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SEAFDEC

Aquaculture Department
Southeast Asian Fisheries Development Center

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SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER
AQUACULTURE DEPARTMENT
Tigbauan, Iloilo, Philippines

AQD ANNUAL REPORT 1987

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FOREWORD

PUBLICATION of this Annual Report came on the heels of the celebration of the 20th foundation anniversary of the Southeast Asian Fisheries Development Center (SEAFDEC) in December 1987. The Aquaculture Department (AQD) therefore dedicates this report to SEAFDEC in praise of its history of achievements in the past two decades.

As a unit of the Center, AQD is not as old, having entered the scene only in 1973. But with the support and encouragement of the SEAFDEC Member Countries, cooperating international organizations, and the Philippine government, AQD was soon in the thick of fisheries development in the region. It was given the task of developing modern technologies that would optimize Southeast Asia's vast potentials for aquaculture and thus ease the serious food problem faced by the ever-growing population in the SEA countries.

Research and development studies on various aspects of aquaculture, manpower training, and information dissemination have been the basic tools with which AQD sought to realize its mission. That the Department has stood well in these endeavors can be seen in the dramatic growth of the aquaculture industry in the region, especially in the Philippines.

The production and export of highly marketable cultured species such as prawns became a major source of national income. More than this, however, AQD has greatly helped to diversify and enhance the social dimension of the industry by putting emphasis on increasing the productivity of the small fish farmers through transfer of technology, training, and greater access to information. This thrust of AQD activities and work programs has been made more visible lately, following the policy of the new government of the Philippines to truly democratize the distribution of wealth in the country. It means the effective implementation of the social justice concept which under the present circumstances should favor more than the poor that form the majority of the population.

The promotion of aquaculture has acquired added significance in recent years. This is due to the decline of traditional and conventional fish production as a result of overfishing which has depleted the natural stock. We can add the massive loss and environmental degradation of known fish habitats and breeding grounds like the mangrove and coral reef areas.

However, we may not find solutions to the problem by simply expanding or intensifying conventional aquaculture practices. Expansion would mean further intrusion into natural coastal fish habitats like the mangrove areas, with obvious negative consequence to the productivity of coastal fishery. Intensification of pond culture is constrained by the high cost of farm inputs, incidence of fish diseases, and lack of needed infrastructure.

A shift or redirection of AQD's mission therefore points to the promotion of alternative systems that would integrate the positive values of captive and capture fisheries without compromising the integrity of the marine and coastal environments. The Department looks forward to be an instrument of innovative aquaculture systems, particularly mariculture or seafarming as successfully adopted in Japan and other countries.

F. J. Lacanilao
Chief
SEAFDEC Aquaculture Department

Acronyms and Abbreviations

ADSEA – Aquaculture Development in Southeast Asia
AFSSRN – Asian Fisheries Social Science Research Network
AQD – Aquaculture Department
ARC – Artemia Reference Center
ATOP – Aquaculture Technology Outreach Program
BFAR – Bureau of Fisheries and Aquatic Resources
BFS – Binangonan Freshwater Station
BRAIS – Brackishwater Aquaculture Information System
CAL – Centralized Analytical Laboratory
CCL – Centralized Chemistry Laboratory
DA – Department of Agriculture
FAO – Food and Agriculture Organization
ICLARM – International Center for Living Aquatic Resources Management
IDRC – International Development Research Centre of Canada
IFREMER/COP – Institute Francais de Recherche pour L' exploitation de la Mer Centre Oceanologique du Pacifique
IFS – International Foundation for Science
LBS – Leganes Brackishwater Station
NACA – Network of Aquaculture Centres in Asia
PCARRD – Philippine Council for Agriculture and Resources Research and Development
TLRC – Technology and Livelihood Resource Center
TRS – Tigbauan Research Station
UP-MSI – University of the Philippines Marine Science Institute
UPV – University of the Philippines in the Visayas

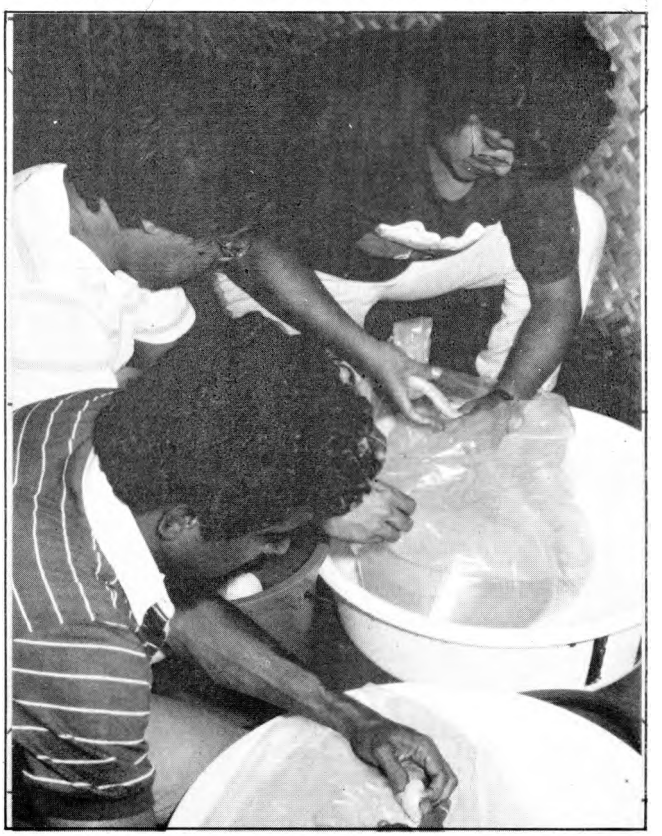
OVERVIEW

OPERATIONS of the SEAFDEC Aquaculture Department (AQD) revolve around activities aimed at developing the potentials of aquaculture in vastly contributing to the food production programs of countries in Southeast Asia. To achieve this objective, AQD undertakes comprehensive research studies on culture of various fish species and application of modern and appropriate aquaculture technologies, as well as effective/innovative management technique. Complementary efforts are pursued in training the necessary manpower, including scientists and researchers, resource managers, field and extension workers, business entrepreneurs, and the small fish farmers. Valuable information come out from all these activities, which the Department processes, stores, publishes, and disseminates to as wide an audience of users as possible.

Taking up the more economically important fish species, AQD's studies focus on four research areas, i.e., breeding; farming systems; feed development; and fish health of finfishes, crustaceans, and molluscs. Among the targets are: 1) the production of an adequate supply of quality seeds from natural sources and by artificial breeding; 2) improvement of culture techniques which includes water quality management practices; 3) formulation of low-cost feeds and propagation of natural food organisms; 4) control of pests, predators, and fish diseases; 5) improvement in the design of culture facilities; 6) control of aquatic pollution in relation to aquaculture; and 7) improvement of stocks through genetic selection.

During the year under review, a total of 83 studies under the four research areas were conducted. Thirty of them were completed per schedule. These will add to the contributions of AQD in introducing improved aquaculture techniques and production systems that continue to raise the level of the aquaculture industry in Southeast Asian countries. Research outputs of the Department, since its establishment in 1973, have for example played a major role in the rapid growth of the prawn industry in the Philippines. Gains have also been achieved through refinements in the culture of economically important species of finfish, mollusc, and crustacean.

In manpower training, AQD has in the past 14 years already trained more than 7,000 technicians and aquaculturists coming from the Philippines and other countries, many of whom have risen to responsible positions in government or achieved remarkable successes in private industry. The Department has also conducted consultation meetings with the scientific community and the



TRAINEES packing prawn fry for transport after a successful hatchery operation.

academe, with extension workers and the ordinary fish farmers; together with national/regional/international conferences and forums attended by multidisciplinary experts, policy-makers and planners, field workers, businessmen, and other interested parties. Over the years, more than 20 of these gatherings have been sponsored by AQD.

The training and assistance extended to fish farmers, such as in pond culture, prawn hatchery, freshwater aquaculture, and mussel and oyster culture, are specially rewarding. Hundreds of these people have benefited from the workshops, seminars, audiovisual demonstrations, on-site evaluations, and extension services rendered by the Department.

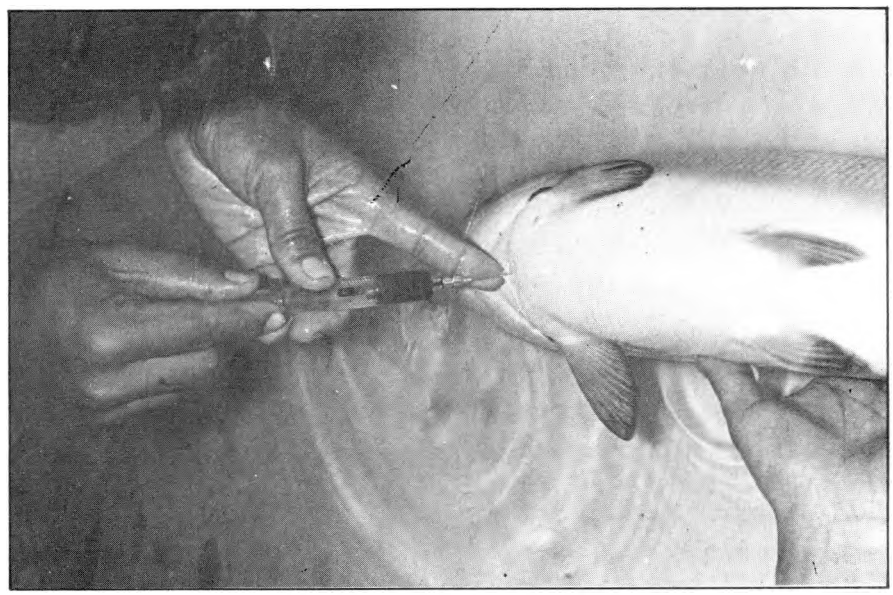
The research, training, and extension activities are supported by a variety of information and communication programs. The information materials generated have not only served as practical guides to the application of modern aquaculture techniques but have also enriched aquaculture literature in general.

Finally, the Aquaculture Department has emerged as the biggest among SEAFDEC's three departments. The other two are the Training Department in Bangkok, Thailand and the Marine Fisheries Research Department in Singapore. SEAFDEC AQD at present has a complement of 581 regular employees manning the research stations and the management and administrative offices. The research stations alone cover a combined total area of some 160 hectares located in Iloilo Province (Tigbauan, Leganes, and Igang) and Rizal Province (Binangonan, Laguna Lake area).

The success of past and present activities of SEAFDEC AQD no doubt has also relied on the assistance and cooperation of non-member governments, international organizations, and Philippine agencies. Among the active participants in this cooperative scheme are the governments of Belgium and France, the International Development Research Centre (IDRC) of Canada, International Foundation for Science (IFS), Food and Agriculture Organization of the United Nations (FAO), ICLARM/Asian Fisheries Social Science Research Network (AFSSRN), and Philippine agencies like the Department of Agriculture, Technology and Livelihood Resource Center (TLRC), and University of the Philippines in the Visayas.

PARTICIPATION of the five SEAFDEC Member Countries (Japan, Thailand, Singapore, Malaysia, and the Philippines) is symbolized by the display of their national flags in front of the Research Building of the AQD main research station in Tigbauan, Iloilo, Philippines.

RESEARCH



BLOOD sampling of milkfish.

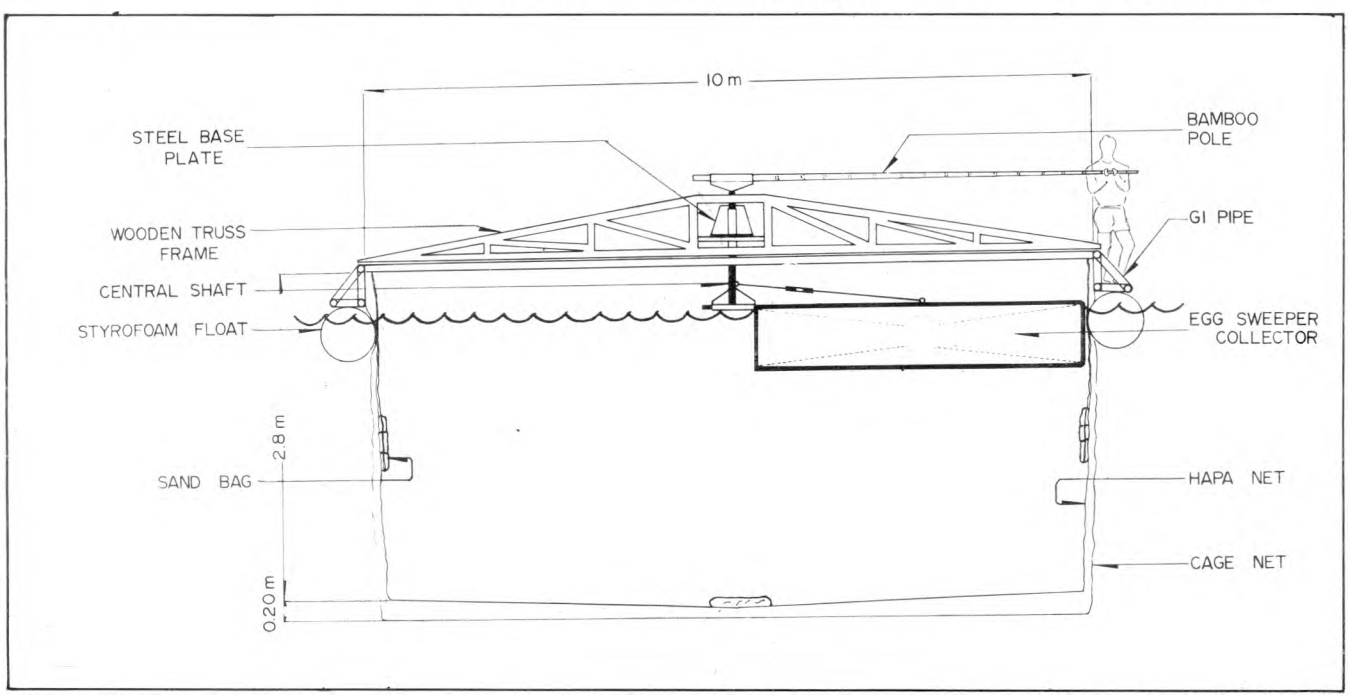
STREAMLINING of AQD operations, which started late 1986, redirected the thrust and priorities of research projects. This was achieved by setting the objectives of research activities into four main categories, namely, 1) Breeding, 2) Farming Systems, 3) Feed Development, and 4) Fish Health. Projects under the first two categories aim to improve and optimize aquaculture production, while those under the latter categories support and complement the production objectives.

Breeding studies intend to develop techniques for mass seed production of economically important fish and shrimp species, and make them easier and cheaper to procure by fish farmers. One of the key objectives in these studies is the refinement of larval rearing techniques that will ensure the quality of the resulting seeds.

Studies in farming systems involve the improvement of methods and techniques in pond, pen, and cage culture of finfishes and prawn. This includes economic feasibility studies and assessment of various fertilization schemes in relation to biomass production in brackishwater ponds and freshwater pens/cages. Special interest has been given to the relationship between growth of cultured fish in cages and present ecological and environmental condition of Laguna de Bay where AQD has its Binangonan Freshwater Station.

For feed development, AQD researches are geared toward the formulation of biologically effective yet economical fish and prawn diets. Efforts are directed to the determination of fish

DIAGRAM of a 10-m diameter floating net cage showing the wooden truss frame, egg sweeper collector, and hapa net.



nutrient requirements, practical diet development, evaluation of indigenous feed resources, feedstuff digestibility, and digestive physiology.

