatcheries along Laguna de Bay showed a very low level of genetic variation. Cage-bred and pond-bred stocks of Nile tilapia fingerlings were also assessed for different biological, stress and growth performance traits. Pond-bred stocks scored generally higher in the biological and survival index traits, but when tested for growth and survival in cages, the cage-bred stocks outperformed the pond-bred fingerlings. This indicates that growth and survival of tilapia do not depend solely on genetics but may be influenced by largely external factors like hatchery management schemes and the grow-out environment. Of the 13 enzymes screened to characterize the silvery therapon collected from the Binangonan and Tanay areas of Laguna de Bay, Sampaloc and Taal lakes, only one indicated possible polymorphism. The very low level of genetic variation among populations of this species from the three different lakes has important implication, considering that the fishery of this species is under threat.



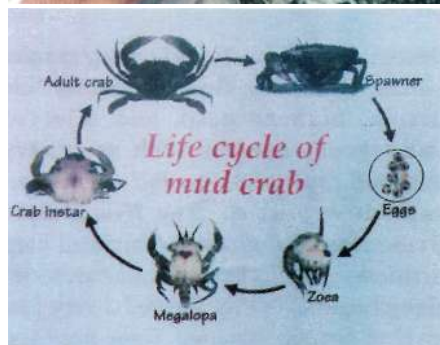
Snapper *Lutjanus argentimaculatus* (left); milkfish *Chanos chanos* (bottom left); berried mud crab *Scylla serrata* (bottom right)



DEVELOPMENT OF IMPROVED TECHNOLOGIES FOR HATCHERY PRODUCTION



Larvae of crab (left) and milkfish



The mud crab's life cycle



Hatchery and nursery husbandry techniques

The studies are aimed at improving the survival of snapper in the hatchery and nursery rearing techniques for snapper, milkfish and mud crab.

Snapper larvae fed the mixed diet (50:50) of brine shrimp nauplii and formulated snapper diet had the best growth and survival compared to those fed brine shrimp and those weaned to the formulated diet at 10% reduction in brine shrimp nauplii. The rate of cannibalism was lowest in the groups that were gradually weaned.

In another experiment, the effects of stocking densities (1-4 /L for Day 21-35;

100, 200, 300/ton for Day 35-50) as well as the use of modified diet plans (increased amounts of untreated/treated/HUFA-enriched brine shrimp) for snapper fry were tested. Growth rate was similar in all stocking densities. Survival was higher (91.6-96%) at day 35 - day 50.

The effect of stocking density on growth and survival of hatchery-bred milkfish in ponds and cages was tested. Stocking at 75/m² in ponds resulted in highest survival. Large variation in sizes was observed at the end of the run. Fry reared in cages showed more uniform sizes. Survival rates ranged from 43-70%.

Rearing of mud crab megalopa was tried in brackishwater ponds. Three different feeding regimes were tested. Growth and survival were highest in groups fed a combination of mussel meat and pelleted diet, and lowest in groups fed the pelleted diet.

Larval requirements and physiology

The nutritional, environmental and health requirements of larvae for improved production in the hatchery was studied. A series of experiments was conducted to establish the appropriate environmental conditions for rearing the

early life stages of grouper. At the onset of feeding, larvae reared at low aeration level, moderate salinity and light intensity had higher growth, survival and feeding incidence compared to larvae exposed to other conditions.

The lipid requirement of grouper larvae was examined. The total lipid content, lipid class composition and lipid mobilization patterns of eggs and larvae, as well as of the natural food organisms were determined. Lipid content of various microalgae ranged from 0.27-3.83%, while that of rotifers fed with these microalgae ranged from 6.11-13.6%. Rotifers fed with *Chlorella* contained the highest arachidonic acid (AA), whereas rotifers fed with either *Chlorella*, *Chaetoceros* and two other locally isolated diatoms had the highest eicosapentaenoic acid (EPA). Only rotifers fed *Isochrysis* or *Thalassiosira* contained docosahexaenoic acid (DHA). Studies on lipid chain transfer from the grouper egg through hatching period were conducted, as well as on patterns of lipid conservation or loss during starvation and feeding of larvae. Lipids decreased from fertilized egg to day 4 pre-fed larvae. Neutral lipids were high in the egg and newly hatched larvae, while polar lipids dominated in 2.5 and 4 day old larvae. At day 4, neutral EPA was depleted, while polar DHA was highly conserved. In fed larvae, both neutral and polar lipid contents increased with age, with nuclear lipids higher than polar lipids. Starved larvae showed the opposite trend: very low nuclear and polar lipids with the latter having higher values. AA, EPA and DHA were

conserved more in polar lipids than in nuclear lipids. DHA was lost after a week in both lipid classes.

A total of 426 kinds of bacteria were isolated from grouper eggs. Of these, 198 were *Vibrios*, 137 were *Pseudomonads*, and 91 were *Aeromonads*. Pathogenicity tests for four *Pseudomonad* species showed that they are not pathogenic to grouper larvae at 10^{11} cfu/ml.

The efficacy of phosphorylated ascorbic acid (Rovimix Stay C-35) as a Vitamin C source during the nursery phase of milkfish was tested. Diets with supplemental L-ascorbyl-s-phosphate supported significantly better growth and resulted in lower incidence of mortalities than the vitamin C-free diet. One hundred mg ascorbic acid per kg diet is the minimum dietary vitamin C level requirement. Vitamin C deficiency symptoms observed included anorexia, lethargy and acute signs of scoliosis. Pathological changes associated with vitamin C deficiency included twisted cartilage of the gill filaments and extreme dislocation of the vertebrae.

Verification of hatchery techniques

Research at SEAFDEC Aquaculture Department on all culture phases of *Scylla serrata* contributed significantly towards developing techniques for reliable hatchery production of mud crab juveniles. The techniques developed were verified prior to dissemination to interested crab farmers. One study compared the reproductive performance of wild caught spawners of *Scylla serrata*, *S. tranquebarica* and *S. olivacea* fed a combination of natural food and the SEAFDEC formulated diet. *S. olivacea* was found to be the most fecund and had the highest average egg fertilization rate.

Alternative live food

Brine shrimp is expensive and thus, the search for potential feed substitutes during the hatchery phase was pursued. The suitability of the cladoceran *Ceriodaphnia cornuta* as a substitute for brine shrimp in the hatchery production of freshwater fishes was examined. Results showed that the most suitable medium for its culture is green water,

where the dominant algal species is *Ankistrudesmus* sp. Optimum growth was observed on the 6th day of culture, when a population of 7,963 ind/L from an initial stock of 200 ind/L was attained. Average offspring production of *C. cornuta* grown in green water was 2 ind/female/day. The second offspring generation was noted 4-5 days from hatching.

Larvae of marine fish require high amounts of highly unsaturated fatty acids (HUFAs). DHA-rich Straminipilous thraustochytrids, which colonize fallen mangrove leaves in tropical swamps, was identified as a possible substitute for commercial fish oils. Fatty acid analyses of selected isolates grown at different salinity and temperature levels showed that total lipid contents ranged from 18.3-33.2% for *Schizochytrium mangrovei*; 16-39.1% for *Schizochytrium* sp. and 11.4-37.5% for *Traustochytrium* sp. Optimum fatty acid production was observed in *S. mangrovei* and *Schizochytrium* sp. grown in 50% SW at 25°C.



Marine fish hatchery and nursery operations

Conducted from 5 June to 13 July, this five-week training provided its 17 participants from SEAFDEC member countries with technical knowledge and skills in operating marine fish hatcheries. During the training, participants conducted actual larval rearing of various fish species such as milkfish, red snapper, sea bass and grouper.

Crab seed production

The course aims to provide participants with technical knowledge and skills in crab seed production with emphasis on *Scylla serrata*. First offered this year, the course ran from 14 August to 13



A training session; graduation ceremonies

September with 23 participants and three observers. The Australian Center for International Agricultural Research (ACIAR) gave funds for the course.



Carp manual published

"Induced breeding and seed production of the bighead carp *Aristichthys nobilis*" is a 40-page manual by AC Gonzal, CB Santiago, AC Fermin and EV Aralar.



DEVELOPING RESPONSIBLE AND SUSTAINABLE AQUACULTURE TECHNIQUES

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 impact 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



Pond with recirculating system



Pond feeding



Nutrient dynamics of aquaculture systems

Aquaculture can produce large quantities of polluting waste. Where this exceeds the capacity of the water environment to dilute or assimilate, pollution results.

In this regard, a study was conducted to determine the environmental capacity* of the receiving water from nutrient loading and effluent of milkfish *Chanos chanos* aquaculture.

With nutrient loading and effluents of milkfish finished in the previous year, studies in 2001 were directed towards predicting the environmental capacity of the receiving water (Punta Pulao River, Dumangas, Iloilo). The fractionation of nitrogen and phosphorous content of milkfish feed (SEAFDEC diet, commercial diet, and "lablab") and feces, done to identify the form on which these nutrients are wasted, was completed.