For fish health, AQD researchers confront the problem of fish diseases which is a major factor in poor aquaculture production. These diseases could either be microbial, nutritional, or environmental in origin. Hence, AQD researches in fish health particularly deal with determination of possible adverse effects of commonly used pesticides on milkfish and prawn, identification of pathogenic bacteria associated with some phytoplankton species, control of the chronic softshell syndrome through dietary manipulation, and investigation of the ulcerative fish disease in Laguna de Bay, for example.

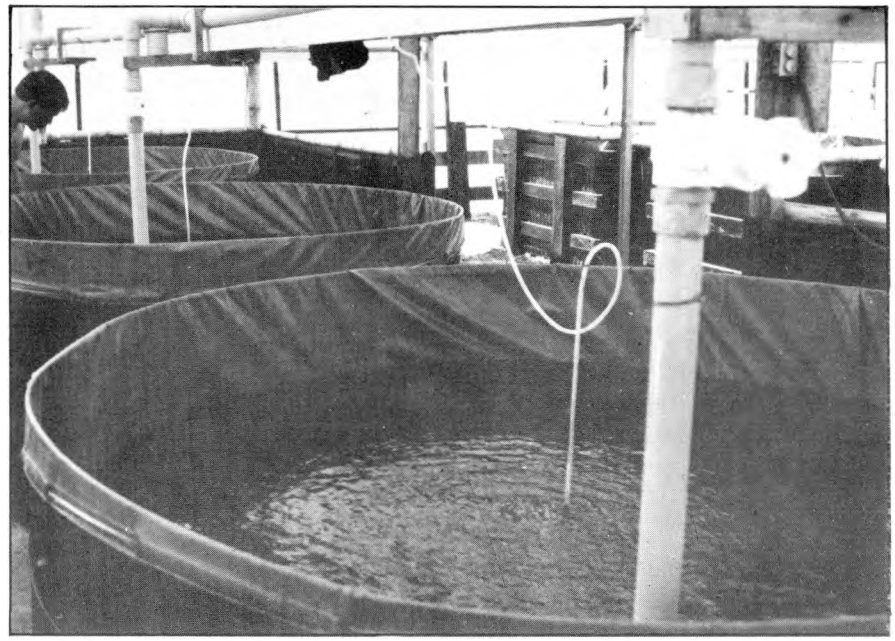
In 1987, a total of 30 research studies in all of the four research categories were completed, while 53 remain in progress. The accomplishment breakdown is as follows: 1) Breeding –14 projects completed, 22 ongoing; 2) Farming Systems – 8 completed, 14 ongoing; 3) Feed Development – 4 completed, 10 ongoing; and 4) Fish Health – 4 completed, 7 ongoing.

Following are the details on the various research activities encompassing the four priority categories mentioned.

Research Studies

BREEDING

Finfish broodstock development. Research studies aim to develop quality finfish broodstock for marine and brackishwater farming. Studies which have been implemented to date include dietary manipulation, monitoring of gonadal development, hormonal induction of spawning, and selective breeding experiments of several marine and freshwater finfishes. Development of techniques for efficient handling and transport of naturally spawned eggs is continuing.



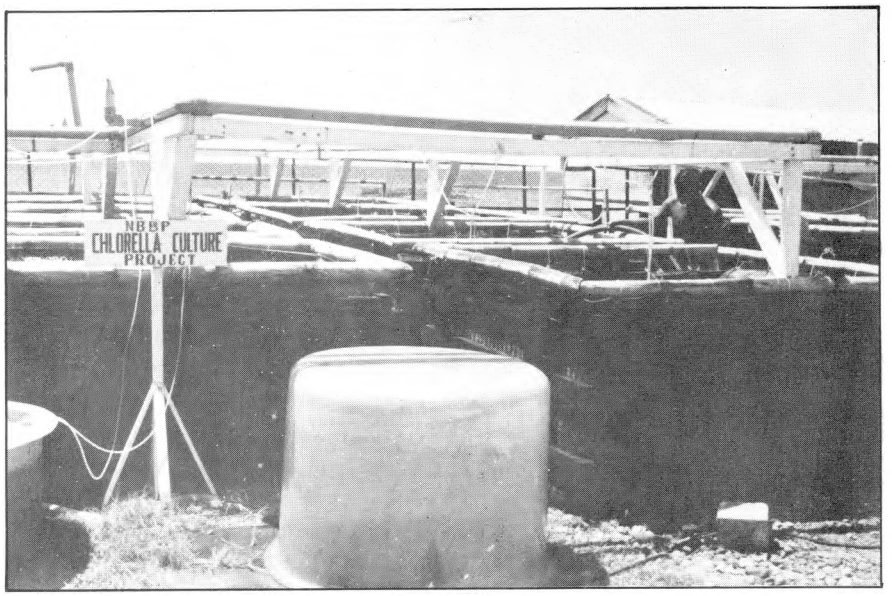
REARING milkfish larvae in the National Bangus Breeding Program hatchery.

• *Development of broodstock diet for milkfish in floating cages: Effect of lecithin on gonadal maturation.* Six to seven years old milkfish in 10 m diameter cages were fed diets enriched with lipids derived from soybean lecithin (SL) and cod liver oil (CLO). Milkfish fed the lipid-supplemented diets spawned four weeks ahead of fish fed ordinary commercial pellet (control diet). More spawnings were obtained from fish fed the control diet (53 spawnings) compared to fish fed the lipid-supplemented diets (SL, 28 spawnings; CLO, 25 spawnings; SL + CLO, 29 spawnings). Fish fed CLO-supplemented diet had the most number of eggs collected. The average number of eggs per spawning of fish fed the CLO-supplemented diet was about three times more than from the other groups.

• *Development of an efficient method of collecting, handling, and transport of newly fertilized milkfish eggs.* Collection of naturally spawned milkfish eggs presently utilizes an efficient device consisting of an egg sweeper mounted on a wooden truss frame and a hapa net. Under simulated transport conditions of 2 and 4 hours, mortality rates of milkfish eggs at an earlier developmental stage (5 and 10 hours post fertilization stage) were significantly greater than mortality rates of eggs at a later stage of development (15 and 20 hours post-fertilization). Hatching rates of transported eggs were variable.

• *National Bangus Breeding Program.* Using SEAFDEC AQD's egg collection design and method, the total number of milkfish eggs collected in the four IDRC-assisted regions were (as of September 1987): Region I (Alaminos, Pangasinan) – 347,106 eggs; Region III (Masinloc, Zambales) – 290,560 eggs; Region VII (Calape, Bohol) – 2,744,042 eggs; Region XI (Sta. Cruz, Davao) – 371,560 eggs.

• *Determination of genetic variation in milkfish.* Single gene analysis was done on a total of about 35 protein loci on samples of milkfish obtained from several sites. Results indicated that milkfish within Philippine waters



CHLORELLA culture tanks for the National Bangus Breeding Program Pilot Hatchery at Tigbauan Research Station.

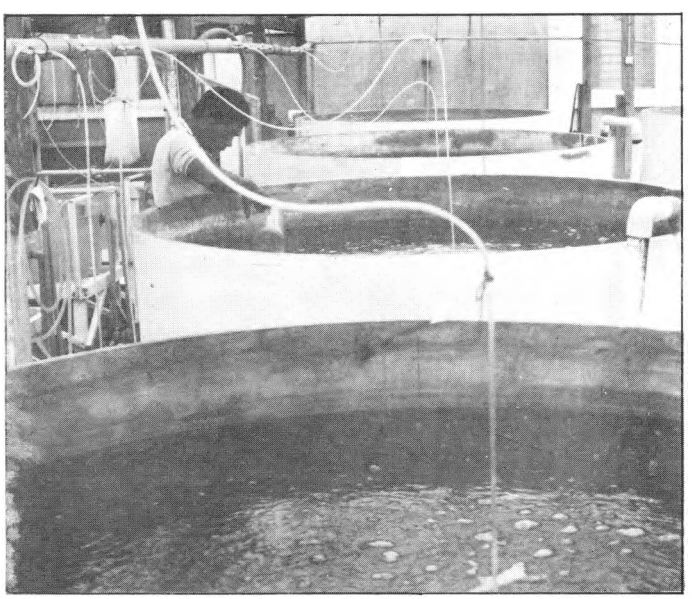
came from a genetically homogenous breeding stock.

• *Mammalian LHRH analogue-induced spawning of sea bass.* A dose-dependent spawning rate (defined as the total number of spawnings per fish over four days) of mature female sea bass was demonstrated at pelleted LHRHa dose levels ranging from 4.75 to 75 *u*g/kg body weight. Implantation of higher dosages of the hormone (150-300 *u*g/kg) resulted in a significant decline in spawning rate. Sea bass eggs from spawners treated with the highest hormone dose had low fertilization rates; hatching rates were not affected by the dose of the hormone treatment. At all hormone doses tested, egg production levels were highest on the first day of spawning and declined on succeeding spawning days.

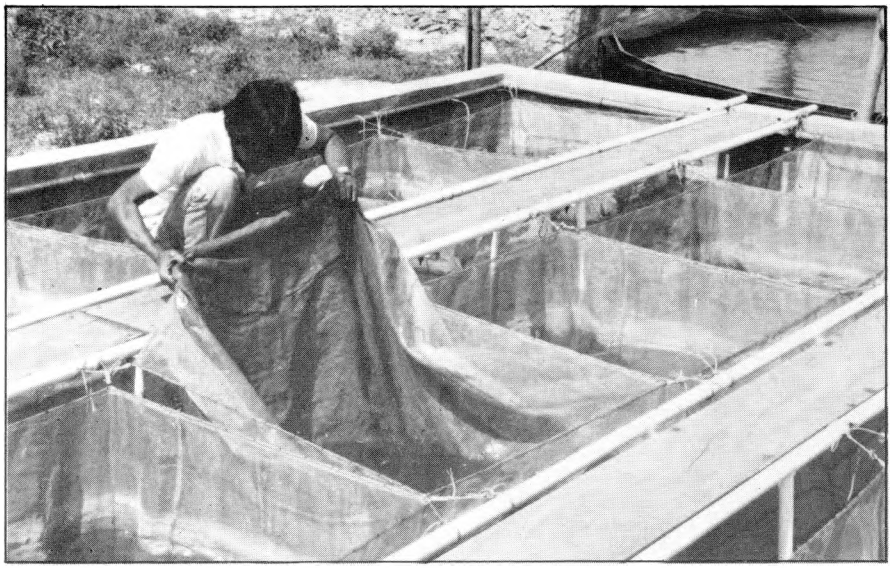
• *Evaluation of the reproductive performance of hatchery-bred* **Siganus guttatus** *broodstock fed different levels of fat.* The influence of diet in captive siganid broodstock on subsequent larval performance was tested. Formulated diets enriched with three levels of fat (12, 15, 18%) were fed to siganid spawners for four months. Larvae from spawners fed 15% fat in their diet yielded better survival rates. Aside from survival rate, yolk volume at hatching, oil globule volume, and larval length can, in part, be used to predict larval performance of siganids.

• *Development of salinity tolerant strains/hybrids of* **Oreochromis niloticus** *for brackishwater culture. I. Salinity tolerance of Taiwan-Singapore strain of* **O. niloticus, O. mossambicus,** *and their F_1 hybrids.* Salinity tolerance of freshwater-spawned and reared Taiwan-Singapore strain of *O. niloticus, O. mossambicus,* and their F_1 hybrids of various ages was studied using MST (mean survival time), ST_{50} (survival time at 50%) and MLS_{96} (mean lethal salinity after a 96-hour exposure) as practical indices of salinity tolerance.

Salinity tolerance generally increased with increasing age of brood. Highly significant inter-specific and age-specific differences were observed



FEEDING sea bass larvae at the Breeding Section of the Tigbauan Research Station (left) and removing debris and fouling organisms from sea bass cages at Igang Substation, as part of cage maintenance (right).



TILAPIA breeding cages are inspected for presence of mouth-brooding females.

for all groups on the basis of MST and ST_{50} indices but not for MLS_{96} index. Salinity tolerance of 15-90 days old *O. niloticus* were significantly lower than those of corresponding age for *O. mossambicus* and F_1 hybrids. MST was relatively the most reliable index for evaluating salinity tolerance in these species.

• *Development of genetic evaluation for* **Oreochromis niloticus** *broodstock: Growth and survival of tilapia in aquaria and net cages.* Growth and survival of juvenile tilapia in aquaria and net cages were compared with the grow-out performance and quality of the same strains in commercial environments. Preliminary results indicated that an internal control population of "red" genotype can be used to statistically correct the variability arising from environmental conditions in aquaria and cages.

• *Development of genetic evaluation for* **Oreochromis niloticus** *broodstock: Tolerance of juvenile tilapia to salinity, temperature, and starvation.* Experiments are in progress to develop an index of between-strain monitoring, comparison, and selection which is suitable for juvenile tilapia. These include the use of micro-developmental abnormalities in scale morphology to measure salinity, temperature – and starvation-related stress responses of fish.

• *Monitoring of gonadal maturation and rematuration of bighead carp* **(Arishtichthys nobilis)** *reared in floating cages in Laguna Lake.* Monthly assessment of gonadal development of bighead carp broodstock in floating net cages in Laguna Lake indicated a high incidence of mature fish in October and November. Some post-spawning females were observed to undergo gonadal rematuration. Initial biological and physico-chemical data of lake water did not seem to have a significant correlation with the sexual maturation cycle of bighead carp broodstock.

Finfish seed production. Research studies in finfish seed production were geared toward the pilot-scale production of milkfish, sea bass, and siganid fry. Development of practical diets for weaning and rearing finfish fry is continuing.

• *Research and development of finfish hatchery technology: Effect of water management and feeding regime on milkfish larvae.* Based on size and weight, a stocking density of 30 larvae per liter was found to be most appropriate for mass-producing milkfish fry. Growth of larvae was comparable in tanks where water change and bottom siphoning were done on alternate days to those reared in tanks where water change was done daily.

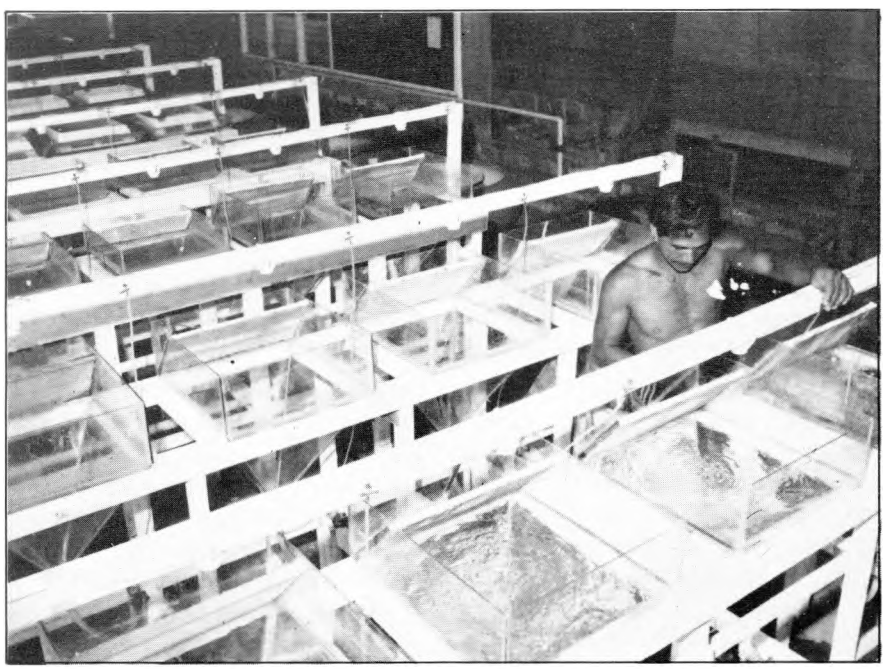
• *The rearing of finfish larvae to metamorphosis using practical diets. I. Milkfish – effect of dietary energy levels.* Artificial diets levels were introduced to milkfish larvae at Day 10 after hatching, and live food completely withdrawn at Day 13. Survival on artificial diet was from 35-45% and about 60-70% with live food while growth rate was generally lower with artificial diets. Effect of dietary energy levels appear to be obscured due to diseases and deterioration of water quality in tanks where artificial diet was used.

• *National Bangus Breeding Program Project (NBBP) pilot hatchery.* A model milkfish hatchery is in operation to determine the economic viability of the production technique developed at AQD. Verification of the existing technique to mass-produce milkfish fry is now being done at four NBBP sites.

• *Stock assessment of milkfish fry near NBBP sites.* Daily milkfish fry collection along the shores of two NBBP sites (Bohol and Pangasinan) was done to investigate possible migration routes of eggs and larvae from spawning site to fry ground. An improved egg and larval trawl net for milkfish was tested and found to be effective. Milkfish fingerlings can now be caught in great numbers near these sites where none has been reported prior to spawning of captive milkfish broodstock in these sites.

• *The effect of thyroxine on the growth and development of sea bass,* **Lates calcarifer.** Metamorphosis of 21-28 day-old larvae can be advanced by thyroxine treatment. However, depending on the developmental stage of the larvae, thyroxine treatment caused spinal deformation and fin differentiation.

• *Weaning of sea bass larvae to artificial diets and rearing them to metamorphosis.* Sea bass larvae were successfully weaned abruptly or gradually to artificial diet as early as Day 10. Larvae weaned to artificial diet starting Day 15 and Day 21 had significantly better growth and survival.



TECHNICIANS (top) monitor physico-chemical parameters in floating cages with carp breeders. Below are flexiglass jars used for hatching carp eggs.

• *Feeding ecology/biology of* **Lates calcarifer:** *Effects of feeding levels and delayed feeding of* **Artemia** *on growth and survival.* The feeding biology of sea bass larvae was investigated to determine the effect of different feeding levels of brine shrimp on their growth rate. Best survival was obtained when sea bass larvae were fed 1 individual/ml/day. Likewise, better growth and survival were observed when *Artemia* nauplii were initially given on day 15 or 18 than on later dates.

• *Feeding ecology/biology of* **Lates calcarifer:** *On satiation and digestion.* Two methods (direct count versus computation method) were followed to determine the daily consumption of rotifers by sea bass larvae. A comparison of these two methods indicated a positive correlation between total length (TL) of larvae and amount of rotifer ingested.

• *Feeding ecology/biology of* **Lates calcarifer:** *Feeding pattern and behavior.* Five phases of the feeding habit of sea bass larvae were identified: a) a phase when larvae depend only on endogenous food (from hatching to about 2.5 mm TL); b) a phase when larvae start feeding on rotifers to the start of feeding on *Artemia* nauplii (to 4.0-4.5 mm TL); c) a phase when larvae take in both rotifers and *Artemia* nauplii (to about 6.0 mm TL); d) a transitional phase of rotifer ingestion (to about 7.5 mm TL) in which the number of rotifer ingestion increased when only rotifers were offered as food; e) a phase when larvae attain the feeding habit of a juvenile (beyond 7.5 mm TL).

• *The effect of stress on the spawning and first feeding of* **Siganus guttatus** *larvae.* Spawning studies through hormonal manipulation were similarly conducted on siganids *(Siganus guttatus).* Results showed that captive siganid broodstock respond well to exogenous gonadotropin injections in addition to stress-related factor(s) enhancing regular monthly spawning activity. Preliminary data indicated that captive broodstock can be hormonally induced to breed throughout the year.

• *Evaluation of selected live food organisms for rearing bighead carp* **(Aristichthys nobilis)** *post-larvae.* After a 21-day rearing period, high growth and low survival rates were observed when bighead carp post-larvae were fed *Artemia* nauplii at 300% of the total fish biomass. Low growth and high survival rates were observed with post-larvae fed nauplii at a ration of 100% body weight. Fish grew and survived best on *Artemia* nauplii. Lake zooplankton-fed fish had lowest growth and survival rates.

Crustacean broodstock development.

• *Assessment of male maturity using* **Penaeus monodon** *broodstock of various sizes and ages.* Histological analysis of samples collected weekly from 155-245 day-old males is in progress. Preliminary results of morphometric measurements from pond-

MACROBRACHIUM rosenbergii *larvae are fed with* Artemia *nauplii (bottom). At right are live specimens of the freshwater prawn* Macrobrachium rosenbergii *Northeastern Morph.*

reared and captive males indicated gonad development of ablated and unablated pond-reared males.

• *Characterization of ovarian maturation stages in* **P. monodon:** *Histology and histochemistry.* Effects of ablation on histology, oocyte frequency, morphometrics, and egg size in wild and pond-reared *P. monodon* were determined at different stages of ovarian maturation. Ovarian histology was similar in wild unablated, wild ablated, and pond-reared ablated females having the same ovarian maturation state. Ablation of wild prawns significantly decreased the number of smaller (proliferating cells) oocytes only. Ablation did not significantly affect carapace/body lengths and body weights of wild and pond-reared prawns although body lengths and gonad/body weights in ablated samples were significantly lower.

• *Histological and histochemical studies on the hepatopancreas of* **Penaeus monodon** *with special reference to molting and gonadal maturation.* Hepatopancreas during the early premolt stage of *P. monodon* lost its cellular integrity with the apparent collapse of hepatopancreatic cells. The condition of these cells improved, however, during the inter-molt and early post-molt stages. Esterase activity in hepatopancreatic cells was intense during the inter-molt stage but decreased during the pre- and post-molt stages.

• *Effect of light quality on maturation and survival of* **Penaeus monodon.** Wild unablated *P. monodon* were subjected to various light wave-lengths in 12 m^3 tanks for 2 months. In terms of the number of spawns, the total number of nauplii produced and hatching rates, exposing prawn broodstock to green light gave better results compared to natural, black, and cool white lights.

• *Effect of temperature and photoperiod on maturation and spawning of* **P. monodon.** Pond-reared prawn broodstock were exposed to 20^0C for 30 days after which time they were acclimated to 28-30^0C. Gonadal development did not progress beyond the initial stage at the start of the test.

• *Maturation and spawning of ablated and non-ablated* **Macrobrachium rosenbergii.** Ablation of *M. rosenbergii* did not advance spawning compared to non-ablated prawns. Rematuration of ablated females occurred at 6-26 days after release of larvae. Incubation to hatching lasted for 18-24 days. Larval production of both ablated and non-ablated prawns were similar.

• *Effect of different protein levels on the maturation/rematuration of* **Macrobrachium rosenbergii.** Feeding immature *M. rosenbergii* high protein diets containing 35-45% crude protein resulted in more spawns.

• *Feeding habits of larval stages of* **P. monodon.** Food selectivity was determined by measuring selectivity indices and consumption rates of different larval stages of *P. monodon* given mono-algal diets and phytoplankton mixtures. *Chaetoceros, Skeletonema,* and *Isochrysis* were highly preferred by zoea 1. *Tetraselmis* was a consistently preferred food of larvae from zoea 2 to mysis 2 stages.

• *Effect of salinity, temperature, and pH on ammonia excretion rates of* **P. monodon** *larvae.* Preliminary results suggested that differences in salinity and pH should be considered in transferring or harvesting post-larvae. Post-larvae acclimated to 32 ppt sea water excreted significantly higher ammonia when transferred to diluted sea water.

In contrast, post-larvae transferred to higher salinity (40 ppt) showed a decrease in excretion rates of about 15% of control values. pH influenced ammonia excretion rates more than salinity since 40% of post-larvae transferred to sea water of pH 9.2 were moribund after two hours of exposure.

• *Temperature-salinity tolerance of* **P. monodon** *larvae.* Salinity tolerance of different stages of *P. monodon* at 29^0 C was investigated. Zoea and mysis and early postlarval stages had better tolerance to higher salinities. Total mortality of all larval stages was observed at 12, 16, and 50 ppt.

• *Comparative economic analysis of* **Penaeus monodon** *hatchery operations: High vs. low density of algal food vis-a-vis low vs. high larval stocking rates.* A comparative economic analysis of *P. monodon* hatchery operations, high vs low algal density vis-a-vis high and low stocking density, was conducted. Preliminary results showed that when fed 50 000 cells per ml of *Chaetoceros calcitrans,* the post-larvae (PL_5) experienced delayed molting and very low survival as compared with treatments using higher algal densities.

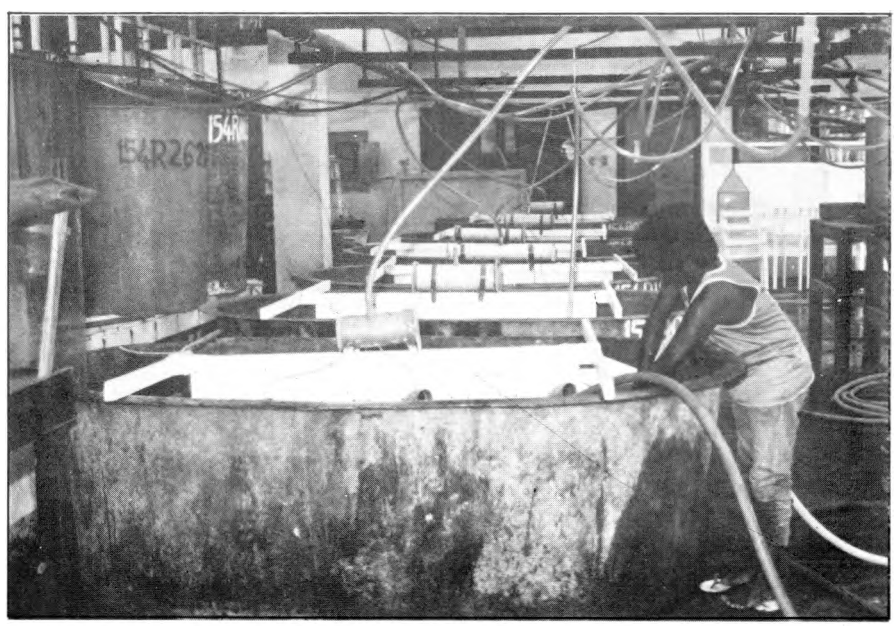
• *Effect of different method of drying and storage of locally produced* **Artemia** *cysts.* Different drying techniques to preserve the quality during storage of locally produced *Artemia* cysts were tested. Fluidized bed drying, air drying, sun drying, and oven drying were compared to storage of cysts in brine. Results suggested that hatching rates are affected by the method of drying, location or environmental condition during culture, and length of storage.

• *Intensive biomass culture of* **Artemia** *in air-water lift raceway and flow-through systems.* The introduction of a semi-flow-through system in *Artemia* culture enhanced production of biomass from 0.5-1.5 kg/ton (using an air-water lift raceway) to 5-7 kg/ton.

• *Culture techniques for the development of small-sized strain of* **Brachionus plicatilis.** Different algal diets were tested as food for *Brachionus plicatilis.* Higher reproduction rate for the six strains of *B. plicatilis* was obtained using *Tetraselmis* and *Chlorella virginica.* Generally, *Isochrysis* and *Nannochloris*-fed *Brachionus* had low population densities. High population growth rate (exponential phase) occurred on the second to the fifth day of culture for all strains fed the five algal test diets. Culture experiments also indicated that lower salinity favored high production of *Tetraselmis*-fed *Brachionus.* This study is aimed at optimizing the quality and production of natural food for larval and postlarval shrimp.

Other study in progress:

• *Optimal growth conditions of the marine diatom* **Skeletonema costatum** *in large outdoor continuous culture.*



THE Leganes Brackishwater Station maintains Artemia *outdoor ponds (top). Intensive indoor* Artemia *production in fiberglass tanks at Tigbauan (bottom).*

FARMING SYSTEMS

Pond culture

• *Culture of sea bass* **(Lates calcarifer)** *in ponds: Effect of stocking density.* Sea bass fry with initial mean weight of 0.5 g stocked at 5/m^2 and 7/m^2 reared in nursery ponds for 45 days were fed a moist diet composed of 75% commercial pellet and 25% trash fish. They were fed twice a day at 20% of biomass for the first week and 10% thereafter. Fry stocked at 5/m^2 had higher mean survival (47%) than those stocked at 7/m^2 (30%).

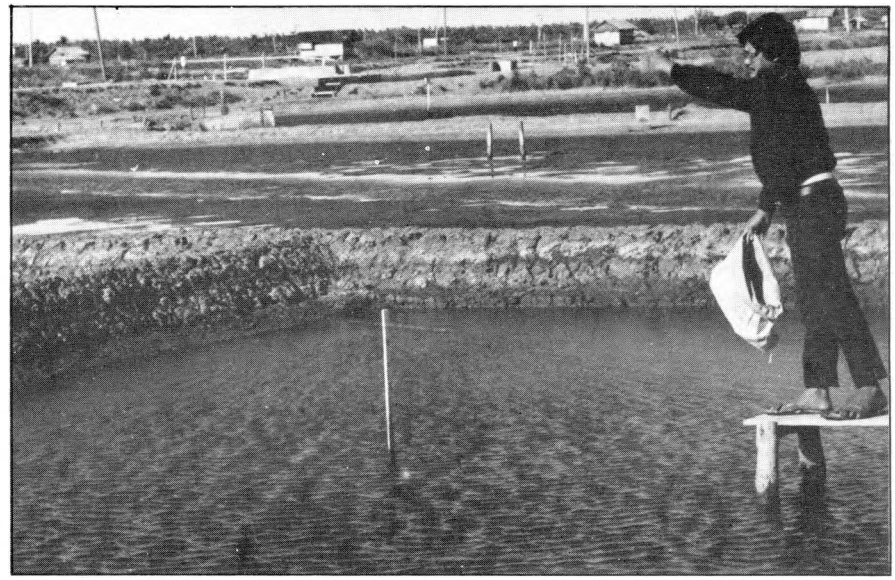
• *Growth and survival of siganids at various stocking densities fed different natural food sources.* Siganid fry (average body weight of .024 g) were stocked at 3, 5, and 7/m^2 in earthen ponds with either filamentous green algae *(lumut)* or *Gracilaria* sp. as food source. Those stocked at 5/m^2 and fed "lumut" attained average body weight of 8.4 g and survival of 77.9% after 45 culture days. Fry stocked at 7/m^2 with "lumut" as food had mean survival of 32.3%. Survival rate was higher for those fed "lumut" at stocking densities of 3 and 5/m^2 than at 7/m^2. Those fed *Gracilaria* sp. at stocking density of 7/m^2 grew the least (2.11 g).

• *Effects of stocking density and food on growth and survival of groupers.* An experiment was conducted for 12 weeks to determine: a) effect of stocking density (1, 2, 3, and 4 individuals/m^2); b) amount of feed (1, 5, 10, and 15% of body weight); and c) feeding frequency (once or twice/day, once in 2 days, once in 3 days) on growth of *Epinephelus malabricus* with initial mean weights of 100 g. Results showed no differences in growth at all the stocking densities, however, animals fed once a day at 15% of biomass had the best growth.

• *Improvement of extensive prawn production using aquatic macrophytes as food organisms in brackishwater ponds.* At a stocking density of 4,000/ha, preliminary results indicated that prawns reared for three months in "kusay-kusay" *(Ruppia maritima)* and plankton ponds attained higher mean survival, mean final weight, and gross production than in "lablab" or "lumut" ponds. Salinity during the culture period ranged from 32 to 49 ppt.