Total ammonia nitrogen (TAN) and phosphate (PO₄-P) excretion rates of milkfish fed three diets at different sizes were determined. Excretion was significantly lower in fish fed dried "lablab" compared to fish fed the



Bioremediation using "imbao" *Anodontia edentula*



Shrimp and milkfish harvests

SEAFDEC formulated diet, but not with fish fed the commercial diet. Ammonia nitrogen and phosphate excretion rates decreased as fish weight increased. TAN and $\text{PO}_4\text{-P}$ excretion accounted for 22-26% of total nitrogen and 21-41% of total phosphorus consumed by fish. On the other hand, 28-43% of total nitrogen and 47-59% of total phosphorus consumed were wasted as feces.

Average production (tons ha^{-1}) was 1.45 in semi-intensive pond (8000 fish ha^{-1}) and 3.65 in intensive pond (20,000 fish ha^{-1}). Total N and Total P output through water discharge (kg ha^{-1}) in semi-intensive ponds averaged 95 N and 2.6 P in the first month of culture, increasing to 284 N and 5.8 P in the last month of culture, including harvest. Based on dissolved oxygen levels and observed mortality of fish, the holding capacity of unaerated milkfish ponds (maximum depth = 100 cm) was found to be 1.35 ± 0.08 tons ha^{-1} . The capacity could be lower (1.02 ± 0.15 tons ha^{-1}) during very calm weather and after rainy days when there is minimum agitation of water and stratification of the water column. For aerated intensive ponds, the holding capacity was predicted to be below 5 tons ha^{-1} using regression analysis.

Feed and waste management

The fate of uneaten milkfish and tilapia feeds was established through controlled laboratory experiments. Several runs on the effects of temperature and pH, as well

as salinity (i.e., fresh, brackish, and marine water) on ammonia and phosphate released in water of submersed feeds for seven commercial milkfish feeds were completed. Results showed that phosphate released was higher at higher temperature and neutral or alkaline pH, while ammonia release rose faster at higher temperature and neutral pH. Release of TAN and $\text{PO}_4\text{-P}$ was also generally higher in freshwater and brackishwater than in seawater. Three runs on phosphorus fractionation of the 7 feed brands were conducted, with the results showing that water soluble P accounted for the highest value (3.2-5.6 mg g^{-1} dw), followed closely by ammonium chloride extractable P (3.2-5.0 mg g^{-1} dw). The total inorganic fractions ranged from 10.5-15.8%, while organic fractions ranged from 84-90%. For feces, the organic fractions ranged from 83.2-97.6%.

Studies were also conducted to estimate the amount of uneaten feed and feces generated by milkfish and tilapia juveniles. Results showed that about 2-32% (dry basis) of the commercial feed ration to milkfish juveniles (22.7 ± 4.1 g fed a total of 5% body weight twice a day, based on common practice) might be uneaten. Not much uneaten feed was collected for tilapia, which almost always consumed their ration. Tilapia generated more fecal matter [12.0-27.1% (dry basis) of the feed ration] than milkfish (2.3%-19.1%).

Culture systems and bioremediation strategies

The sulfide-oxidizing potential of the lucinid clam "imbao" *Anodontia edentula* was evaluated in preparation for its polyculture with milkfish or shrimp as a food crop and as a pond sediment cleaner. Pond experiments were conducted in Ibayay, Aklan to determine the sulfide uptake rate of "imbao." Stocking density was seen to affect net consumption rates of sulfide by "imbao," with $0.56 \mu\text{M hr}^{-1}$ and $0.77 \mu\text{M hr}^{-1}$ observed for 20 and 40 clams, respectively, obtained from the same lot and stocked in 1m^2 compartments. The salinity tolerance test conducted showed 50% of clams surviving at 10 ppt on day 7 and 0% on day 17 in all replicates. Survival rate on day 30 was 70% at 15 ppt and 100% at 20-35 ppt.

Pond grow-out culture techniques of the native Asian catfish *Clarias macrocephalus* (Gunther) was evaluated, using juveniles from captive hatchery-bred and wild broodstock, at various stocking densities, and fed SEAFDEC formulated feed of 34% crude protein. The first experimental runs were completed in April. Total production (21.2 kg in 12m^2) was significantly higher in fingerlings from hatchery bred spawners at 40 fish m^{-2} stocking density compared to those of other treatments.

Microbial and phytoplankton flora associated with "green water culture" of *Penaeus monodon* was studied. Total bacterial counts of rearing waters of tilapia, shrimp, and shrimp cultured with tilapia at 15-60 days of culture ranged from 10^2 - 10^3 cfu/ml. Total bacterial counts of monocultured shrimps were positive for luminous bacteria, while those cultured with tilapia had undetectable levels. Luminous bacteria were not detected in tilapia mucus but were present in its gut. Bacterial flora consisted of non-luminous *Vibrio*, *Pseudomonas*, *Enterobacteriaceae* and *Aeromonas* at varying percentages. The fungal population in all test waters was relatively similar. Tilapia had significantly higher levels of yeast and filamentous fungi compared to shrimps cultured with

***Environmental capacity** is the ability of the environment to accommodate a particular activity or rate of activity without unacceptable impact. The principal adverse impacts include the destruction and fragmentation of natural habitat; changes in soil, water, and landscape quality; changes in the abundance of species; impoverishment of genetic and biological diversity; introduction of diseases and parasites, and disturbance of ecosystem processes.

Culture systems...(cont.)

or without tilapia. Yeast flora was predominantly *Rodotorula* and *Saccharomyces* while filamentous fungi were predominantly *Mycelia sterilia*, *Penicillium* and *Aspergillus*. Microalgal population consisted of *Chlorella*, *Melosira*, *Thallosiosira*, *Navicula*, *Nitzschia* and *Anabaena*.

The efficiency of seaweed *Gracilariopsis bailinae* as a biofilter and amenability of grouper *Epinephelus coiodes* to intensive tank culture were evaluated in integrated recirculating tank culture systems equipped with upflow sand filters, primarily for solids removal. Data were analyzed to determine the performance of the integrated systems in terms of water quality, grouper growth, and *Gracilaria* growth and agar quality, and to establish the nutrient dynamics of the system. Initial results indicated that, together with the nitrification achieved in the upflow sand filter, 3 kg of *Gracilaria* provides sufficient uptake rate of ammonia nitrogen produced from 2.0 kg of SEAFDEC AQD formulated and manufactured grouper grow-out diet.

The integrated, intensive recirculating pond culture of *Penaeus monodon* with seaweeds and bivalves as biofilters and tilapia as biomanipulators was tested. Three identical recirculating systems

consisting of four adjacent, serially connected 225 m² pond compartments with a recirculating channel have been set up in AQD's Dumangas Brackishwater Station. The first two compartments in each setup was stocked with shrimp at 30 pieces m⁻², the third with oysters (5 pieces m⁻²), "imbao" (1 piece m⁻²), and tilapia (10 pieces m⁻²). The last compartment was used as a settling pond, while *Gracilaria* was stocked at 1 kg m⁻² using hanging long line along the recirculating channel. Operational flow rates of 600-800 L min⁻¹ were attained in each system using 3 hp submersible pumps. The nutrient dynamics of the system was assessed by determining mass balance budgets for nitrogen, phosphorus, and carbon from inputs (feed, fertilizers, etc.) and nutrient retention in pond components, including shrimp, fish, seaweeds, bivalves, rearing and receiving water, soil sediments, as well as nutrient losses from uneaten feed, and from wastes and metabolites. The first run was completed in November after 120 days of culture. Average shrimp body weight ranged from 19.6 to 24.6 g, FCR from 2.0 to 2.34, percent survival from 32.0 to 48.5%. Very good water quality was observed in all pond systems.

Socioeconomics and policy issues in aquaculture

One hundred thirty-nine aquaculture grow-out operators and 59 input suppliers were interviewed in a national survey that ended in May 5 to study input-market development strategies and suggest a policy agenda for Philippine aquaculture. Results revealed that the average fishpond grow-out operator is around 48 years old, with tertiary education and 14 years of experience in aquaculture. Seventy-eight percent claim ownership of the land (23 ha on the average). Eighty two percent of respondents have farm sizes less than average, with bigger farm sizes accounting for only 17% of respondents. Thirty-six percent of respondents have farm sizes less than one ha. Milkfish is the main species cultured by 40%. Thirty and 19% grow tilapia and shrimp, respectively. Less than 10% grow mudcrab (7%) and grouper (2%). Fluctuation of prices of marketable-size milkfish was a major problem among respondents; thus, time series models of wholesale and retail prices in Manila, Dagupan, Iloilo, Cebu and Zamboanga were analyzed to understand and predict price movements.

Preliminary tabulations of input supplier responses showed that 63% of respondents

NUTRITIONALLY-EFFICIENT FEEDS USING ALTERNATIVES TO FISH MEAL AND FISH BIOMASS



Nutrient requirements of fish

Inexpensive formulated diets may be the "savior" of modern day aquaculture, which traditionally relies on low value fish that has become less available, impractical, and costly, considering the benefits derived from it by direct human consumption. To effectively incorporate ingredients into the diet, though, requires that their digestibility values for the target fish species be known.

Potential feed ingredients for grouper



Vitamin C, a necessary component in formulating diets

were suppliers of seedstock; 25%, feeds; 18%, technology; and others, construction materials, labor and utilities. By island groups, 48% of the suppliers were from Luzon, 32% from the Visayas, and 20% from Mindanao. In another study, acceptability of the raft-hanging method, an improved oyster and mussel farming technique was found difficult by farmers because of the following factors: unsuitability of the local area (low water depth), comfort with the traditional method, high costs, access to poachers, and too much labor. While 81% favored the traditional method, 76% were not aware of the improved method. LGUs and extension workers believed that information dissemination and establishing demonstration farms could facilitate fast acceptance of the new method. Respondents believed that the main reason for the decline in their production was mainly due to pollution and siltation, and that environment-friendly technology can resolve the problem. The growers, who consider mussels as their main source of income, favored zoning to prevent navigation problems and solve the conflict over seabeds.

diets were analyzed for their proximate composition, and their apparent digestibility coefficients for dry matter (ADMD) and crude protein (APD), determined. Highest ADMD coefficients were attained by gluten meal (94%), followed by corn germ meal (85%), tuna fish meal (75%), poultry feather meal (74%), meat and bone meal (61%), and lupin seed meal (47%). The protein content of lupin seed, corn gluten, and meat and bone meals were comparatively digestible (98-99%). Imported blood meal had the lowest ADMD and APD values. Four practical diets (meals of meat and bone, corn gluten, tuna fish, and processed blood-based diets) were formulated (45% protein, 10% fat, and 375 kcal/100 g metabolizable energy) for the growth experiment. Chilean fish meal was used as the control. Except for the blood meal-based diet (28% digestible protein), all of the diets had comparable digestible protein (40-43%). Specific growth rates of fish fed these diets (around 3%/day) were significantly higher than those for fish fed the blood meal-based diet (2.4%/day). ADMD values for the control, gluten, tuna fish and blood meal-based diets were close ranged (74-83%). Meat and bone meal-based diet had the lowest ADMD value (60%). APD values for the control, gluten, tuna fish meal-based diets were comparable (93-95%) and significantly higher than the meat and bone and blood meal-based diets (88-89%).

Adequate levels of ascorbic acid or Vitamin C in the fish feed optimize feed conversion enhancing growth, survival

and reproductive performance. A most effective derivative is the phosphated form because of its stability and bioavailability. Snapper and sea bass fed diets without dietary L-ascorbyl-2-phosphate Mg (APMg) had significantly lower final weights and protein efficiency ratios, poor feed conversion ratios (FCRs) and showed clinical signs of vitamin C deficiency (hemorrhagic fins, bulging eyes, dark color, soft bodies) compared to those fed diets containing APMg. Recommended minimum dietary level of APMg for growth is about 50-60 ppm; a level of 100 ppm is appropriate as an allowance for losses during feed manufacture and storage.

Development of environment-friendly feeds with minimum amount of fish meal

The export market for grouper is growing. With the interest in its culture, there is this urgent need to find a practical diet that is based on terrestrial (animal and plant-based) proteins as potential replacement for fish meal in its diet.

Results of a study on the development of a practical diet for juvenile grouper showed that up to 80% of fish meal protein can be replaced by processed meat meal and blood meal coming from terrestrial animals with no adverse effects on growth, survival and feed conversion efficiency of *E. coioides*. Best weight gain and growth was obtained by fish fed a diet with 20% fish meal replacement. The diet achieved significantly higher ($p < .05$) growth than the diet that had 100% fish meal replacement. Survival rates of fish fed the experimental diets were significantly higher ($p < .05$) than that of fish fed fish biomass.



Feed, in its extruded form and dried



Mariculture

This special training conducted from 24 Feb to 30 May was funded by the Center for International Training and Education and Department of Education, Training and Employment in South Australia. Sixteen participants came from Mindanao.

Freshwater aquaculture

The course was conducted at the Department's Binangonan Freshwater Station from 18 April to 17 May, with 12 participants from SEAFDEC member countries. The one-month course aimed to provide participants with technical



knowledge and skills on artificial propagation and culture of selected freshwater species such as tilapia, carp and catfish.

Management of sustainable aquaculture farming system

Conducted from 9 May to 14 June, the course aimed to provide its 12 participants from SEAFDEC countries with technical knowledge and skills for actual operation and management of grow-out facilities for fish, crustaceans, mollusks and seaweeds.

Fish nutrition

Aiming to provide aquaculture technicians and fish nutritionists with basic theoretical information and technical skills on aquaculture information, the fish nutrition course ran for five weeks, from October 16 to November 22. Ten participants from



Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, Thailand, Vietnam and the Philippines joined.

Individual training (internship and practicum)

Ninety-two persons underwent on-the-job training, while 33 had internships at the Department in 2001. They worked at various AQD stations and offices; these include: TMS, BFS, the Natural Food Laboratory, Integrated Fish Broodstock Hatchery Complex, Farming Systems Section, Feed



Fairs and exhibits

During the year, the Aquaculture Department participated in the following exhibits

- *Agri-Food Fair 2001* in March, Iloilo City. Exhibit was spearheaded by RAFC-VI and the Western Visayas foundation in cooperation with the Department of Agriculture
- *FishLink* sponsored by the University of the Philippines Aquaculture Society in May, Iloilo City. AQD's exhibit focused on environment-friendly shrimp farming

- *Philippine independence celebration in June*, Luneta Park, Metro Manila. The Department's exhibit focused on technology verification and extension activities
- *Japan International Cooperation Agency (JICA) meeting* in June, Mandaluyong City. The Department's exhibit focused on the JICA-sponsored Third Country Training Program
- *8th International Agribusiness Trade Exhibition and Seminars (AgriLink) and 2nd International Food Processing, Packaging and Food Products Exhibition (Food Link)*, October 18-20 at the World Trade Center in Roxas Blvd, Pasay City, Metro Manila



Development Section, Breeding Section, Grouper Project, Seaweed Laboratory, Library and Data Bank. Schools/colleges/universities represented in the student training included: Zamboanga Slate College of Marine Sciences and Technology, Mindanao State University (in Iligan, Marawi and Naawan), University of the Philippines Visayas, University of the Philippines-Diliman, Davao del Norte State College, Aklan National College of Fisheries, Leyte State School of Fisheries, Sultan Kudarat Polytechnic College, Iloilo State College of Fisheries, and Philippine Science High School-Iloilo.

Distance learning courses

Since March, University of the Philippines - Open University and AQD training staff have been preparing topics on fish health management, the first course to be offered via long distance learning.

- *Philippine Agribusiness 2001*, December 6-9 at Lamberto Marcias Sports Complex, Dumaguete City. Agricultural producers, traders and investors were among those who attended the affair. It was organized by the Philippine offices for trade and industry, agriculture, the local council for agriculture and fisheries, and LGUs of Negros Oriental and Dumaguete City
- *Agribusiness in Focus 2001*, December 12-16 at PNB Multi-Purpose Hall, Iloilo City. The Regional Agricultural and Fishery Council West Visayas Foundation Inc. organized the event

AQD online

The AQD website www.seafdec.org.ph was visited by more than a thousand browsers each month. A description of R&D programs has been changed to follow the revised program of work for 2001-2005. Issues of AQD's aquaculture newsletter, general information flyers, and institutional reports were made available as downloadable pdf files.

Library services

Current collection (2001) stands at 16,370 monographic volumes, 8,415 pamphlets, 3,474 SEAFDEC publications and 5,589 journal volumes (bound). Additional materials this year were sourced from subscriptions (some on CD-ROMs), gifts and publication exchanges. In-house or AQD users were informed of new arrivals through the Library Acquisitions List, of which 49 issues were circulated. A total of 10,560 readers were recorded for 1,041 hours of library service, making an average of 10 readers per hour; 3,183 materials were borrowed, averaging 49 for 131 days of library service.

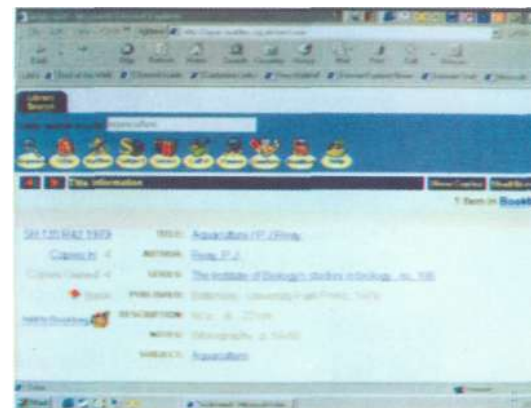
The Library was used by an average of 8 readers (mostly AQD research staff with some students, AQD trainees and other users) per hour for 249 days of library service.

The AQD Library's bibliographic databases can be accessed online by clicking on the Library icon on the AQD homepage. Visits to the site are being monitored by a third party. The first monthly monitor in May registered 902 visitors.

AQD also served stakeholders by replying to queries: there were 144 written and phone queries received from 37 countries. More requests were served for CD-Rom search: 369. Commodities of interest include crab



AQD homepage



The Library online

or mudcrab, grouper, milkfish, tilapia and others. There was a total of 72 news releases about SEAFDEC AQD in newspapers.