• *Comparative study of various SEAFDEC-formulated feed and commercial feed in semi-intensive culture of* **P. monodon.** *P. monodon* juveniles fed various feeds were stocked at 5/m^2 and reared in 350 sq m ponds for 103 days. Results showed that animals fed grower and finisher feeds containing 45.6 and 46.3% crude protein, respectively, attained the highest average final weight of 27.13 g while those fed grower and finisher feeds with 59.5 and 53.6% crude protein, respectively, had the lowest mean final weight (18.5/g). Survival rates were similar for all treatments, and ranged from 83-89%.

• *Natural food succession in ponds using different organic fertilizers.* Diatoms and gastropods comprised the



BROADCASTING feeds over a prawn pond of the Leganes Brackishwater Station.

INSPECTION and maintenance of siganid cages at the Igang Substation.

benthos in the fertilized ponds. Analysis of the benthic community in each of the treatments is in progress.

• *Prawn culture techniques for ponds with free-flowing tidal water.* A culture system wherein free-flowing tidal water is utilized for rearing *P. monodon* juveniles to marketable size is being assessed. The 0.1 hectare pond located at the mouth of the creek (Gui-gui creek) was designed in such a way that a 12 meter wide inlet wooden gate allows 90 to 100% of water exchange during highest high tide. Pond depth is around one meter during low tide. At a stocking density of $9/m^2$ and feeding commercial feed at 4-8% of body weight 4 x a day, prawns weighed 14.0 g after 45 days from an initial average weight of 3.3 g.

• *Production of* **Artemia** *cysts and biomass in earthen salt-ponds.* The evaporation compartment of a 1.1 hectare salt-pond system was inoculated with *Artemia* cysts from Great Salt Lake, Utah at a stocking density of 50 nauplii/liter. Cysts and biomass harvested after a month of culture were analyzed for hatching quality, storage, and nutritional quality. A total of 1,000 sacks (50 kg/sack) of salt was also harvested in the crystallization area.

• *Factors affecting mass production of* **Moina** *and* **Brachionus** *in culture tanks. Moina* was cultured in chicken manure and water hyacinths containing various levels of phosphorus (PO^4-P) (0, 1, 5, and 10 mg/l of culture medium). Results showed that growth of *Moina* was inhibited as levels of PO^4-P were increased.

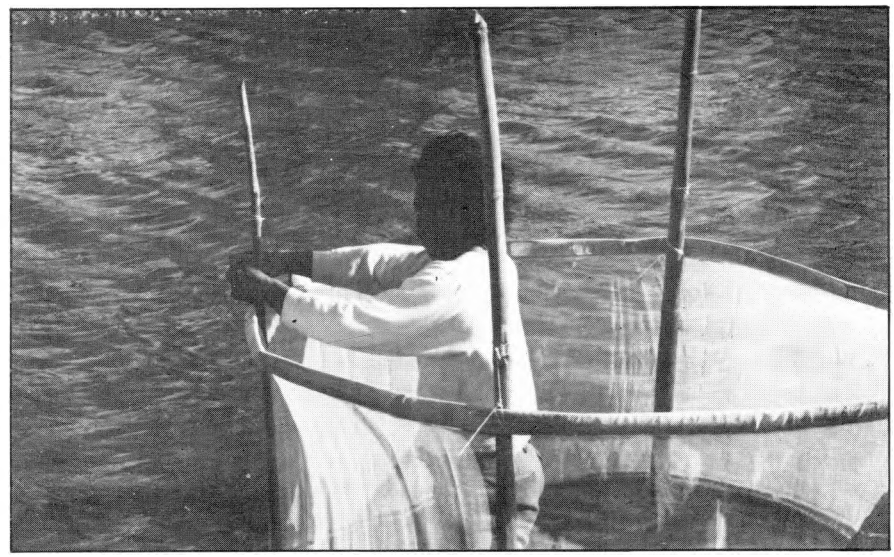
In a related experiment, partial harvesting and replenishment of 50% of the culture medium sustained higher production of *Moina* in culture tanks as compared to cultures of *Moina* where there was no harvest and replenishment.

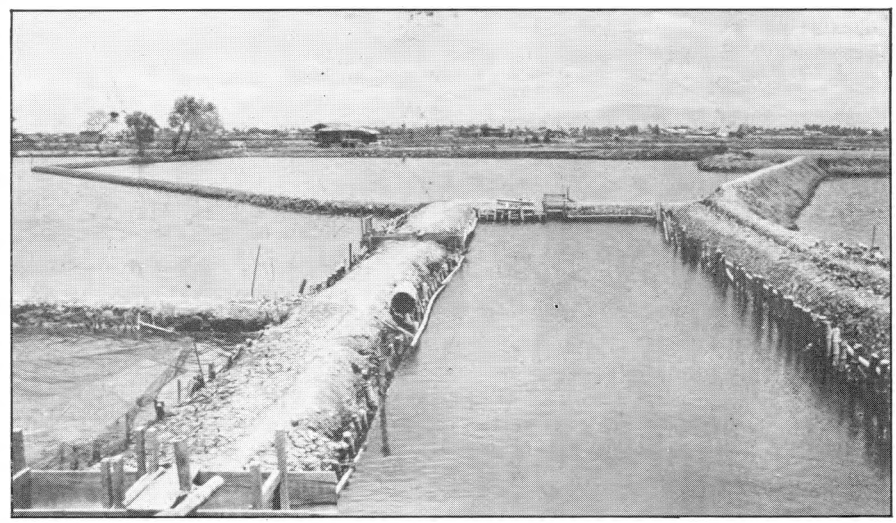
Lake ecology

• *Primary and secondary productivity studies and their relationship to fish production in Laguna Lake.* Five stations around Laguna Lake — West, Central, East Bays, West Cove, and Diablo Pass — were sampled for various ecological parameters. From January to March, the lake was turbid with high total filterable solids and low Secchi disc transparency, hence, gross primary production and phytoplankton biomass were low. From April to June, water clarity improved and phytoplankton biomass was dominated by *Anabaena* and *Closterium.* Fish growth and zooplankton biomass increased. Lake level was also low (1.5-2 m) but rose by an average of 1 meter from July to September. Turbidity during the 3rd quarter caused a decline in gross primary production, phytoplankton biomass, and fish growth. *Therapon plumbeus* (ayungin) was the dominant fish stock in the lake.

Important ecological events occurred in 1986 and 1987. Lake production in 1987 was relatively lower than in 1986. There was more rainfall in 1986 which inundated lake shore villages while a significant volume of sea-water back-flow occurred in 1987.

• *Determination of conversion factor of natural foods for selected fishes in Laguna Lake.* Fish growth in cages in the lake and those in





SCREENS are installed to prevent the entry of fish predators (top). Below, a grouper pond converted from a milkfish pond.

tanks were compared by quantifying phyto- and zooplankton biomass available in a known volume of lake water and related to the growth of stocked fish. Initial results showed tilapia in cages grew 90% faster than those grown in tanks. Relative food conversion for phytoplankton based on **chlorophyll a** ranged from 3.9 to 6.6% efficiency for tilapia in cages and 0.12-0.44% for tilapia in tanks. For zooplankton, relative food conversion efficiency was 4.3-7.2% and 0.13-0.48%, for tilapia in cages and tanks, respectively.

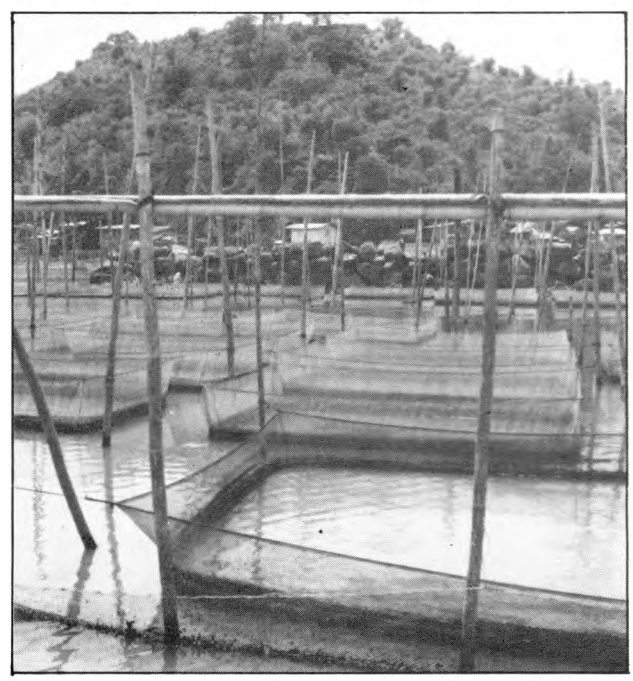
• *Fish stock assessment of Laguna de Bay.* Thirty-nine (39) fishing operations, 15 experimental fishing trips, and 432 interviews were undertaken from August-December in 20 municipalities in Laguna and Rizal provinces to assess fish stock in Laguna de Bay. Results indicated a declining trend in fish catch from 3.14 kg/person/hr in August to 0.28 kg/person/hr in November. Fish were caught with a gear known as "Takibo."

• *Nutrient dynamics in Laguna de Bay: The compartmentalization of nitrogen and phosphorus in the ecosystem.* Wide variations characterized the levels of nitrogen and phosphorus of water samples from the littoral and limnetic zones in the West, Central, and East Bays while the concentration of nitrogen was much higher than phosphorus in both photic and aphotic layers in all the stations. Sediments contained more phosphorus than nitrogen but no spatial or temporal trends were evident in both littoral and limnetic zones of the three bays. Monthly fluctuations in phytoplankton biomass in the sampling sites were also noted. Results of the nitrogen-phosphorus ratio in the photic, aphotic, and sediment compartments of the lake indicated that the ecosystem was undergoing eutrophication and pollution.

• *Pollution in Laguna Lake: Toxic heavy metals in the sediments, water, and tissues of selected finfishes.* Sediment, water, and fish samples from San Pedro, Alabang, Sucat, and Pasig were analyzed for mercury, lead, cadmium, copper, and zinc. Water samples collected in February, April, June, and August showed mercury values lower than 2.0 ppb, the permissible limit for water set by the National Pollution Commission. Sediment samples from Sucat were generally higher (0.3-0.9 μg Hg/g) than those collected from the other station. Furthermore, Hg levels in the sediment ranged from 0.03-0.09 ppm dry weight, was below detectable to 1.4 x $10^{/4}$ ppm in water, and below detectable to 0.012 ppm wet weight in fish.

• *Uptake and physiological effects of mercury in* **Eichhornia crasipes.** Physiological responses of water hyacinth to various levels of mercury (0.005, 0.1, 0.05, 1.0, and 2.0 ppm) incorporated in Hoaglands half-strength nutrient medium was investigated. Plant ramets died after about a week when grown in nutrient medium containing 2.0 ppm mercury. Lower levels apparently had no inhibitory effect on root and stem growth, leaf expansion, and biomass production.

• *Costs-and returns analysis of newly developed aquaculture production systems in the Philippines.* Of fifteen culture systems identified in a study on the economics of newly developed

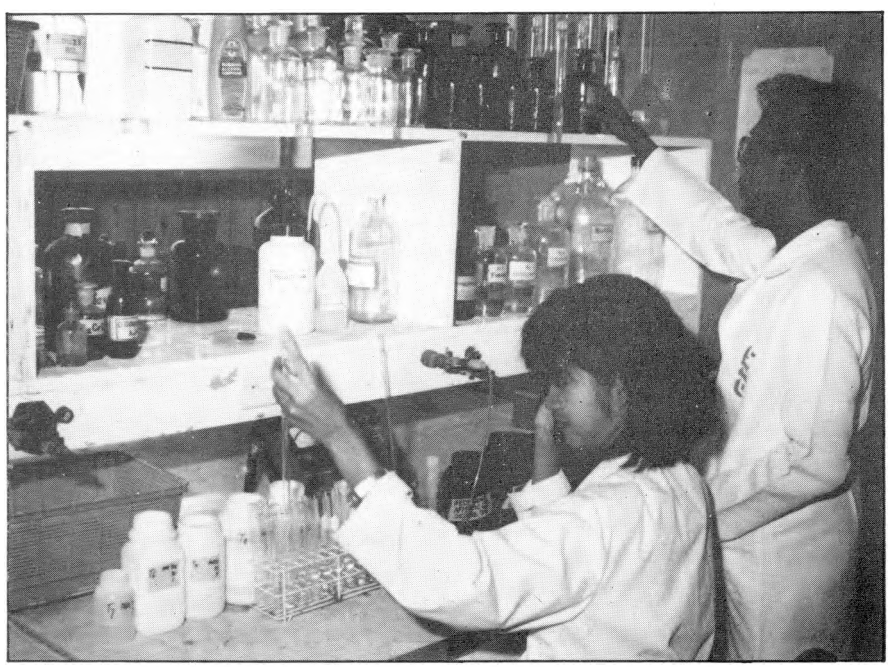


WATER sampling in a prawn pond at Leganes (left). At right are hapa nets for tilapia hatchery/nursery in Laguna de Bay.

WATER sampling in Laguna Lake.

aquaculture production systems in the Philippines, only six culture systems were found to be feasible. These are: Prawn Milkfish Polyculture System, Milkfish Modular System, Prawn Modular System, Crab-Milkfish Polyculture System, Prawn Floating Nursery System, and Stunting of Milkfish Fingerling System.

• *A socio-economic profile of the fishpen industry at Laguna Lake.* Ninety-three percent of legal fishpens covering 333 hectares of fishpens was surveyed and 57 respondents were interviewed at the eastern shores of West Bay. Preliminary results showed a drop in average return on investment, worsening economies of scale, and longer rearing period for milkfish culture. Tilapia culture predominated over that of milkfish and bighead carp.



ANALYSIS of the physico-chemical parameters of water.

Other studies in progress:

• *Socio-economic analysis of the National Bangus Breeding Program.*

• *Growth and survival of* **P. indicus** *at different stocking density using various SEAFDEC-formulated feeds.*

• *Occurrence of an off-flavor in "bangus" and tilapia in Laguna Lake.*

• *Statistical analysis of the size distribution of selected freshwater species at different stages of growth.*

• *Statistical analysis of the length-weight relationship of selected freshwater finfishes grown in pens in Laguna Lake.*

FEED DEVELOPMENT

Finfish nutrition

• *Lipid class composition and fatty acid profile of spawned eggs of milkfish* **Chanos chanos** *broodstock fed different diets.* Spawned eggs from captive milkfish broodstock fed a commercial pellet with or without supplemental lipid: (cod liver oil, soybean lecithin, and a combination of both), were collected, weighed, and freeze-dried prior to lipid analysis. Preliminary results showed that while there was no significant variation in weight and moisture content of eggs among treatments, average total lipid levels differed with the dietary treatments, i.e., no supplement, 18.8%; CLO-supplemented, 17.4%; SBL-supplemented, 21.4%; and CLO-SBL-supplemented, 23.03%.

• *Lipid nutrition of milkfish: Effect of various levels and combination of n-3 and n-6 fatty acids.* The essential fatty acid requirement of milkfish was determined using eight purified diets containing various levels and combinations of n-3 and n-6 fatty acids. Results suggested that milk-

fish require fatty acids of the n-3 series. Competitive inhibition of n-3 and n-6 fatty acids in a 1:1 ratio also appears to operate.

• *Amino acid nutrition of milkfish: Quantitative lysine requirement.* The lysine requirement of milkfish was determined using six semi-purified test diets containing graded levels of lysine at 7-27 g/kg dry diet. Results suggested that 20 g lysine/kg dry diet may be required by milkfish. The experiments were subsequently affected by severe disease problems which resulted in poor survival at the end of the 12-week feeding period.