The Follet Circulation Plus software for charging and borrowing of information materials was made operational in 2001, while data inputting and editing of various databases continued. Total records in the Follet database (books, serials, proceedings, journal articles, microfiche) as of December 28 were 21,829 titles and 32,005 volumes/copies.

Newsletters, manuals, reports, CD-Roms

The following information materials were released in 2001:

SEAFDEC Asia Aquaculture newsletter. Issues released included topics on Indonesia, career opportunities in aquaculture, marine hatcheries and stock enhancement



- "Farming of the seaweed *Kappaphycus*," a 25-page manual written by AQ Hurtado and RF Agbayani



- "Simpleng gabay sa pagtitilapya: Pagpapalaki ng tilapia," a 57-page revised edition of a 1996 manual discussing culture methods of tilapia. Written by RV Eguia, MRR Eguia and ZV Basiao.

- "Simpleng gabay sa pagtitilapya: Pagpapaanak or pagpaparami ng tilapia," a 51-page revised edition of the 1996 manual, discussing the spawning of tilapia in hatcheries, and the hatchery operations of tilapia. Written by RV Eguia, MRR Eguia and ZU Basiao



- "Health management in aquaculture," 187 pages, the first title of SEAFDEC/AQD's textbook writing project made, as requested by the Iloilo State College of Fisheries (ISCOF). The book has 11 chapters on viral, bacterial, fungal, parasitic diseases and pests, and the various ways to prevent and control these. Edited by GD Lio-Po, CR Lavilla-Pitogo, ER Cruz-Lacierda



- "Responsible aquaculture development in Southeast Asia," 274 pages, the volume contains papers presented during ADSEA '99, the triennial conference that sets R&D priorities of SEAFDEC/AQD for 2000-2003. Edited by LMB Garcia



- "Use of chemicals in aquaculture in Asia," 235 pages, documents the proceedings of the meeting convened by SEAFDEC/AQD, FAO/UNDP and CIDA in May 1996. Country and area papers on the use of chemicals in various aquaculture systems, and the country regulations regarding their distribution and usage are included. The volume also covers the effect of chemicals on human health and environment, problems with drug-resistant fish



- "An assesment of the coastal resources of Ibayay and Tangalan, Aklan: implications for management," a 60-page report on the state of marine resources in several coastal barangays in northern Panay island, where AQD has collaborative projects. Recommendations from this report



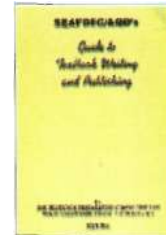
pathogens and the delivery of chemicals through feeds and water. Edited by JR Arthur, CR Lavilla-Pitogo, RP Subasinghe. Available in CD-Rom format

will guide fisherfolks and other stakeholders, particularly local government units in their development plans. Edited by LMB Garcia

- "Highlights 2000," a 28-page report of AQD's activities, highlighting the collaborative projects with the private sector and the three international conferences that AQD hosted



"SEAFDEC/AQD's guide to textbook writing and publishing," a 12-page authors' guide written by the Textbook Preparation Committee.



- "Binangonan Freshwater Station," a 2-page brochure on the AQD R&D station in northern Philippines



- "International coastal cleanup," a 20-page brochure written by FishWorld



- "Husbandry and health management of grouper," a 94-page fully illustrated full color book prepared by SEAFDEC/AQD for the Asia-Pacific Economic Cooperation Fisheries Working Group. ER Cruz-Lacierda, CR Lavilla, JD Toledo, NV Golez, NJ Ogburn are the project team writers



SCREENING NEW SPECIES FOR 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 finfishes and shellfishes have been identified as possible aquaculture candidates either for food or for the marine ornamental fish trade.

The number of eggs collected from natural spawns of captive stocks of a surgeonfish, the blue tang (*Paracanthurus hepatus*), has increased to date. Its embryonic development from fertilization to hatching has been documented. The rate of embryonic development was similar in all salinities tested (20-32 ppt), but larval survival appeared best at 24 ppt. Blue tang larvae are tiny and have a small mouth, underscoring the need to screen appropriately sized natural live food organisms and artificial diets for first feeding larvae of this species. Live food organisms such as *Isochrysis*, *Tetraselmis*, *Brachionus rotundiformis*, copepods, thraustochytrids, *Chlamydomonas*-like oyster eggs and trocophore larvae, and artificial diets like sieved milkfish larval feed (40-60 μ) and Revolution I (<50 μ) have been fed to larvae in various combinations.

Among the shellfishes, research under this program has focused on the mudcrab (*Scylla* sp.) and the portunid crab (*Charybdis feriatus*). In the mudcrab, morphometric and non-morphometric traits of wild and hatchery-reared stocks of *S. olivacea*, *S. tranquebarica*, and *S. serrata* juveniles of various size groups have been measured in order to provide empirical basis for differentiating these species. From a sample having a range of body weight of 0.16-16.97 g and carapace width (CW) of 1.08-5.19 cm, 27 ratios of



Blue tang (top); portunid crab (above)

these morphometric data were obtained to standardize these traits, which were then subjected to stepwise discriminant analysis. Of the 27 standardized characters, nine may be used to distinguish at least two of *Scylla* sp. Specific restriction endonucleases applied to gene fragments amplified by polymerase chain reaction was able to

completely discriminate among the different *Scylla* species.

However, identification through external morphology of *S. tranquebarica* and *S. serrata* of less than 3 cm ICW did not match those discriminated by gene markers, demonstrating the difficulty of identification based on morphological traits alone of these two species at this size.

DEVELOPING STRATEGIES FOR STOCK ENHANCEMENT

AQD is committed to promote stock enhancement in the region to increase fish supplies from inland and coastal waters. 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

- Release, marking and monitoring
- Transplantation of breeding adults
- Release of hatchery-produced juveniles
- Co-management of resources



Adoption of breeding and hatchery production technologies of appropriate species for stock enhancement

Refinement of seed production techniques for abalone has been carried out to mass produce juveniles for stock enhancement. Abalone juvenile production was doubled from the usual 10,000 juveniles/year (1998-2000) to 21,446 juveniles in 2001, mainly due to: 1) increased larval settlement rate from 1-5% by using pre-grazed diatom plates (mucus production) and 2) increased survival of early juveniles by transferring the plates with settled larvae to outdoor tanks 7-10 days after larval stocking (5x more and 20% bigger than those in indoor tanks for 2 months). The 2-3 month old juveniles were fed an artificial diet for 1-2 months to produce a bluish-green shell band that can be used to identify hatchery-produced abalone for stock enhancement.

As part of the preparation for stock enhancement, a study on the genetic variation between wild and hatchery-produced abalone was conducted by a Ph.D. student at the University of Queensland. Results indicated that the hatchery-produced juveniles (second generation) can be released to Sagay Marine Reserve but not to Guimaras Island, because the genetic structure of the hatchery-bred stocks was more similar to Sagay stocks.

Evaluation of the broodstock diet for abalone confirmed that the combination of seaweeds and artificial diet gives the highest fecundity, total number of spawnings, and egg and larval production than seaweeds or artificial diet alone. Larval quality based on

development, settlement and metamorphosis will continue to be investigated in 2002.

The study on the use of different attachment substrates and other cues showed that 1) diatoms grow best on roughened plexiglass surface using the F medium or a commercial fertilizer; 2) larval settlement is highest on mixed diatoms followed by *Navicula*, *Navicula* + *Nitzschia*; and 3) Gamma amino butyric acid (GABA) is more effective than potassium chloride (KCl) in inducing larval settlement and metamorphosis.

With the objective of purifying and characterizing biochemical cues for larval settlement and metamorphosis of abalone, proteins were extracted from



Candidate species for stock enhancement (from left): abalone (note distinctive green shell band); top shell (with reddish pink shell band), seahorse, and capiz shells



abalone mucus, foot muscle, larvae, *Navicula*, mixed diatoms, and mucus-filmed diatoms. Molecular weight of proteins from mucus and foot muscle was about 100 kDa. A second band in the foot muscle sample was about 200 kDa. Protein concentration was highest in the foot muscle, followed by mucus, *Navicula*, abalone larvae, mucus-filmed diatoms and mixed diatoms. Larval settlement was highest on mucus and foot muscle extracts. Further purification work will be undertaken in 2002.

Seed production techniques for seahorses are being refined at the SEAFDEC/AQD hatchery to mass produce juveniles for stock enhancement in the future. Top shell juveniles (3,000 pcs) were provided by a private hatchery in Palawan for AQD's stock enhancement work. These too were fed with an artificial diet to produce a distinctly colored shell band that can be used for identification of hatchery-produced top shell for stock enhancement. These will either be released in a selected site or used as broodstock for AQD future seed production work. Giant clam *Tridacna gigas* juveniles (500 pcs) were provided by UP MSI and are now being reared in the AQD mollusk hatchery in preparation for stocking in AQD's Igang Marine Station.

Development of release and stock enhancement strategies

In preparation for the release and stock enhancement of abalone, top shell and seahorse, initial assessments were conducted on the following resources in Sagay Marine Reserve: 1) abalone, 2) top shell, 3) seagrasses and seaweeds, 4) corals, 5) reef fishes, and 6) mangroves. Abalone and top shell stocks are low indicating the need for stock enhancement by releasing hatchery-produced juveniles. The abundance of seaweeds indicated the availability of food for abalone. Future work under this study includes 1) socio-economic assessment, 2) in-depth stock assessment in all reefs within the reserve to obtain sufficient baseline data prior to stock enhancement, and 3) experimental release of abalone, top shell and seahorse.

Another restocking of the window-pane shell *Placuna placenta* was carried out in Panay Gulf with the objective of repopulating the area. Stocks were placed inside stainless steel pens for better protection and easier monitoring. Monitoring for survival, gonad development and recruitment is ongoing. Initial results of the IFS-funded study on the impacts of marine protected areas and

artificial reefs on coral reef fisheries in Malalison Island, Antique and Tangalan, Aklan showed that protected areas with artificial reefs had the highest catch volume and number of species, whereas unprotected areas with artificial reefs had the lowest catch volume and number of species.

The ICLARM - funded study on the scale question in co-management has been started to determine the processes involved in the transition from a small-scale co-management (Malalison Island) into a bay-wide management scale (LIPASECU Bay), and to determine the capabilities and social preparedness of LIPASECU for stock enhancement projects and other resource management interventions. Key informant interviews indicated that of the four municipalities of LIPASECU, the strongest in terms of political will and enforcement of fishery laws is Libertad, whereas the weakest is Pandan. Group interview data in Malalison indicated that education and training are important to the success of a CRM activity. Encroachment of fishers from other municipalities outside of LIPASECU in the sanctuary is one of the major problems that Malalison fishers have encountered.



Capiz shell's offshore pens

SPECIAL PROGRAMS

SEAFDEC AQD collaborates with other aquaculture research funding institutions to bring to fruition a number of special programs: Association of Southeast Asian Nations-SEAFDEC Fisheries Consultative Group (ASEAN-SEAFDEC FCG) Projects; Japanese Trust Fund projects (*Mangrove-friendly shrimp culture project* and *Aquaculture disease management program*); Bureau of Fisheries and Aquatic Resources-SEAFDEC Collaborative Program; and the Japan International Cooperation Agency's *Third country training program*

ASEAN-SEAFDEC FCG PROJECTS

During the first meeting of the ASEAN-SEAFDEC Fisheries Consultative Group in Bangkok, Thailand in March 1999, four projects were approved for implementation under the FCG collaborative mechanism. Among these is the promotion of mangrove-friendly aquaculture in SEA countries, which has AQD as the lead department of SEAFDEC, and Thailand as the lead country for ASEAN. It was later agreed that this project would focus on shrimp culture. Another collaborative project is the *Regionalization of the code of conduct for responsible fisheries* for implementation by the SEAFDEC Secretariat. At the meeting of FCG in Malaysia, four more projects were approved including the Regional Fish Disease Project at AQD.

MANGROVE-FRIENDLY SHRIMP CULTURE PROJECT



Nutrient cycle

This activity aims to determine the nature of complex inter-relationships among the bio-physico-chemical factors influencing pond performance. Conducted at AQD's Dumangas Brackishwater Station, this research study focuses on nutrient cycles with emphasis on the recirculating closed system. Ponds are constructed in a modular form with biological treatment for nutrient removal in order to keep 'clean' water and maintain a reduced to zero water exchange, by adopting an

improved aqua- engineering design. Stocking of shrimp fry (PL₁₅) at 30 pieces per m²; oysters, 3-5 pcs/m²; clams (*Anodonta edentula*), 1 pc/m²; tilapia, 5 pc/m², and seaweeds, 1 kg/m², was done in May-June 2001. SEAFDEC formulated diet (39.5% CP) was used as feed. Activity is ongoing.

Capacity of mangroves to absorb effluents

A study on the capacity of mangroves to process shrimp pond effluents in impounded mangrove wetlands has been undertaken. Partial results showed that bacterial counts in the water (*Pseudomonas-Aeromonas*, *Vibrio* and luminous bacteria) from the creek tended to decrease when held in the reservoir pond before pumping into the shrimp

Monitoring of bacteria levels in reservoir, shrimp ponds and mangrove ponds



A harvested pond with mangrove filter (background), where effluents are drained



P. monodon harvest at 2.8 tons/ha/crop from mangrove-friendly grow-out systems



pond, probably because of the presence of milkfish and/or mangrove trees in the reservoir pond.

P. monodon were stocked at 25/m² and harvested at 20g ABW after 4 months. Low levels of WH₃, NO₃, PO₄ and TSS were observed up to the second/ third month and increased only afterwards. DO and BOD levels remained similar throughout the culture period. The shrimp pond showed higher TSS, BOD and NH₃ than the mangrove pond in the latter half of the culture period.



Recent approaches for sustainable shrimp farming

A number of mangrove-friendly shrimp culture verification studies were conducted in the region by SEAFDEC/AQD in cooperation of Thailand's Department of Fisheries.

Philippines

Conducted at AQD's Dumangas Brackishwater Station, this verification activity is intended to refine techniques developed by the Department based on results of previous studies on growth, survival and production of *Penaeus monodon* using environment-friendly schemes, conducted in other sites of the Philippines.



A verification tour of Myanmar's mangroves (opposite page, top left); MFSC trainees in Thailand (above & bottom left, opposite page)

Two successful runs in 2000 had an average production of 5.0 tons/ponds (0.9 ha and 0.8 ha) after 150 d of culture; another run was started in June 2001. This run intends to refine further the closed recirculating system for intensive shrimp farming. Four ponds (average area: 1,500 m²) are used for this run and stocked with shrimp fry at 60/m². This run is ongoing.

Vietnam

Although initially under the Management for Sustainable Coastal Fisheries (MSCF) project of the SEAFDEC Secretariat, this activity on shrimp semi-intensive culture has been included in the MFSC since 2000. This activity is being implemented in Phu Long, Cat Hai District, Hai Phong, Vietnam, with the collaboration of the Research Institute of Marine Products (RIMP) of the Ministry of Fisheries, Vietnam. Its objective is to produce 1.5-2 tons of shrimp per crop, along with the conservation of mangrove forests.

Thailand

Seawater irrigation for intensive marine shrimp farming

This activity was developed as part of an ongoing royal project in Kung Krabaen Bay, Chantaburi, Eastern Thailand to integrate the management of resources in the Bay for sustainable shrimp farming.

Studies indicated that effluents from intensive shrimp farms do not impact water quality in the bay and in drainage canals. The finding is in contrast to earlier results obtained for water quality in the sea. Significant sedimentation in the drainage canals indicated an accumulation of organic matter and fermentation in the sediment layer of drainage canals. *Avicennia alba* grew faster than other mangrove species. Analysis of data on water quality of wastewater from drainage canal (before treatment and after treatment by mangrove trees) seemed to indicate that there was a significant difference in water quality before and after treatment.

Integrated physical and biological technologies for water recycling in shrimp farms

This activity intended to verify reduction of water consumption in shrimp farms by recycling water using physical, chemical, and biological water treatments. Since effluent from shrimp farms is characterized by high volume, turbidity and organic load, integration of physical and biological treatment technologies can be extensively used to recycle pond water. Two studies were conducted at the Marine Shrimp Research and Development Center of the Department of Fisheries-Thailand in Songkhla. Results after a one-month culture period indicated a stability of water quality parameters in the grow-out pond after the effluent was recycled through the treatment pond.

Mangrove plantation for enhancing the natural food web in water recycling shrimp farms

Conducted at the Chachaengsao Coastal Aquaculture Development Center in Bangpakong District, Chonburi, Thailand, the project intends to verify the use of mangroves in recycling shrimp farms to absorb nutrients and enhance the natural food web in shrimp ponds.

Mitigation measures of effluents from shrimp farming on mangroves and coastal resources

Conducted at the Andaman Marine Shrimp Research and Development Center of the Department of Fisheries-Thailand in Phuket, this study aims to assess the mitigated volume of some parameters of water from shrimp culture ponds using the seaweed treatment.

Myanmar

AQD and the Department of Fisheries-Myanmar started planning for this MFSC project after a site survey conducted by a team comprised of AQD and Myanmar fisheries staff.



Mangrove-friendly shrimp aquaculture

The first session was started in the second week of September. Participants were representatives from SEAFDEC member countries. The session included a practical session at AQD's Dumangas Brackishwater Station and a field visit of various sites of the project in Thailand.

On-site training in Myanmar

The *Training on mangrove-friendly shrimp aquaculture* at the Department of Fisheries, Myanmar on 27 November - 07 December was attended by more than 40 Myanmar nationals.



Publications on shrimp farming

Closed-recirculating shrimp farming system is a 27-page documentation of the successful intensive shrimp operation of the Marine Shrimp Research and Development Institute, Department of Fisheries, Thailand. The publication is a collaborative effort of ASEAN and SEAFDEC. DOF Thailand's Siri Tookwinas wrote it.

Environment-friendly schemes in intensive shrimp farming is a 24-page documentation of the low discharge system of shrimp culture worked out at Dumangas Brackishwater Station as part of the ASEAN-SEAFDEC mangrove-friendly shrimp culture project. It is authored by D Baliao.