• *A reference fatty acid and amino acid profile for* **Lates calcarifer** *juveniles.* Sea bass juveniles fed either of the following: enriched *Artemia*, rice-bran fed *Artemia*, trash fish and artificial diet containing different attractants, were analyzed for proximate chemical composition. Samples obtained at weekly intervals were analyzed for total lipid content and fatty acid profile. The amino acid profile of these samples will also be determined. Results shall be used as basis for diet development of sea bass juveniles.

• *The effect of different dietary lipid sources on reproductive performance, tissue composition, and growth of Nile tilapia* **(Oreochromis niloticus)** *broodstock.* Seven isonitrogenous and isocaloric diets were prepared as dry pellets and were fed to Nile tilapia broodstock for 24 weeks. Five of the diets with fish meal as sole protein source contained cod liver oil, corn oil, soybean oil, a commercial cooking oil, and the combination of cod liver oil and corn oil as added lipid sources. Fish fed diets containing cod liver oil had the highest growth increment but had the lowest total number of spawnings and fry production while fish fed diets containing soybean oil had the highest total number of spawnings and fry production.

TRAINEE preparing larval diets.

Crustacean nutrition

• *Histo-physiological study of* **Penaeus monodon** *hepatopancreas fed with various supplemental histidine levels. P. monodon* juveniles (initial mean weight of 0.53 g) were reared for 26 days on semi-purified diets supplemented with various histidine levels: 0, 0.21, 0.42, 0.63, and 0.84%. The diet that had similar histidine level to that of prawn muscle (0.63% level) gave the highest weight gain but was not statistically different from other treatment means. Survival rate was highest at 0.21% and lowest at 0.84%.

Result of the histological study showed that after 14 days of feeding, juveniles with 0.63% histidine-supplemented purified diet had the least alterations in hepatopancreas ultrastructure. Signs of hepatopancreas degeneration were seen in prawns fed diets with low added histidine levels (0.21 and 0.42%) while those fed diets with 0.84% supplemental histidine had hepatopancreatic cells showing intense development of endoplasmic reticulum, pinocytic vesicles, and vacuoles.

• *Effects of dietary calcium/phosphorus ratio on shell quality of* **P. monodon,** Nutritional manipulation using various Ca:P ratios in the diet were made to control soft-shelling disease in *P. monodon.* Tissue levels of Ca and P in prawns fed various Ca:P ratios were determined. Results showed that Ca levels in the hepatopancreas, exoskeleton, and other tissues increased with the increased amounts of dietary Calcium. Phosphorus, however, increased only in the hepatopancreas. An optimum Ca:P ratio of 1:1 was found to be effective in improving shell quality.

• *Digestibility of protein at varying levels of carbohydrate in formulated feeds of* **Penaeus monodon.** Four isonitrogenous diets were formulated to contain 5, 15, 20, and 35% carbohydrate. All diets contained animal to plant protein ratio of 2:1 and 1% chromic oxide as indicator. Preliminary results suggested that increasing carbohydrates in the feed decreased the assimilation of protein and fat as indicated by the increased amount of protein and fat in feces.

• *Refinement of SEAFDEC-formulated diet for pond-reared* **Penaeus monodon** *broodstock: Effect of lecithin.* The effect of dietary phospholipid on the reproductive performance of pond-reared *P. monodon* was assessed.

PRAWN larval diets.

SEAFDEC-formulated broodstock diet was refined to contain varying levels of soybean lecithin while maintaining cod liver oil at 6%. Lecithin levels were 0%, 2%, 3%, and 4% for Diets A_1, A_2, A_3, and A_4, respectively. Results showed that Diet A_4 promoted the highest number of spawnings, average number of eggs per spawning (fecundity), and percentage of complete spawnings while Diet A_2 promoted the highest hatching rate.

• *Refinement of SEAFDEC-formulated larval diet for* **Penaeus monodon:** *Carotenoid levels.* SEAFDEC-formulated Carrageenan-Microbound Diet (C-MBD) for prawn larvae was refined with inclusion of 3 levels of carotenoid (canthaxanthin). Diets of different particle sizes were fed to the different larval stages. Results showed that survival and growth of larvae fed diets containing 0.5% and 0.75% carotenoid were not significantly different from each other but were higher than in larvae fed the diet containing 0.25% carotenoid. Larval pigmentation improved with 0.75% canthaxanthin in the diet. Larval metamorphosis was similar in all treatments.

• *Amino acid composition of feedstuffs used as protein sources in aquaculture feeds.* A method to simplify procedure for amino acid analysis of feedstuff through preparation of a single protein hydrolysate is of advantage in aquaculture nutrition studies. With the use of synthetic amino acid mixtures and aquaculture feedstuffs, 4N methanesulfonic acid (MSA) was compared to 6N hydrochloric acid (HCl) as hydrolizing agent for complete amino acid analysis. Tryptophan was detected in prawn tissues hydrolyzed with 4N MSA but not with 6N HCl. A higher amino acid recovery was also obtained with 4N MSA than with 6N HCl in all samples.

Studies in progress:

• *Effects of dietary protein levels on the gonadal development of bighead carp* **(Aristichthys nobilis)** *reared in floating cages.*

• *Dietary protein requirement of bighead carp* **(Aristichthys nobilis)** *fry.*

• *The effect of dietary carbohydrates, lipid and energy on growth, feed efficiency, and tissue composition of bighead carp* **(Aristichthys nobilis).**

FISH HEALTH

• *Establishment of fish cell line from milkfish, sea bass and siganids.* Primary monolayer cultures of cells from non-feeding milkfish fry and 3-day old sea bass were initiated using explant and trypsinization methods. Tissues initiated from trypsinized milkfish fry without NaC1 supplementation resulted in rapid growth of epithelial cells after two weeks. The cell line has been passed sixteen times and is now a homologous line. Explanted milkfish fry tissues cultured with NaC1 supplementation resulted in growth of fibroblast cells only after 51 days. The cell line has been passed only once due to its characteristic slow cell multiplication. Characterization of these cell lines will be done after 50-60 tissue passages. Explanted and trypsinized sea bass fry tissues gave unsuccessful results so far.

• *Studies on the effects of rotenone and saponin on milkfish and tilapia with special reference to histopathology and hematology.* Static 96-h bioassays were conducted to establish the tolerance of 3- and 24-g milkfish and 32-g *Tilapia mossambica* to rotenone at salinity levels of 0, 15-17, and 32-34 ppt. The tolerance level of milkfish was similar in all salinity levels. Tilapia was more sensitive to rotenone in fresh water (0 ppt) than in higher salinity levels.

To determine whether significant degradation of the pesticide in fresh water occurred within 24 h, 0.15 ppm rotenone (lethal level for tilapia) was exposed for 0, 3, 6, 12, 18, and 24 h prior to stocking of tilapia. Tilapia in rotenone exposed for 24 h had 100% survival rate after 48 h. Survival rates were observed to decrease with decreasing hours of exposure to rotenone.

• *Studies on the ulcerative fish disease in Laguna Lake: Fungal infections.* Fish samples manifesting the

disease included a goby, *Ophiocephalus striatus, Puntius* sp. and *Trichogaster* sp. Examination of infected parts showed the presence of septate and branching mycelia entwined in the deteriorating fish tissues. Initial attempts to isolate and culture the fungus were unsuccessful.

• *Studies on the ulcerative fish disease in Laguna Lake: Associated parasites.* No ectoparasite was found in and around the lesions of the ulcerated fishes examined. A number of endoparasitic helminths, however, were identified from ulcerated and non-ulcerated fish samples, including an unreported species of trematode.

• *Studies on the ulcerative fish disease in Laguna Lake: Predisposing and environmental factors.* Sediment and fish samples collected from Laguna Lake for heavy metal analysis showed the presence of copper and zinc during the period April to June. Water, soil, and fish samples contained residues of chlorinated pesticides like aldrin, dieldrin, BHC, and DDT but were within the limits set by the FAO-WHO Joint Meeting on Pesticide Residues (1967-1969).

• *Isolation and identification of bacteria causing larval and postlarval prawn diseases.* Luminous bacteria were isolated from different samples collected from prawn hatcheries in Aklan, Capiz, and Iloilo. Biochemical and morphological characterization showed that the present 97 isolates very closely resemble *Vibrio harveyi,* a luminous vibrio commonly isolated from nearshore sea water. Heavily infected larvae were weak and luminiscent in the dark. Microscopic examination showed the presence of large numbers of motile bacteria in the tissues of the larvae.

• *Tolerance of larvae/post-larvae to chemicals/drugs used for control of bacterial diseases.* The tolerance of *Penaeus monodon* larvae to five bactericides was determined in a 24-h static bioassay procedure. The larvae showed tolerance to 10 ppm Chloramphenicol, 1 ppm Dimetridazole-HCl, 100 ppm Erythromycin, 100 ppm Oxytetracycline, and 1 ppm Prefuran for 24 h. However, some morphological deformities like bent setae/appendages and deformed carapace were observed at the end of the experiments.

• *Histopathological effects of diets stored at various temperature levels and duration on* **P. monodon.** SEAFDEC-formulated diets stored at 0, 10, 28-31.8, and 40^0C were fed to prawn juveniles at 10% of the body weight twice daily for ten weeks. Diets stored at higher temperatures showed significantly higher peroxide levels than those stored at lower temperatures after two months. Lower growth rate of prawns and severe histopathological changes were observed after four weeks of feeding with diets stored at higher temperatures.

• *Microbiology of spoilage of pond-grown prawn* **(Penaeus monodon)** *during ice storage.* Marketable-sized prawn were subjected to various post-harvest treatments to determine their effects on the bacterial, chemical, and sensory qualities of the prawn. The initial aerobic plate counts (APC) of freshly harvested prawn averaged 2.0×10^3/g while spoiled samples had APCs ranging between 10^5 and 10^7/g. The main spoilage organism in non-vacuum packed samples was *Pseudomonas* while *Moraxella* was predominant under vacuum packaging. Values for total volatile nitrogen (TVN) and

EXAMINATION of fish sample for ulcerative disease (left). Propagation of fish cell line for viral isolation (right).

ISOLATION of bacteria from diseased prawn larvae.

MICROSCOPIC examination of prawn larvae exposed to bactericides.

trimethylamine (TMA), chemical indicators of spoilage, were unrealistic at less than 5 mg N/100 g and 1 mg N/100 g, respectively, despite the samples being obviously spoiled. Results indicated significant extension of shelf-life under conditions of washing, beheading, vacuum packaging, and ice storage but are inconclusive.

• *Effects of farming phase and in-plant processing on the microbial quality of prawn* **(Penaeus monodon).** The bacteriological loads of farm-raised (brackishwater) prawns upon harvest and at different points during processing were determined. The total plate counts of prawns were 6.8×10^4 to 1.5×10^5/g upon harvest, decreasing to 2.1×10^4 to 6.6×10^4/g after processing. These counts are within the range of reported levels from temperate countries and are lower than the international standard of 10^6/g.

Animal (chicken) manure was found to be a source of *Salmonella* contamination in prawns during the farming and fertilizing phase and its use must, therefore, be avoided. High quality and safe products which meet international standards could only be obtained through proper handling and quality control immediately after harvest and during processing.

Abstracts of Research Publications

Alava, V.R. and Pascual, F.P., 1987. Carbohydrate requirements of *Penaeus monodon* (Fabricius) juveniles. *Aquaculture*, 61:211-217.

P. monodon juveniles with an initial mean weight of 0.62 g were fed isonitrogenous (45%) and isolipidic (10%) semi-purified diets containing 10, 20 and 30% trehalose, sucrose and glucose for 56 days. Shrimp fed the diet with 20% trehalose had the highest weight gain. Of the three types of sugar tested, shrimp fed diets containing trehalose and sucrose exhibited better weight gains than those fed glucose diets. A dietary sugar level of 20% resulted in the best weight gain whereas the 30% level gave the lowest weight gain.

The survival of shrimp was also affected by the type of carbohydrate fed. Trehalose and sucrose diets promoted higher survival rates than glucose diets. The different types and levels of carbohydrates showed combined effects on the dry matter percentages of crude protein and total lipid. Trehalose and sucrose diets generally promoted increased protein deposition. Trehalose at 30% and sucrose at 20% depressed lipid content.

Almendras, J.M.E., 1987. Acute nitrite toxicity and methemoglobinemia in juvenile milkfish (*Chanos chanos* Forsskal). *Aquaculture*, 61:33-40.

Nitrite was about 55 times more toxic to milkfish juveniles in fresh water than in 16% brackish water: the 48-h median lethal concentrations were 12 mg NO_2-N/1 (95% confidence limit = 7.4-19.6) and 675 mg NO_2-N/1 (95% confidence limit = 435.8-1,045.4), respectively. Methemoglobin levels were higher for a given concentration of nitrite in milkfish kept in fresh water than in the brackish water. Methemoglobin decreased to a normal level with 24–26 hours of the removal of nitrite.

Avila, E.M., 1986. The ultrastructure of the hepatocytes of the giant seaperch, *Lates calcarifer* (Bloch) (Pisces: Centropomidae), during starvation and refeeding with different diets. *Asian Mar. Biol.*, 3:129-137.

Three groups of immature seaperch (17.5–22.5 cm standard length) acclimated in the laboratory on a mixed commercial pellet and minced trashfish diet were starved for 30 days. Thereafter, the first group was starved for 7 more days, the second was refed with commercial pellets, and the third with trashfish. Through transmission electron microscopy, it was found that after the acclimation period the hepatocytes of *Lates calcarifer* were primarily lipid-storing. Upon starvation, the following modifications in the hepatocytes were evident: decrease of lipid reserves, hepatocyte shrinkage, mitochondrial swelling, dilation of the cisternae of the rough endoplasmic reticulum (RER), and the presence of lysosomes. It was evident in the electron micrographs that while the number of lipid inclusions progressively declined with food deprivation, there was also a marked increase in the number of glycogen particles in the hepatocytes of the fish starved beyond the 30-day period. Among the refed fish, only the hepatocytes of those which were given trashfish recovered from the injury. Recovery was indicated by the restitution of the morphology of the mitochondria, development of parallel stacks of RER, increase in lipid and glycogen, and the distinct compartition of the hepatocytes.

Avila, E.M. and Juario, J.V., 1987. Yolk and oil globule utilization and developmental morphology of the digestive tract epithelium in larval rabbitfish, *Siganus guttatus* (Bloch). *Aquaculture*, 65:319-331.

The purpose of this study was to find out how yolk and oil globule absorption in *Siganus guttatus* proceed as the digestive tract develops, in order to determine the probable causes of early larval mortality. Yolk and oil globule absorption in the rabbitfish were compared with the same processes in the more sturdy seaperch larvae during the first 10 days of larval life under identical rearing conditions in 32% sea water at 27^0-30^0C. The rapid decline of yolk in both species coincided with the rapid development of the digestive system within 24 h from hatching, indicating that most of the yolk was used for organogenesis. Whereas yolk was depleted in both fish in 3 days, the oil globule persisted in the rabbitfish only for 4 days and in the seaperch for 7 days. Oil globule depletion in the rabbitfish coincided with a negative mean length increment, implying an energy deficit even when the larvae had already started to feed. Ultrastructural observations of the gut epithelia of the rabbitfish revealed pinocytosis in the hindgut cells immediately after ingestion of rotifers, well in advance of complete yolk and oil globule absorption. Therefore, starvation due to exhaustion of the endogenous energy reserves in addition to

the physical inability to feed were ruled out as major causes of larval mortality in rabbitfish.