Operationalization of the mangrove website

The new website for the ASEAN-SEAFDEC project on *Mangrove-friendly*



shrimp culture (MFSC) www.mangroveweb.net was uploaded to the internet in December. The website contains, against the backdrop of The World of Mangroves, all information about the MFSC project. One can find the MFSC project sites in the Philippines, Thailand, Vietnam, and Myanmar; the project's current researches; state-of-the-art technologies; reading materials; and training sessions. There is also information on available mangrove resources and linkages to related websites.

Mid-project workshop

This workshop was conducted in Bangkok, Thailand in September to review progress of activities of the project in 2000, and to confirm and finalize the program of activities for 2001.

AQUACULTURE DISEASE MANAGEMENT

In the last 10 years, aquaculture production in Southeast Asia has grown rapidly and contributed to worldwide food supply. However, with the rapid and uncontrolled development of aquaculture, a number of infectious diseases have emerged, threatening the sustainability of aquaculture in the region. Moreover, the widespread use of chemicals including antibiotics to control these diseases has posed a danger to consumers' health and become an obstacle for trading of the cultured produce. It is, thus, urgent to establish effective control measures against infectious diseases, as well as monitoring methods for chemical use.

Realizing these needs, ASEAN and SEAFDEC collaborated on the *Development of fish disease inspection methodologies for artificially-bred seeds* project (2000-2003) with the SEAFDEC Aquaculture Department as implementing agency. The project aims to conduct the following activities

- Research to develop a standardized diagnostic method for the region, disease control husbandry technique, and monitoring method for residual chemicals in aquaculture products
- International workshop for the regionalization of the standardized diagnostic method, as well as disease control husbandry method
- Hands-on training on diagnostic methods for important diseases in the region

- Development of a surveillance system for disease problems in the region



Establishment and standardization of diagnostic methods

The polymerase chain reaction (PCR) technique adopted by AQD was established as a detection method for white spot syndrome virus (WSSV). Hepatopancreatic parvovirus (HPV)- and monodon baculovirus (MBV)-infected *P. monodon* fry were obtained and preliminary experiments for MBV and HPV infections were successful. The diagnostic method using a squash preparation of the hepatopancreas stained with Malachite green was considered



Adult *Penaeus monodon* with WSSV



Detection of VNN from grouper larvae by PCR

practical and can be used in establishing principal diagnostic techniques for the proposed training course.

To ensure the health of aquaculture broodstock, it was considered important to identify populations of wild shrimp that are free of systemic virus. Thus, a countrywide survey on the distribution of viruses in the natural shrimp population in the Philippines was carried out. Dry and wet season samplings were done for shrimps in seven sites, which were considered to be primary sources of broodstock and spawners in the country.

Biology and pathogenesis of disease agents

Parasitic infestation has been known to cause mass mortalities in many marine and freshwater fishes. To effectively control parasites necessitates knowledge of their life cycles, good health management of culture systems of the host fish, and the availability of treatment methods.

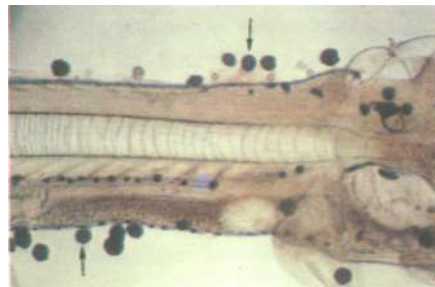
A series of studies was conducted to screen economically important fishes for the presence of parasites; determine diagnosis and pathology of the infections and host-parasite relationships; and establish methods of prevention and control.

Screening of important parasites in grouper showed infestation by protozoans, monogeneans, didymozoid digenean and marine leech. Red snapper harbored ciliated protozoans, a digenean, copepod, and a nematode. Rabbitfish had ciliated protozoans, monogenean and nematodes. Milkfish larvae from a private hatchery experienced mass mortality due

Results of a study on the detection and identification of viral pathogens in cultured marine finfishes seemed to indicate that the mass mortality of grouper larvae observed at AQD was caused by viral nervous necrosis (VNN). This is the first confirmative identification of VNN in grouper in the Philippines. Taking into consideration the impact of VNN in hatcheries in the region, a study establishing preventive measures against the disease in finfish hatcheries was undertaken.

to the dinoflagellate *Amyloodinium*. This was the first occurrence of *Amyloodinium* infestation in milkfish.

For the biology and pathogenicity of the gill monogenean the effect of different salinities on the hatching and development of eggs of the parasite until the oncomiracidial stage was determined. No hatching was observed at salinity 0 and 60 ppt. Assessment of the effects of different levels of monogenean infection has caused fairly high level of mortality among the test grouper larvae.



Amyloodinium infestation in milkfish fry

All leech samples collected from tank-reared grouper and milkfish, and from pond-reared tilapia did not carry blood parasitic protozoans, as analyzed microscopically. However, when the leech samples were tested by PCR, products similar to positive control was obtained.

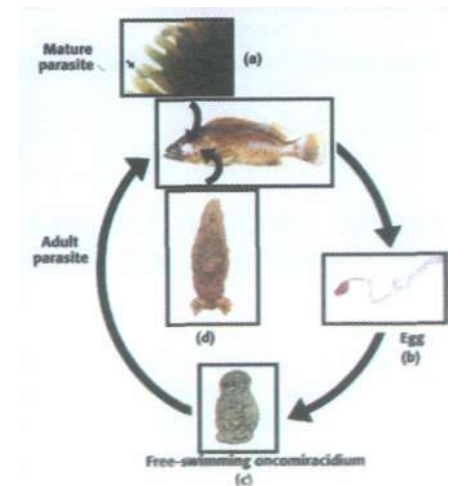
An earlier study noted that the gill monogenean *Pseudorhabdosynochus* sp. is the most abundant parasite of pond-reared grouper. The study also clarified the life cycle of this parasite.

In order to control this monogenean, the efficacy of bath treatments using freshwater, hypersaline, formalin, and hydrogen peroxide was studied. Results indicated that formalin and hydrogen peroxide were effective. However, the use of hydrogen peroxide was recommended from the standpoint of environmental hazardous effects.

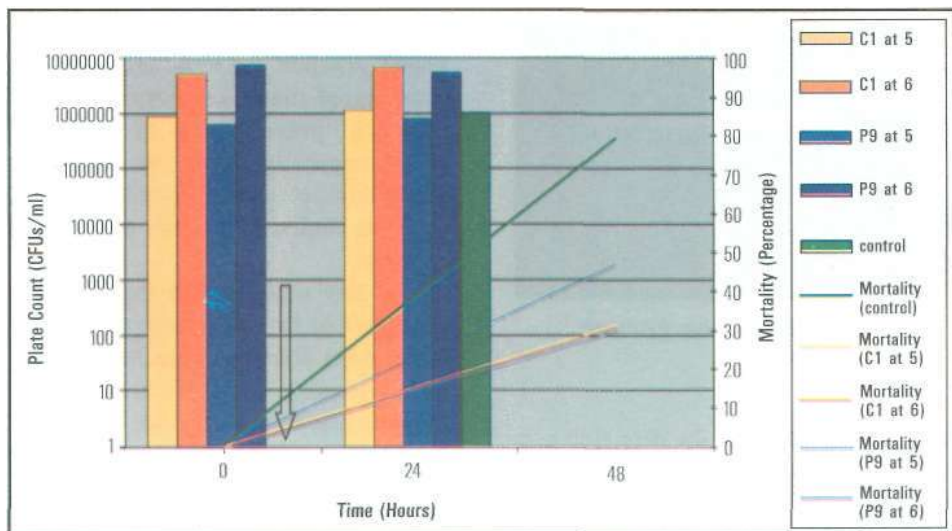
Disease prevention and control

Research in this section aims to develop husbandry techniques such as application of probiotics and the green water culture system as alternative strategies of disease control and prevention.

Potential probiotic bacteria were isolated from healthy hatchery-reared shrimp and crab larvae, and their environment. Out



The life cycle of *Pseudorhabdosynochus* sp. parasitizing the gills of *Epinephelus coioides*. (a) mature worm on gill; (b) egg; (c) free-swimming oncomiracidium; (d) adult parasite.



Mortality (line graphs) of zoea 3 crab larvae upon exposure to probiotic strains C1 and P9 (bar graphs). No bacterium was added into the control treatment (arrow), but after 24 h up to 10⁶ cfu/ml (9% which were luminous bacteria) were recovered

of 80 bacterial isolates, 10 bacterial strains were found to suppress the growth of *Vibrio harveyi*. Among these, one isolate from green alga *Chlorella* sp. was considered a promising probiotic for crustacean hatcheries since the bacterium is not pathogenic to crab and shrimp larvae; can easily associate with the larvae and dominate its bacterial flora; is readily incorporated into live rotifer, the feed animal of the larvae; and can be easily cultured in liquid media.

An experiment was carried out in order to develop an experimental system for testing the efficacy of probiotics. The

effect of probiotics through incorporation in the food and culture water was estimated in two culture systems (recirculating and non-recirculating). The results indicated that the probiotic effect was more efficiently evaluated by adding probiotics through the rearing water in the recirculating system.

Screening tests for the inhibitory action to *Vibrio harveyi* were done for bacteria, fungi and algae for their extracellular and intracellular metabolites. The results indicated that extracellular and intracellular metabolites of some bacterial, fungal and phytoplankton flora

of the "greenwater" culture system of *P. monodon* inhibit the multiplication of *V. harveyi*. In the preliminary tank experiment, results suggested that the existence of tilapia reduced the concentration of luminescent *Vibrio*. This tank experiment is expected to clarify the mechanism of greenwater (or finfish integration) shrimp culture system.

Establishment of evaluation methods for residual chemicals in aquaculture products

The presence of chemical residues in aquacultural food products threatens human health. To answer the need for risk-free, nontoxic food, research in this area aims to develop monitoring methods for chemicals in aquaculture products and manuals for the safe and efficient use of chemicals.

One study aimed to validate, standardize and develop analytical methods for sampling, extraction and quantification of pesticides in aquaculture products, optimizing the use of the new gas chromatograph with electron capture detector. Various extraction techniques prior to gas chromatography and procedures for some aquaculture products such as shrimp, milkfish, grouper, sea bass, siganids, catfish, tilapia, and seaweeds were standardized. Recovery and efficiency, detection limits and reproducibility of the methods for 18 pesticide residues were established.

REGIONALIZATION OF THE CODE OF CONDUCT FOR RESPONSIBLE FISHERIES: AQUACULTURE DEVELOPMENT

SEAFDEC has initiated a program on *Regionalization of the code of conduct for responsible fisheries* (RCCRF) to address missing areas and certain omissions of important issues in the Food and Agricultural Organization (FAO) *Code of conduct for responsible fisheries* that concern the development of fisheries in the region. The global *Code of conduct for responsible fisheries* (CCRF) was adopted by FAO in 1995. In the development of RCCRF, specific regional issues were diluted or in some cases, even avoided with a view of finding acceptable global compromises and consensus on controversial issues.

Thus, SEAFDEC launched the RCCRF program, which has four components: fish operation; aquaculture development; fisheries management and post-harvest technology. It aims to develop codes of conduct for the different components of fisheries development in Southeast Asia.



Shrimp disease workshop

The seminar-workshop on Disease Control in Fish and Shrimp Aquaculture in Southeast Asia: Diagnosis and Husbandry Technique was convened in Iloilo City, Philippines from 4 to 6 December 2001, in collaboration with the Office International des Epizooties (OIE). The workshop was attended by 60 participants

from nine SEAFDEC Member Countries and 3 other countries. During the workshop, current researches on the diagnostic techniques for viral diseases of marine fish and shrimp, and husbandry methods for controlling luminescent Vibriosis in shrimp and crab aquaculture were reviewed. The possibility of AQD

conducting a training on *Diagnosis for important viral diseases in shrimp and marine fish* was discussed, prioritizing the diseases and diagnostic techniques to be included in the training. Areas of possible collaboration with OIE and NACA for the regional aquatic animal disease control system were also discussed.



SEAFDEC-OIE The seminar-workshop on Disease control in fish and shrimp aquaculture in Southeast Asia



Government consultation on the Regionalization of the Code of conduct for responsible fisheries



Code for responsible aquaculture



"Responsible aquaculture," is a 43-page second volume in the series titled "Regional guidelines for responsible fisheries in Southeast Asia."

This is a result of a year-long consultation among experts to regionalize Article 9 (aquaculture development) of the FAO Code of Conduct for Responsible Fisheries.

BFAR-SEAFDEC COLLABORATIVE PROGRAM

SEAFDEC AQD has continued to strengthen its linkage with various agencies and institutions in the Philippines, its host government, specially 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 soon be duplicated in other SEAFDEC member countries

DEVELOPMENT OF APPROPRIATE TECHNOLOGIES FOR USE OF LAKES

This program 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 lakes.



Cost-effective intensive culture of tilapia

A study on a cost-effective intensive culture of Nile tilapia *Oreochromis niloticus* in tanks using lake water showed that fish growth and survival rates were directly related with the flow rate of water. The quality of effluent water from the flow-through setup in both experiments generally improved when passed through a baffle system that settles solids and

oxygenates water before its discharge to the lake. Preliminary results indicate that water from the lake can support intensive tilapia production even without the use of a blower and similar facilities; however, this system becomes more economically feasible if grow-out operations per cropping are done on a larger scale.

Toxins in algae

Fish kills, occur quite regularly in Laguna de Bay during summertime. In other countries, several cases of fish kills are associated with the toxins produced by cyanobacterial blooms such as *Microcystis*. A study was conducted to investigate the presence of toxins on a local isolate of the algae *Microcystis aeruginosa*.

Three types of microcystins, microcystin-LR (most dominant), 3-desmethyl-microcystin LR and 6-Adda-microcystin-RR were found in *M. aeruginosa* samples collected during algal bloom occurrence. Aside from the microcystins, a cytotoxin known as microcyclamide was identified

and isolated from the bloom materials. Effects of purified microcystin-LR (MC-LR) on red tilapia (*Oreochromis sp.*) fingerlings were investigated. Fish injected with the highest dose of MC-LR, i.e. 100 µg/fish or 10,000 µg/kg started to show signs of distress 30 min after injection and all died 1½ h after injection. Prior to death, fish showed abnormal swimming behavior such as swimming upside down or sideways, which suggested loss of balance and disorientation. Mortalities were observed in the fish injected with 10,000 and 1,000 µg/kg concentrations of MC-LR (93.3% and 50%, respectively). The intraperitoneal LD₅₀ value of MC-LR in red tilapia is 1,300 µg/kg.

The freshwater fish *Carassius auratus* (wakin) given the same concentrations of MC-LR showed an intraperitoneal LD₅₀ value of 380 µg/kg. In the fish injected with a lethal dose of microcystin-LR, i.e. 100 µg/fish or 10,000 µg/kg, pathological changes were observed in gills, intestine, liver and kidney.



Laguna lake; harvest of Nile red tilapia *Oreochromis niloticus*



A JMANTTP skills development session (right); a visit to a pilot demonstration farm (far right)



The Mariculture Park in Igang, Guimaras (left); shrimp harvest in Calape, Bohol (bottom)



Proceedings on Philippine lakes workshop



"Conservation and ecological management of Philippine lakes in relation to fisheries and aquaculture" is a 187-page

proceedings of a seminar-workshop convened by SEAFDEC/AQD, PCAMRD, and BFAR. It is edited by CB Santiago, ML Cuvin-Aralar, and ZU Basiao.

COMMERCIALIZATION AND PROMOTION OF DEVELOPED TECHNOLOGIES

The Joint Mission for Accelerated Nationwide Technology Transfer Program (JMANTTP) is a program conceived by SEAFDEC, AQD and BFAR in 1999 to undertake an essentially techno-transfer activity, which utilizes technical, financial, physical and manpower resources to

- Promote sustainable aquaculture technologies that are economically viable, environment-friendly and socially equitable to increase fish production and for export revenues and employment and livelihood options for the fisher folk
- Facilitate technology transfer by demonstrating sustainable technologies in strategic areas nationwide to serve as skill-learning centers for fishfarmers, fisherfolk, entrepreneurs, and other end users through field demonstrations and hands-on training
- Implement the *Oplan Sagip Sugpo* consistent with the MakaMASA Program for fisheries, the AFMA and RA 8550
- Conduct skills development sessions nationwide for speedier technology information dissemination



Environment-friendly schemes in shrimp farming

The initial program of activities of JMANTTP is a continuation of the *Oplan Sagip Sugpo* program of the government, which aims to rehabilitate the country's ailing shrimp industry.

A field test of schemes used in shrimp farming under different environmental conditions in 2000 resulted in major breakthroughs that made fine tuning of the technology developed by SEAFDEC AQD, in Dumangas, Iloilo suit the specific requirement of a particular area, where the technology would be implemented. Pilot demonstration farms in strategic sites in the country were thus,

set up; these were in their 2nd run of techno-demo operations in 2001.

The technology, which employs the closed recirculating system had impressive results in two sites: Butong, Taal, Batangas and Pacita, Lala, Lanao del Norte. Another site, BFAR Bentig, Calape, Bohol still has to complete its run in February 2002.

Mariculture Park. The JMANTTP Mariculture Park was launched last August 4 at AQD's Igang Marine Substation in Nueva Valencia Guimaras. A mariculture park is akin to an industrial park where spaces are available for lease. In a mariculture park where aquaculture is the industry involved, the park operator

sets up a common facility such as a mooring system and cage frames. With everything in place, prospective growers are spared of the high initial cost involved in cage farming but instead pay only a certain fee for the space of the netcage. The mariculture park in Samal Island, Davao is for commercial purposes.

The Igang station serves as a demonstration and training center, and has been stocked with milkfish and high-value finfishes, such as grouper, red snappers and siganids. It is used as a hands-on training site on cage farming for requesting parties coming from local government units (LGUs) and the private sector.