Bagarinao, T. and Kumagai, S., 1987. Occurrence and distribution of milkfish larvae, *Chanos chanos* off the western coast of Panay Island, Philippines., *Environ. Biol. Fish.*, 19:155-160.

The occurrence and distribution of milkfish larvae (~3-17 mm TL) off western Panay Island, Philippines are reported based on 594 plankton net tows made in April and May 1980. Forty-two tows yielded 44 larvae, together with 1149 milkfish eggs by 98 tows. About 70% of the larvae of all stages came from stations less than 100 m deep and 1-2 km from land. Younger larvae up to 6 mm and about 1 week old occurred at stations of various distances from shore, while older larvae occurred only near shore. About 49% of larvae of all stages were caught by surface tows; younger larvae occurred also in deeper layers (20 and 30 m). Larval abundance increased towards May. Younger larvae tended to occur during the quarter moon periods and older ones during the full and new moon periods.

Baliao, D.D., Franco, N.M. and Agbayani, R.F., 1987. The economics of retarding milkfish growth for fingerling production in brackish-water ponds. *Aquaculture*, 62:195-205.

Two experiments were conducted to measure the economic viability of retarding milkfish growth (stunting) in brackishwater ponds. In the first experiment, 2-month-old fish were reared for 6 months in ponds with initial stocking densities of 15, 20, 25, and 30 fish/m^2. The second experiment had a common stocking density of 20 fish/m^2 with rearing periods of 6, 9, and 12 months. All experiments followed the lab-lab method of growing natural food plus additional substrates. Supplemental feeding using rice bran mixed with ground trash fish started 60 days after initial stocking.

Under Philippine conditions stunting milkfish fingerlings at 20 fish/m^2 for 6-9 months is most cost effective; this permits the production of milkfish fingerlings for lower cost than they can be purchased.

Baticados, M.C.L., Coloso, R.M. and Duremdez, R.C., 1987. Histopathology of the chronic soft-shell syndrome in the tiger prawn *Penaeus monodon*. *Dis. Aquat. Org.*, 3:13-28.

One of the disease problems that affect the production of tiger prawn *Penaeus monodon* Fabricius in brackish-water ponds is the chronic soft-shell syndrome, a condition in which the prawn shell is persistently soft for several weeks. To determine the extent of damage in affected prawns, the histopathology of this syndrome was studied using light microscopy, transmission and scanning electron microscopy, and histochemical determination of calcium. Light microscopic studies of the exoskeleton of soft and normal hard-shelled prawns showed several distinct layers: an outer epicuticle, a thick exocuticle and a thinner endocuticle overlying the epidermis. The cuticular layers of the soft shell often had a rough or wrinkled surface and were usually disrupted and separated from the epidermis while those of the hard shell were generally intact and attached to the epidermis. The exocuticle and endocuticle of the hard shell were considerably thicker than those of the soft shell. Ultrastructural observations revealed the presence of a very thin membranous layer under the endocuticle. Tegumental ducts and pore canals traversed the 4 cuticular layers and were distinctly observed as pore openings on the epicuticle surface. The epicuticle had a bilaminar and non-lamellate structure. The exocuticle had more widely-spaced lamellae consisting of fibers arranged in a more compact pattern than in the endocuticle. Histochemical determination of calcium was done in exoskeleton and hepatopancreas of soft- and hard-shelled prawns. The hepatopancreas of soft-shelled prawn stained more intensely for calcium than that of the hard-shelled one. There was no great difference in calcium content of hard and soft shell, although the former stained slightly more intensely. Histopathological changes in the hepatopancreas of soft-shelled prawns were also observed.

Duray, M.N., 1986. Biological evaluation of three phytoplankton species *(Chlorella* sp., *Tetraselmis* sp., *Isochrysis galbana)* and two zooplankton species *(Crassostrea iredalei, Bracchionus plicatilis)* as food for the first-feeding *Siganus guttatus* larvae. *Philipp. Sci.*, 23:41-49.

First-feeding *Siganus guttatus* larvae were given different species of phytoplankton *(Chlorella, Tetraselmis, Isochrysis)* and zooplankton (oyster trochophores, *Brachionus)* or a combination of both on the first day when they can feed. None of the phytoplankton species when used as the only food source for the larvae could support life beyond four days from hatching. *Brachionus* of sizes less than 90 microns was the most suitable food for the first-feeding larvae. A food mixture of the three phytoplankton species and *Brachionus* resulted in survival rates

that were significantly higher than with other treatments. Larval growth, however, did not differ significantly ($p > 0.05$).

Different *Brachionus* densities were also used during the first-feeding days. Although the range of 10 to 15 *Brachionus* per ml gave better survival, no significant differences existed. Growth was slightly greater but not significantly different at higher densities.

Duray, M.N., Duray, V. and Almendras, J.M., 1986. Effects of salinity on egg development and hatching in *Siganus guttatus*. *Philipp. Sci.*, 23:31-40.

Experiments were conducted to determine the tolerrance of *Siganus guttatus* eggs to salinity changes. In the first run, the female was induced to spawn spontaneously by using human chorionic gonadotropin. The fertilized eggs were transferred to seawater of salinities ranging from 8 to 40 o/oo either at the blastomere or at the gastrula stage. In the second run, the eggs were stripped from the female and artificially fertilized following the dry method.

Results indicated that eggs transferred at gastrula stage were more tolerant to salinity changes than those transferred at the blastomere stage. Hatching occurred at all salinities but was highest at 24 o/oo. Percentage of viable larvae was highest at 24 o/oo and lowest at 8 o/oo. The larvae that hatched at low salinities were relatively longer than those that hatched at ambient and higher salinities.

Ferraris, R.P., Tan, J.D. and De la Cruz, M.C., 1987. Development of the digestive tract of milkfish, *Chanos chanos* (Forsskal): histology and histochemistry. *Aquaculture*, 61:241-257.

The digestive tract of the newly hatched milkfish larva is a simple undifferentiated tube. Three days after hatching, differentiation of the esophagus begins with development of mucous-secreting cells. At this time, the intestine can be distinguished from the anterior portion of the digestive tract by its tall columnar cells with centrally located nuclei and brush border with cytoplasmic projections. After 14 days, mucosal folds develop in the esophagus. In 21-day-old larvae, the stomach differentiates into the cardiac and pyloric regions while goblet cells start to develop in the intestine. In fish undergoing metamorphosis ($\geqslant$42 days old), the mucosal cells of the cardiac stomach develop into two distinct cell types: the columnar cells which make up the folds nearest the lumen, and the cuboidal cells which constitute the gastric glands. The cardiac stomach is the only region in the digestive tract where mucus secretion is not acidic. From 3-day-old larvae up to the older stages, alkaline phosphatase is localized only at the brush border of the intestinal epithelial cells. Aminopeptidase is also found only in the brush border of enterocytes, but only in 21-day and older milkfish. Intestinal esterases are present not only in the brush border but are also diffusely distributed in the cytoplasm of enterocytes of 3-day or older fish. Esterase is also found in both the columnar and gland cells of the cardiac stomach, but only in postmetamorphic (60-day or older) fish. These morphological and histochemical changes of the gut seem to parallel dietary and habitat shifts throughout development, which encompasses life stages spent in pelagic, coastal or inland waters.

Gonzal, A.C., Aralar, E.V. and Pavico, J. Ma. F., 1987. The effects of water hardness on the hatching and viability of silver carp *(Hypophthalmichthys molitrix)* eggs. *Aquaculture*, 64:111-118.

An investigation was conducted to establish water hardness concentration for optimum hatching of silver carp *(Hypophthalmichthys molitrix)* eggs. Eggs were incubated for 19 h at 26.5°C at six levels of water hardness: 100, 200, 300, 400, 500 and 600 mg/1 $CaCO_3$. Water absorption at 100-200 mg/1 $CaCO_3$ caused eggs to burst prematurely and minimal water absorption occurred at 600 mg/1 $CaCO_3$. Chloride concentration at 0 and 6 h postfertilization was significantly related to egg hatchability. Total ammonia-nitrogen at 6 h, pH at 6 h, magnesium hardness at 18 h and chlorides at 18 h significantly influence viability of larvae. A water hardness of 300-500 mg/1 $CaCO_3$ is recommended for the successful hatching of silver carp eggs.

Lio-Po, , G. and Sanvictores, E., 1987. Studies on the causative organism of *Oreochromis niloticus* (Linnaeus) fry mortalities I. Primary isolation and pathogenicity experiments. *J. Aqua. Trop.*, 7:25-30.

Oreochromis niloticus fry reared in 50L aquaria at a density of 1,000 fry manifested mortalities of 15% daily. Afflicted two-week old fry exhibited darker pigmentation, emaciation lesions, and surface swimming. Parasites and

fungi were not observed upon direct microscopic examination of affected fry. Bacterial isolations from weak fry yielded the predominant growth of *Pseudomonas* sp. Subsequent pathogenicity experiments showed that *Pseudomonas* sp. is pathogenic at a dose of 10^7 cells/ml rearing water but not at a dose of 10^6 cells/ml rearing water. By and large, the presence or absence of feed during infection did not affect virulence of the test bacteria. Antimicrobial sensitivity tests revealed sensitivity of *Pseudomonas* sp. to Chlortetracycline, Colistin. Kanamycin, Oxytetracycline and Polymyxin B, and resistance to Nitrofurantoin and Sulfamethoxazole trimethoprim.

Llobrera, A.T. and Gacutan, R.Q., 1987. *Aeromonas hydrophila* associated with ulcerative disease epizootic in Laguna de Bay, Philippines. *Aquaculture*, 67:273-278.

Aeromonas hydrophila was consistently associated with necrotic ulcers and lesions in mudfish/snakehead *(Ophiocephalus striatus).* Thai catfish *(Clarias batrachus),* crucian carp *(Carassius carassius)* and goby *(Glossogobius giurus)* in Laguna de Bay, Philippines, during the months of December 1985 through February 1986. The bacterium was isolated from body lesions and ulcers of all fish examined and rarely from the kidney and liver of carp and catfish. The disease was characterized by hemorrhages, lesions and open necrotic ulcers on the body of the fish, particularly the head (just behind the eyes), the mandible and the maxilla, and the caudal peduncle regions. Erosion of the head bone tissues and the tails was observed in very severe cases. The presence of *A. hydrophila* is believed to be secondary to some predisposing factors existing in Laguna de Bay.

Makinouchi, S. and Primavera, J.H., 1987. Maturation and spawning of *Penaeus indicus* using different ablation methods. *Aquaculture*, 62:73-81.

Wild immature *Penaeus indicus* females (11.5 ± 3.1g body weight) were ablated by pinching, cautery or tying of one eyestalk, and stocked with control (unablated) females and males (9.2 ± 1.5 g) in a 12-m^3 maturation tank. Full ovarian maturation and spawning were attained 4 days after ablation/stocking in all treatments, with a peak at 5-6 days. Seventy-five percent of ablated and unablated females spawned during the study period. Average egg numbers from complete spawns increased with size of females for all treatments. There was no significant difference in fecundity of complete spawns from the various treatments. However, hatch rates of unablated *P. indicus* were significantly higher than eyestalk-pinched females but not those ablated by cautery and tying. Similarly survival after the 15-day period was lowest among pinched females.

Marte, C.L., Sherwood, N.M., Crim, L.W. and Harvey, B., 1987. Induced spawning of maturing milkfish *(Chanos chanos* Forsskal) with gonadotropin-releasing hormone (GnRH) analogues administered in various ways. *Aquaculture*, 60:303-310.

The response of mature female captive milkfish to mammalian and salmon gonadotropin-releasing hormone analogues (mGnRH-A and sGnRH-A) was investigated. Prior to spawning, six groups of three females received (1) 10-16 μg mGnRH-A from an osmotic pump implanted intraperitoneally (IP); (2) 100 μg mGnRH-A from a cholesterol/cellulose pellet implanted IP; (3) 10 μg/kg mGnRH-A as an intramuscular (IM) injection; (4) 10-16 μg sGnRH-A from an osmotic pump implanted IP; (5) 100 μg sGnRH-A from a cholesterol/cellulose pellet implanted IP, and (6) a cholesterol/cellulose pellet without analogue implanted IP.

The most effective treatment was 100 μg sGnRH-A/fish given in a cholesterol/cellulose pellet; all (3/3) of the fish spawned. However, mGnRH-A was more effective (2/3) compared with sGnRH-A (1/3) if osmotic pumps were used to administer GnRH-A. If the dose and method of administration were not considered, then the salmon and mammalian GnRH analogues were equally effective (62-67%) for induction of ovulation and natural spawning in milkfish. Gonads of control fish regressed.

At the doses tested, injections or pellet implantations were more effective compared with osmotic pumps. All pellet-implanted and injected females responded to treatment and 75% (6/8) spawned; half (3/6) of the pump-implanted females spawned. Spawning occurred from 18 to 36 h after treatment.

Muroga, K. and Cruz, M.C. dela, 1987. Fate and location of *Vibrio anguillarium* in tissues of artificially infected ayu *(Plecoglossus altivelis). Fish. Pathol.*, 22:99-103.

Ayu *(Plecoglossus altivelis)* were infected with *Vibrio anguillarum* by a water-born method. At 6, 12, 18, 36, 38-45 (moribund stage) and 48 h (dead) after infection, fish were sampled to determine the fate and location of the bac-

terium in various tissues by viable cell count and the enzyme-labelled antibody technique (ELAT).

V. anguillarum was first detected in the skin at 12 h by bacterial isolation. It appeared in the muscle, spleen and liver at 24 h, but was not isolated from the gills or intestine until 36 h or 38-45 h. The same trend in the fate of the pathogen was confirmed by ELAT, and the cells were found in dermal layer of the skin from the early stage (12 h) of infection. Based on these observations, it was concluded that the first colonization site of *V. anguillarum* in ayu was the skin.

Nakai, T., Kanno, T., Cruz, E.R. and Muroga, K., 1987. The effects of iron compounds on the virulence of *Vibrio anguillarium* in Japanese eels and ayu. *Fish. Pathol.*, 22:185-189.

When Japanese eels *(Anguilla japonica)* were injected intramuscularly (IM) with ferric ammonium citrate (FAC) at a sublethal dose of 10 μg/g and followed by IM-injection with various doses of *Vibrio anguillarum,* FAC injection enhanced greatly the virulence of the pathogen to eels, lowering the LD_{50} value from $10^{7.9}$ to $10^{4.2}$ CFU/100 g. Similar effects were obtained with ferrous sulfate and ferric chloride in eels. However, such a virulence-enhancing effect of FAC was scarcely observed in ayu *(Plecoglossus altivelis),* which has high susceptibility to the pathogen by nature. It was also found that addition of FAC (10 μg/ml) in fish sera accelerated the bacterial growth *in vitro* but the effect was much greater in eel serum than in ayu serum. The results of these *in vivo* and *in vitro* experiments demonstrated that the availability of free iron in host fish would have a significant influence on the pathogenesis of *V. anguillarum* infection.

Palisoc, F.P., 1987. Observations on the host-parasite relationship of *Epipenaeon ingens* nobili (Epicaridea: Bopyridae) and *Penaeus semisulcatus* de Haan. *Philipp. J. Sci.*, 116:281-293.

Samples of *Penaeus semisulcatus* or Tiger shrimp ("hipong bulik") from Manila Bay and Tayabas Bay, and from waters off Palawan, Cebu, Samar and Capiz were obtained from the Navotas Fishery Port during the period from March, 1978 to February, 1979. The prevalence of *Epipenaeon ingens* in *P. semisulcatus* is 4.83/1000. No significant difference ($P>0.5$) in the prevalence of infection between the sexes was found. The parasite *(E. ingens)* was lodged on either side of the host's carapace and there was no significant difference in the regression analyses of tumor size on carapace length whether tumor is on the right or left side of the carapace of either male or female host. Despite the homogeneity of regression lines in the comparative analyses of length-weight relationship of infected and uninfected *P. semisulcatus,* the slope of the regression lines of the infected samples are always higher than the values for the uninfected ones.