STRAIN IMPROVEMENT OF COMMERCIALY IMPORTANT SEaweEDS



Development of improved strains of *Euclima* and *Gracilaria* through biotechnology

Research was focused mainly on strain improvement and development of culture systems of the carageenophytes *Kappaphycus* and *Euclima*. Repeated propagation of vegetative thalli of these seaweeds in the Philippines for 30 years has resulted in declining quality of carrageenan, unstable biomass production, vulnerability to "ice-ice" disease and poor post-harvest management. The application of "genetic manipulation" (protoplast fusion, tissue culture and mutagenesis, cell-cell fusion) techniques to seaweed aquaculture may increase growth rates and improve carrageenan composition.

Young plants of regenerants of UV-treated and untreated *E. denticulatum* from calli were outplanted and grown

vertically inside a cylindrical cage. After 120 days of field growth, growth rates ranged from 5.1 to 7.4%. Molecular analysis of variance of these plants showed that all 16 regenerants were significantly different from the wild plant. Among the regenerants, however, RU 12-1, RU 3-3 and RU 3-5 were significantly different from the rest, suggesting that these plants were "new strains." Carrageenan analysis of these plants showed different yield. Further analysis of molecular and chemical properties of each carrageenan is being done to further verify the authenticity of the "new strains."

Very young plants of *K. striatum* (brown, green and red) treated and untreated with different concentrations of NTG were

obtained by tissue culture after 5 months of incubation. These plants will be subjected to outplanting and field growth, and carrageenan characterization (physical, chemical and molecular).

Assessment of improved cultivars for culture

Preliminary isolation of protoplasts from *Gracillaria firma*, *Gracillariopsis heteroclada*, and *Kappaphycus alvarezii* was done using a mixture of cell wall-lytic enzymes. Growth and development of protoplasts were monitored periodically.

Young plants of *G. changii*, *G. firma* and *G. heteroclada* that originated from spores liberated under laboratory conditions were outplanted for further propagation.

Exposure of *Gracillariopsis bailinae* to different levels and times of Cd, Cu, Pb and Zn, and processing of dried thalli and agar were completed. Flame atomic absorption spectrophotometer measurement of the thalli and agar of *G. bailinae* will commence upon availability of the equipment.



Seaweed planning workshop

Held in August 2-3, the workshop described the status of seaweed farming in the Philippines and pushed for the creation of a code of practice for the seaweed industry.



Seaweed workshop (above); tissue culture of seaweeds (below)



Gracillariopsis bailinae



Eucheuma denticulatum

THIRD COUNTRY TRAINING PROGRAM

The *Third country training program on responsible aquaculture development* (TCTP-RAD) is implemented by SEAFDEC AQD with financial support from the government of Japan through the Japanese International Cooperation Agency (JICA). The program aims to intensify dissemination of sustainable aquaculture technology. Already on its second phase, this program is for a 5-year period from 1999 to 2003 with one training course conducted annually.



Responsible aquaculture development



RAD brochure

The RAD course offered in September 4-October 29, 2001 aimed to intensify dissemination of responsible and sustainable aquaculture technology. Thirteen countries from Asia and Africa were invited to participate. The 15 accepted applicants came from Cambodia (2), People's Republic of China (1), India (1), Indonesia (2), Kenya (1), Myanmar (2), Mozambique (1), Nigeria (1), Pakistan (1), Sri Lanka (1), and the Philippines (2).



"Group training on responsible aquaculture development" is a brochure on the training course funded by JICA through TCTP.



Responsible aquaculture development training session and closing ceremonies

ASEAN-SEAFDEC COLLABORATIVE PROGRAM



The Millennium Conference sessions (above), and exhibit (bottom right)

THE MILLENNIUM CONFERENCE



Fish for the people

The *ASEAN-SEAFDEC conference on sustainable fisheries for food security in the new millennium "Fish for the people"* was convened in Bangkok, Thailand from 19-24 November. Exhibits were from 21-24 November. The conference, jointly organized by ASEAN, SEAFDEC, FAO and the Department of Fisheries-Thailand reviewed the fisheries situation, analyzed problems and formulated policies and strategies for better management of fisheries in the SEA region.

In preparation for the regional conference, AQD hosted a two-day seminar in April 18-19 in collaboration with DA-BFAR. About 100 participants for the academe, government institutions, and private sectors attended. AQD officials and senior researchers also participated. Three themes were tackled: aquaculture, fisheries management, and postharvest. Points discussed formed part of the technical working documents and draft resolution and plan of action, which were presented at the Millennium Conference.



AQD's national seminar for the Millennium Conference

PROMOTION OF SUSTAINABLE FISHERIES THROUGH SOUTH-SOUTH COOPERATION



Sustainable aquaculture

Four participants from Cambodia, Laos, Myanmar and Vietnam arrived at AQD on June 2001 to attend a 3-month training on *Sustainable aquaculture*, which forms part of a program on *Promotion of sustainable fisheries through South-South cooperation*.

Funded by the ASEAN foundation, the program aims to minimize gaps in degrees of economic development and technical capabilities in achieving sustainable fisheries among ASEAN

member countries. Through the program, mid-level government officials, who have potentials to be involved in planning and development of fisheries and aquaculture in their countries, may upgrade their English communication capability; acquire additional knowledge on current development of fisheries in the region; obtain practical experience and exchange views in respective disciplines; and relate themselves to networks of fisheries experts and institutions in the region for future collaboration.

SEAFDEC hopes to continue helping these four countries improve their capabilities in developing sustainable fisheries and aquaculture. This South-South regional cooperation is expected to benefit SEAFDEC and ASEAN countries.

OTHER SEAFDEC/AQD COLLABORATIVE AGENCIES, RESEARCH GRANTS AND FELLOWSHIPS

Australian Center for International Agricultural Research (ACIAR)

Studies on grouper *Epinephelus coioides*: semi-intensive seed production; environmental factors affecting embryonic development, hatching and survival; development of the digestive system in larvae; lipid nutrition studies; development of a practical diet for juveniles; and apparent digestibility of selected feed ingredients

European Union (EU)

Studies on the development of bio-encapsulated feed for larval fish based on nutritionally enriched nematodes as feed for bighead carp larvae, and grouper, sea bass and mudcrab larvae

International Center for Living Aquatic Resources Management (ICLARM)

A study on the scale question in co-management: Malalison Island and LIPASECU Bay Management Council, Inc.

International Foundation Science (IFS)

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

Rovithai Limited, Bangkok, Thailand

Studies on the influences of Vitamin C diet supplementation on milkfish broodstock's reproductive performance and larvae

Universiti Putra Malaysia, Malaysia

Ongoing graduate research assistantship for an M.S Aquaculture (Fish Nutrition) degree for researchers *E. Aralar* and *M. Laron*

University of Hohenheim, Germany

Ongoing fellowship grant for degrees in Ph.D. and M.S. at the University of Hohenheim, Germany for *M.L. C. Aralar* and *A. C. Gonzal*, respectively

United States AID (USAID)

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

USA - Dry Pea and Lentil Council

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

Japan [Japanese Government Research Scholarship Program, Ministry of Education (Monbusho)]

A fellowship grant for a Ph.D. program, Tokyo University of Fisheries for *E. Amar*

Philippine Council for Aquatic and Marine Resources Research and Development (PCARMD/DOST)

Ongoing fellowship grant and research project for *N. Sumagaysay-Chavoso* for a Ph.D. degree at the Marine Science Institute, University of the Philippines, Diliman, Quezon City. Her study is on the determination of environmental capacity of receiving water from nutrient loading and effluents of semi-intensive and intensive milkfish pond

PERSONNEL AND MANAGEMENT



Rolando Platon, Ph.D.
Chief



Susumu Ito
Deputy Chief



Clarissa Marte, Ph.D.
Head, Research



Wilfredo Yap
Head, Technology Verification
& Commercialization

AQD/FISHWORLD VISITORS

A total of 98 groups composed of 9,465 individuals visited SEAFDEC/AQD and/ or FishWorld in 2001. The groups were composed of 47 elementary schools, 31 high schools and colleges and 20 others.

AQD staff totaled 407: 139, Research; 23, Training and Information; 9, Technology Verification and Commercialization; 107, Administration and Finance Division; and 18, Office of the Chief.

Twelve AQD employees were separated from the service due to retirement (6),

death (2) and termination (4).

Top officials of AQD include: **Rolando Platon**, Ph.D. as Chief; **Susumu Ito**, Deputy Chief; **Clarissa Marte**, Ph.D., Research Division Head; **Wilfredo Yap**, Technology Verification and Commercialization Division Head; **Pastor Torres, Jr.**, Training and

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Pastor Torres, Jr.
Head, Training & Information



Dan Baliao
Head, Administration & Finance

Information Head; and **Dan Baliao**, Administration and Finance Head.

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SEAFDEC/AQD'S RESPONSE TO INDUSTRY'S NEEDS



Queries on aquaculture farming schemes lead to lively discussion



SEAFDEC/AQD shows support for DA-BFAR's *Nationwide fisheries technology caravan*, a venue for disseminating information and technology transfer on fisheries



Mass production of hatchery-bred juveniles contributes to the enhancement of depleted stocks



The AQD-BFAR mission for accelerated technology transfer (JMANTTP) conducts aquaculture skills development sessions nationwide



JMANTTP skills sessions encourage shrimp farmer graduates to boost production through environment-friendly schemes



All the right ingredients mixed together spell success...and make for a bountiful harvest!



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 Station

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