Pantastico, J.B., 1987. Algal production in wastewater: progress and problems. *Arch Hydrobiol. Beih*, 28:105-121.

Algal production in wastewater is reviewed in two major areas: (1) production of single-cell proteins, and (2) its integration with aquaculture for the production of natural feeds. Progress achieved so far in the various aspects of algal production in the laboratory and outdoors is discussed, as are biotechnological problems in the operation and maintenance of high-rate algal ponds. The need for more basic and applied research is emphasized.

Pantastico, J.B., Baldia, J.P. and Reyes, D.M., Jr., 1986. Feed preference of milkfish *(Chanos chanos* Forsskal) fry given different algal species as natural feed. *Aquaculture*, 56:169-178.

Acclimated milkfish fry (Mean wet weight, 6.0 mg) were fed with unialgal cultures of five species of freshwater algae: *Oscillatoria quadripunctulata, Chroococcus dispersus, Navicula notha, Euglena elongata* and *Chlorella ellipsoidea.* In the first experiment, the filamentous blue-green alga, *Oscillatoria,* appeared most acceptable to milkfish fry throughout the growing period, while feeding milkfish fry with the unicellular species, *Chroococcus,* resulted in lower weights and survival. In the second experiment, increases in weight of milkfish fry fed with *Oscillatoria* alone or in combination with *Chroococcus* were comparable. However, a significant increase in survival was obtained with the combination feeding. A third experiment showed that high density cultures of *Oscillatoria* resulted in significantly large weight increments in all growth stages. The other algae tested did not support growth of milkfish fry.

^{14}C-Labeled algae of the same species were fed to milkfish fry. Significantly high assimilation rates were observed in almost all growth stages of milkfish fry with *Oscillatoria* alone or *Chroococcus* alone. Negligible amounts of *Navicula, Chlorella* and *Euglena* were assimilated.

Parado-Estepa, F.D., Ferraris, R.P., Ladja, J.M. and De Jesus, E.G., 1987. Responses of intermolt *Penaeus indicus* to large fluctuations in environmental salinity. *Aquaculture*, 64:175-184.

The osmotic and chloride regulation by 5- to 10-g intermolt *Penaeus indicus* was investigated by abruptly changing medium salinity from seawater (32 ppt) to test salinities of 8, 20, 32 (control) or 40 ppt. Hemolymph samples were taken at 0, and then at 0.25, 0.5, 1, 2, 5 and 10 days after the change in salinity, and were analyzed for osmolality and chloride concentrations. Tissue water content was also determined. Throughout the study period, daily mortality was low (1.8%), and was the same among control and experimental salinities. Hemolymph osmolality and chloride as well as tissue water content were stable within 0.25 to 0.5 days after the abrupt salinity change, except for tissue water content at 8 ppt which did not reach a steady state for 2 days. Intermolt *P. indicus* exhibited hyperosmotic or hyperionic regulation in salinities below isosmotic or isoionic salinities, and hypoosmotic or hypoionic regulation in those above. Hemolymph osmolality and chloride were positive linear functions of external osmolality and chloride concentrations (slope=0.24 ± 0.02 and 0.20 ± 0.02, respectively). Isosmotic and isoionic values were 780 mOsm/kg and 330 mN, respectively. Percentage tissue water decreased as a function of external osmolality (-0.0056% kg $mOsm^{-1}$) and hemolymph osmolality (-0.0232% kg $mOsm^{-1}$), indicating that tissue cells were relatively permeable to hemolymph water, and that the hemolymph acted as a barrier to buffer the cells from large fluctuations in external salinity. These results indicate that, like many penaeids, *P. indicus* is a good osmoregulator suitable for culture in brackishwater ponds where there are large fluctuations in salinity.

Santiago, A.E., 1987. Evaluation of the high rate algae pond system for softdrink waste treatment and for fish culture. *Asian Environ.*, 9:28-34.

The High Rate Algae Pond System (HRAP) as secondary treatment for Cola effluents showed potential for reducing both COD load (about 88%) and high pH level down to pH 7.0 -8.0). The effluent quality improved and can be used for raising tilapia.

The algae production was low, that photosynthetic oxygen input alone was insufficient to satisfy oxygen requirement for microbial oxidation process and for fish respiration. Mechanical aerators, therefore, cannot be dispensed with for an aerobic condition.

The low algae production was reflected in the growth increment of the test fishes and its low fat content (1%) indicative of starvation.

Santiago, C.B., Aldaba, M.B. and Reyes, O.S., 1987. Influence of feeding rate and diet form on growth and survival of Nile tilapia (*Oreochromis niloticus*) fry. *Aquaculture*, 64:277-282.

Young Nile tilapia (12 mg mean body weight and 11 mm total length) were stocked at a density of 5 fish/l in twelve 50-l aquaria filled with 30 l of tap water. They were fed pellet crumbles containing 35% crude protein at various daily feeding rates expressed as percentages of fish biomass. Mean increases in body weight after 5 weeks were 63, 198, 232 and 228 mg for the 15, 30, 45 and 60% feeding rates, respectively, when ambient temperature ranged from 19 to 21 °C. Corresponding survival rates were 53, 85, 87 and 84%. Growth and survival rates were enhanced significantly ($P<0.01$) at the 30, 45 and 60% feeding rates.

Two feeding trials were conducted to compare the growth and survival of fry fed pellet crumbles and an unpelleted form of the same diet. Results showed that growth and feed conversion were similar for both forms of diet. However, the survival rate of fry fed pellet crumbles was significantly higher ($P < 0.01$) than the survival rate of fry fed the unpelleted diet. Prior pelleting of the formulated diet for the tilapia fry given at 30% to 45% of fish biomass daily ensured high survival, fast growth and efficient feed conversion.

Segner, H., Burkhardt, P., Avila, E.M., Juario, J.V. and Storch, V., 1987. Nutrition-related histopathology of the intestine of milkfish *Chanos chanos* fry. *Dis. Aquat. Org.*, 2:99-107.

A histopathological study was conducted on the intestine of milkfish larvae *Chanos chanos,* subjected to different nutritional conditions. Newly caught milkfish fry, ca 20 d old, were starved for 7 d and then fed with either *Artemia* nauplii or *Chlorella* sp. The latter diet, as already shown in other studies, is detrimental to young milkfish. A third, control, group of fry was starved for a further 2 d. In larvae fed with *Artemia,* 1 to 2 h after feeding, intensive lipid absorption was noted in the first part of the intestine (Intestine I, lipid-absorbing zone, midgut). The second part of the intestine (Intestine II, hindgut) was characterized by pinocytotic activity and the presence of large supranuclear vacuoles. Food deprivation for 9 d resulted in cellular

hydration, transformation of mitochondria, disturbances of the basal labyrinth and appearance of autolytic vacuoles in enterocyte cytoplasm in Intestine 1, with a proximo-distal gradient of severity of enterocytic degeneration. In Intestine II, supranuclear vacuoles were replaced by dense bodies; pinocytotic activity was maintained at a reduced level. Microvilli were fragmented over the whole length of the intestine. *Chlorella*-fed larvae, although containing broken algae within the gut lumen, displayed no signs of nutrient absorption as detectable by electron microscopy. In Intestine I, enterocytes contained bizarre nuclei, an enhanced number of lysosomes and occasionally large intracellular vacuoles. In addition, intercellular spaces were dilated. Mitochondria appeared pale and swollen throughout the gut. Histological alterations in Intestine II were similar to those for starved fry.

Segner, H., Burkhardt, P., Avila, E.M., Storch, V. and Juario, J.V., 1987. Effects of *Chlorella* feeding on larval milkfish, *Chanos chanos* as evidenced by histological monitoring. *Aquaculture*, 67:113-116.

Milkfish, *Chanos chanos,* larvae were found to suffer 100% mortality within 6 days of feeding when reared on *Chlorella* sp. According to the liver ultrastructure, *Chlorella*-fed fish underwent starvation. Likewise, no signs of lipid absorption were observed in the intestine of *Chlorella*-fed larvae. On the other hand. *Chlorella*-related histological alterations of the enterocytes in the anterior part of the intestine were different from starvation-related alterations. It is concluded that *Chlorella*-feeding creates a starvation situation for larval milkfish, but the early losses with this diet are due to an additional stress specifically introduced by *Chlorella*-feeding.

Taki, Y., Kohno, H. and Hara, S., 1987. Morphological aspects of the development of swimming and feeding functions in the milkfish *Chanos chanos*, *Jap. J. Ichthyol.*, 34:198-208.

Development of swimming and feeding abilities based on morphological development of larval and early juvenile *Chanos chanos* was investigated. In larvae smaller than about 6.5 mm SL, mechanical supports of fins and branchial arches were in a primordial stage of development. Supports and rays of the vertical fins and branchial arches rapidly developed from 6.5 mm SL,and all components appeared by about 10.5 mm SL. Thereafter body depth proportion changed and the supports and rays of the paired fins and gill-rakers developed. These developmental events were nearly or totally completed by about 17 mm SL, and we concluded that the larvae transformed to juveniles at this size. By this time, the mode of swimming of the fish shifted from undulating locomotion to caudal propulsion and that of feeding from swallowing particulate food to filtering and concentrating substrate food matters using gill-rakers and the epibranchial organ. One of the most characteristic, and well-known, phenomena in the life history of *Chanos chanos* is the mass occurrence in the surf zone of postlarvae of a limited size range. In view of the scheme of the development of mechanical supports of the body and fins, they may acquire a swimming ability strong enough to move against the current only upon reaching about 10.5 mm SL, and if active shoreward migration of the larvae occurs, it is only during the late period of their journey from the spawning grounds to the shore. The sudden disappearance from the surf zone of larvae larger than 15-16 mm SL is obviously related to a change in food habit.

Walton, M.J., Cowey, C.B., Coloso, R.M. and Adron, J.W., 1986. Dietary requirements of rainbow trout for tryptophan, lysine and arginine determined by growth and biochemical measurements. *Fish Physiol. Biochem.*, 2:161-169.

Three separate studies were performed to determine the dietary requirements of rainbow trout *Salmo gairdneri* for tryptophan (Trp), lysine (Lys) and arginine (Arg) from both growth and biochemical data. The growth studies were carried out over a 12-week period. From graphical plots of % mean weight gain against % amino acid in diet the following requirement values were obtained, Trp 0.25% diet (0.4% dietary crude protein); Lys 1.9% diet (4.3% dietary protein); and Arg 1.6–1.8% diet (3.6–4% dietary protein). Plasma and liver amino acid concentrations measured 20 h after feeding did not prove useful for determination of requirement values. Hepatic activities of Trp pyrrolase (TP), Lysα ketoglutarate reductase (LKGR) and arginase were not significantly affected by varying levels of Trp, Lys and Arg respectively in the diet. TP has a cytosolic location and a Km of 0.2 mM for Trp; LKGR is mitochondrial and the Km for Lys is 7.3 mM; arginase is also mitochondrial and has a Km of 4.9 mM for arginine. Measurements of expired $^{14}CO_2$, after injection of a tracer dose of ^{14}C amino acid, did allow estimates of requirement levels to be made. The values obtained from the oxidation studies reinforced the values obtained from the growth data but were not precise enough to justify using this method on its own.

Research Seminars

Date	Topic	Speaker
23 March	Goldfish ovarian steroidogenesis in vitro	L. Ma. Garcia
24 March	Some notes on the development of practical diets for finfish larvae	G. Pution
30 March	Response of *Penaeus indicus* post-larvae to different artificial diets	V. Alava
06 April	Acute nitrite toxicity and methemoglobinemia in juvenile milkfish	J.M.E. Almendras
	Notes on the role of the gut in osmo-regulation of juvenile milkfish	
13 April	Polyculture of the tiger prawn with Nile tilapia in brackishwater ponds	K. Corre
20 April	Growth and reproduction characteristics of different *Artemia* strains	P. Dhert
04 May	Improvements in the use of live diets in larval rearing	P. Lavens*
07 May	Integrated commercial *Artemia* production system in the Philippines	N. Jumalon-Ogburn
08 May	Purification and properties of milkfish trypsin	L. Benitez
18 May	Use of C-MBD as feed for *P. monodon* larvae	M. Bautista
02 June	The effect of salinity on the lipid composition of milkfish	I. Borlongan
08 June	Haematological and histopathological changes in *Tilapia mossambica* intoxicated with pesticides	E. Cruz
23 June	Digestibility of protein in feed stuffs for *Penaeus monodon*	M. Catacutan
16 July	Studies on the chronic soft-shell syndrome in the tiger prawn, *P. monodon*	M.C.L. Baticados
17 July	Histopathological studies on Japanese eels injected intramuscularly with *Vibrio anguillarium* extracellular products (E.C.P.)	M. de la Cruz
23 July	Poisoning caused by red tide organisms in Japan	Y. Fukoyo*
24 July	Population dynamic simulation of food organisms in culture ponds	A. Ohno*
29 July	Integrated vs. individual prawn production systems: which is more profitable	D. Israel
14 August	Use of dinoflagellate, *Gymnodinium splendens,* as a live food source for initial larval feeding of small-mouthed marine finfish	E. Rodriguez
20 August	Control of prolactin hormone secretion in fish	T. Barry*
24 September	Daily growth increment of otoliths in larval *Chanos chanos*	H. Kohno
25 September	Sodium EDTA effect on growth and survival of *Penaeus monodon* larvae	Ma. S. Licop
05 October	Activities in Dr. Grizel's laboratory	H Grizel*
06 October	Recognition of microorganisms and parasites of molluscs	H. Grizel*
15 October	Effect of salinity on maturation and spawning of ablated *Penaeus monodon*	R. Posadas

21 October	Growth response to different feed ration levels in common carp *(Cyprinus carpio)*	J. Llobrera
22 October	Sex differentiation in *Macrobrachium rosenbergii*	J. Janssen*
23 October	Effect of diet deficiency with some water-soluble vitamins on the growth and mid-gut cells of *P. monodon* juveniles	M. Catacutan
04 November	Prawn culture in Brazil	L.A. Gomez*
04 November	Genetics of growth in tilapia	R. Doyle*
13 November	Induction of bacterial infection on *Oreochromis mossambicus*	G. Lio-Po
19 November	Pond-verification of a SEAFDEC-formulated diet for prawns	F. Pascual
20 November	Relationship of food consumed with growth of sea bass, *Lates calcarifer*	A. Triño
25 November	Salinity tolerance of *Oreochromis mossambicus, O. niloticus,* and their F_1 hybrids	C. Villegas
08 December	1) Effect of tank color and tagging in *Penaeus monodon* maturation 2) Feeding rhythm of *P. monodon* 3) Prawn culture in China	J. Primavera

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*AQD guests

DR. **F.J. Lacanilao**, *AQD Chief, delivers the Welcome Address at ADSEA '87.*

TRAINING

AQD conducts regular training programs on long- and short-term durations, as well as seminars, workshops, and forums on various areas of interest in aquaculture. Participants come from different countries, including those sent by Philippine government agencies, academic institutions, interested groups in the private sector, and small fish farmers.

Notable among the regular training courses are the following: the year-long NACA/AQD/FAO-UNDP/UPV Training Course for Senior Aquaculturists in Asia and the Pacific Region, the Prawn Hatchery/Nursery Operations and Management Course, and various regular courses on brackishwater and freshwater aquaculture.

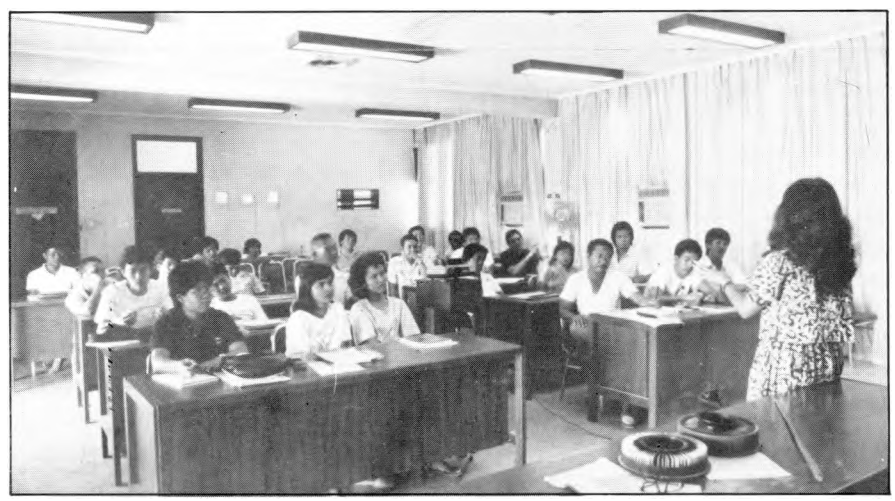
Following is a summary of training activities undertaken by AQD during the year.

Regular Courses

Sixth UNDP/FAO NACA-UPV-SEAFDEC/AQD Training Course for Senior Aquaculturists in Asia and the Pacific Region, May 1986-April 1987. Graduates of this one-year training program, which was launched in 1981, now total 119. The sixth session accommodated 19 participants from the following countries: People's Republic of China, 2; India, 4; Malaysia, 1; Philippines, 4; Thailand, 3; Indonesia, 2; Pakistan, 1; and Sri Lanka, 2. Training venues for the course included AQD's Tigbauan Research Station (TRS) and Leganes Brackishwater Station (LBS), University of the Philippines in the Visayas (UPV), and NACA Regional Lead Centres in India, Thailand, and People's Republic of China. International/regional agencies extended fellowship grants to support the following number of participants: IDRC, 7; UNDP/FAO NACA, 10; and Asian Development Bank, 2.

Prawn Hatchery/Nursery Operations and Management. Four sessions of this training course, the 19th to the 22nd in the series, were conducted by AQD during the year (4 March-23 April, 7 May-25 June, 8 July-27 August, and 23 September-12 November). A total of 95 participants joined the course: 2 came from Malaysia, 2 from Thailand, 86 from the Philippines, and 5 from other regions. Seven participants in the 22nd session were sponsored by the Government of Japan and 6 by UNDP/FAO.

Brackishwater Pond Culture. Conducted at LBS and TRS, two sessions of the course were held on 2 April-9 May and 7 October-17 November 1987. Of the 49 trainees who attended the sessions, 2 were from Malaysia, 2 from Thailand, 42 from the Philippines, and 3 from other regions. Seven



TRAINEES during lecture session (top). Trainees doing actual harvesting of milkfish as part of practical session (bottom).

participants were awarded fellowship grants provided by the Government of Japan and 3 by UNDP/FAO.

Hatchery of Marine Finfishes, June 2-July 23, 1987. This training course was conducted at TRS and Igang Research Substation. It was attended by participants from five countries, viz., Philippines, 8; Sri Lanka, 1; Brazil, 1; Malaysia, 1; and Thailand, 2. Of the trainees, 11 were sponsored by IDRC and two by the Government of Japan.

Freshwater Aquaculture, 10 September-13 October 1987. Of the nine participants who attended the course conducted at the Binangonan Freshwater Station, 1 came from Malaysia, 1 from Thailand, 6 from the Philippines, and 1 from other regions. Three participants were sponsored by the Government of Japan and one by the Norwegian Research and Development (NORAD).

Sanitation and Culture Techniques for Tropical Bivalves, 1 October-10, November 1987. Conducted at TRS and Batan, Aklan, recipients of this training were 2 participants from Malaysia, 2 from Thailand, and 7 from the Philippines. Four participants were sponsored by IDRC and seven by the Government of Japan.

Fish Health Management, 2-27 November 1987. Although scheduled for the 1988 training season, this course was conducted in 1987 for 8 extension workers from the Department of Agriculture-Aquaculture Development Project, 2 from the Bureau of Fisheries and Aquatic Resources, and 2 from the private sector.

Seminars/ Workshops/ Meetings

Prawn Management Seminar, January 16-17, 1987. AQD conducted this two-day seminar upon request of the Manila-based Vitarich Corporation, an agri-business firm. It was held at TRS and LBS and attended by 27 Vitarich company officials. Topics discussed included overview of world aquaculture and the prawn industry, prawn biology, hatchery and nursery systems, pond culture of prawn, nutrition and feeding, soft-shelling, prawn processing, economics and marketing.

NBBP Project Evaluation/Annual Meeting, January 20-24, 1987. Held at TRS, the meeting discussed status reports and accomplishments of the National Bangus Breeding Program (NBBP), the program of activities for 1987, as well as administrative, financial and technical matters. The conference was attended by officials from the Department of Agriculture acting as NBBP project leaders, members of the Bureau of Fisheries and Aquatic Resources (BFAR) Coordinating Team, and NBBP Technical Staff from AQD.

Workshop on Managing the Teaching-Learning Situation, February 26-27, 1987. This workshop was organized for staff members of the AQD Research and Training Divisions who are in charge of implementing the Department's Aquaculture Training Program for 1987. Various aspects of the program were considered and discussed, including the communication process, teaching the adult learner, setting up learning objectives, learning aids, audiovisual equipment handling and operation, and group dynamics.

Popularization and Utilization of Aquaculture Technology, June 11-13, 1987. This seminar-workshop was given to 25 members of the AQD research and communication staff. Topics discussed were: Research/technology utilization process and institutional strategy, principles of effective writing, writing for extension publications, and design and production of leaflets.

Seminar on Aquaculture Development in Southeast Asia (ADSEA '87), September 8-12, 1987. AQD, with the cooperation of the SEAFDEC Secretariat and the government of Japan, organized this seminar in Iloilo City attended by senior aquaculturists from Japan, Malaysia, Singapore, Thailand and the Philippines; senior research

TRAINEES with researcher prepare water samples for heavy metal analysis.

staff of AQD; and observers from funding organizations, fisheries agencies, and the private sector. There were a total of 36 official delegates and 147 observers. Held in commemoration of the 20th anniversary of SEAFDEC, the seminar participants set the regional research priorities in aquaculture for the coming years.

Tenth SEAFDEC Program Committee Meeting, September 15-18, 1987. The meeting evaluated past and present accomplishments of SEAFDEC and recommended future programs of activity. In addition to members of the committee, attending the meeting were observers from France, Norway, Philippines, and international agencies including FAO-RAPA, IDRC, NACA, SEAMEO, and SEARCA.

Study Tour

AQD played host to four fishery officials from Indonesia who visited the Department on July 21-25 for a study tour of AQD's facilities. The same assistance and courtesy was extended to a fishery officer from India who came as observer on September 20-October 17. Both study tours were sponsored by UNDP/FAO.

Practicum Training

AQD extends practicum training to students of various colleges and universities, lasting for a period of one to two months. During the year, admitted were 20 students from Western Institute of Technology, Iloilo City; 2 from Bicol University, Albay; 4 from the University of San Agustin, Iloilo City; 3 from the Iloilo State College of Fisheries, Barotac Nuevo, Iloilo; 2 from Tario Lim Memorial Antique School of Fisheries, Tibiao, Antique; 8 from the Northern Iloilo Polytechnic State College, Estancia, Iloilo; 6 from the Mindanao State University; 7 from Pasacao School of Fisheries, Pasacao, Camarines Sur; 3 from Agro-Industrial Foundation College of the Philippines, Davao; and 1 from Davao Regional Institute of Fisheries Technology, Davao.

Internship

Internship training on various aquaculture areas of specialization was also given by AQD. The following number of trainees took advantage of this program: 35 in phycology/*Artemia* culture; 5 in nutrition and feed development; 5 at the Centralized Analytical Laboratory; 7 in fish health/microtechniques; 3 in finfish/prawn hatchery; 5 in broodstock development; and 1 in pond management.

EXTENSION SERVICES

DURING the year, extension services rendered by AQD centered on socially oriented projects, especially in favor of small fish farmers and poor fisherfolk in coastal communities of the Philippines. This is in line with the strong commitment of the Philippine Government to establish a firmer structure for social justice or social equity based on the principle that the poor deserves much more benefits than that formerly given to a privileged few in the use of the country's natural resources. Participation in the following projects is among the involvement of the SEAFDEC Aquaculture Department.

Agri-Aqua Caravan Fair '87. To help small fish farmers, AQD joined the Agri-Aqua Livelihood and Poultry Caravan Fair '87 sponsored by the Department of Agriculture. The mobile fair was held at three sites in the country, namely, 1) PHILCITE, Metro Manila, March 22-29, 1987; 2) Cebu City, April 25-May 2; and 3) Cagayan de Oro City, May 17-24. AQD maintained display booths with audio-visual facilities and conducted aquaculture seminars and consultations with the small fish farmers, benefiting

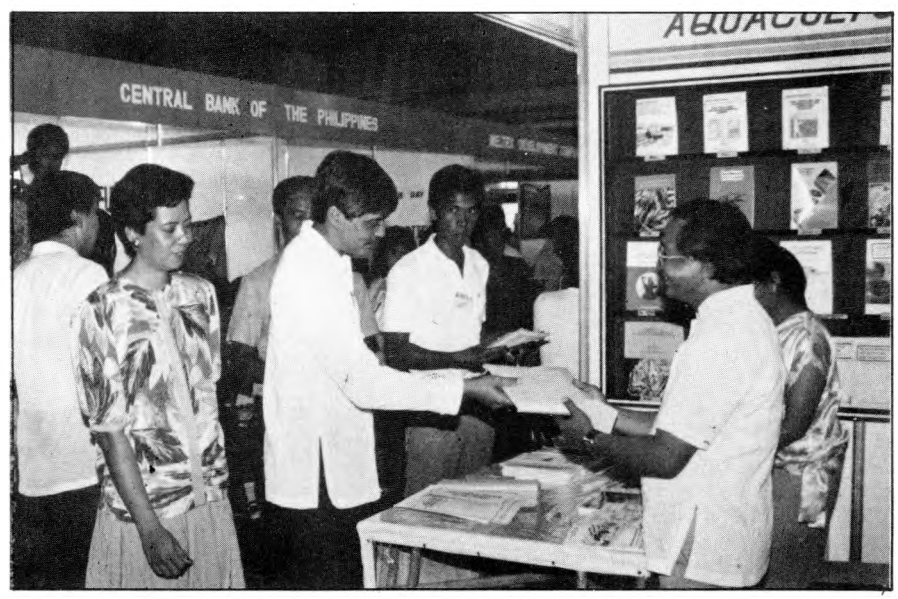


EXHIBIT of AQD publications as part of its extension services.

more than 500 of them.

Aquaculture Technology Outreach Program (ATOP). This is a comprehensive technology dissemination and promotion program funded by the Technology and Livelihood Resource Center (TLRC) and implemented by AQD. It aims to provide the following:

1) Various technology communication materials for all forms of mass media;

2) Various kinds of technology publications, film and video materials;

3) Training courses/seminars/forums/workshops;

4) Information management and databanking services; and

5) Financing programs for technology livelihood projects.

Since operationalization of the program during the period under review, the following seminar-workshops were conducted at the TLRC office in Metro Manila:

1) Prawn Culture (Grow-Out) and Management, July 20-25;

2) Prawn Hatchery Operation and Management, August 17-22;

3) Hatchery of Marine Finfishes, October 5-10;

4) Prawn Culture (Grow-Out) and Management, October 26-31;

5) Prawn Hatchery Operation and Management, November 23-27; and

6) Hatchery of Marine Finfishes, December 7-11; and in Tigbauan, Iloilo on Popularization of Aquaculture Technology, June 11-13, 1987.

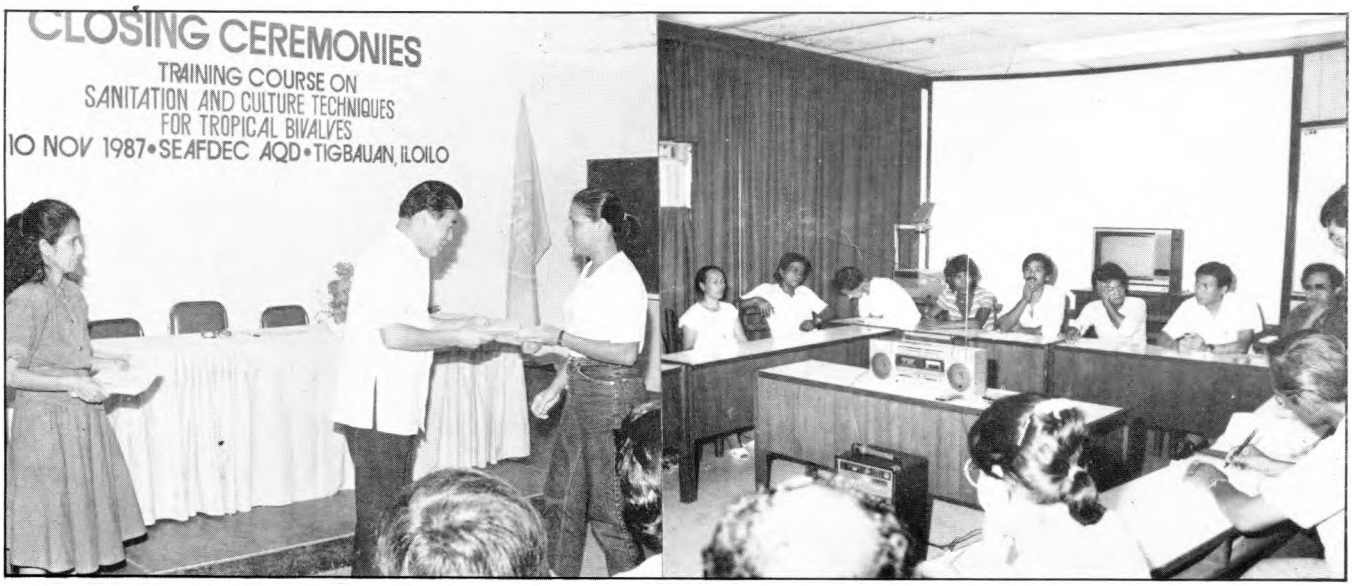
In addition, members of the AQD technical staff have also been sent to some parts of the country to conduct or participate in related seminars.

One of the activities of ATOP is also known as "Alay Palaisdaan", which seeks to bring modern or innovative aquaculture technology to the grassroot level through lectures, discussions and dissemination of information materials. The project was launched at a seminar on prawn culture held in Antique Province on June 15-18, 1987.

Farmers' Profitability Campaign. Strongly endorsed by the Department of Agriculture, AQD's model activity for the national government's Farmers' Productivity Campaign goes by the slogan: "Increasing Milkfish Production through Improved Pond Management." This project is designed to demonstrate the benefits of the following culture technologies: 1) milkfish/prawn polyculture; 2) milkfish/crab polyculture; and 3) integrated farming of poultry with milkfish and shrimp.

"Ugnayan sa Lawa". This project (translated as "Consultation in the Lake" or series of dialogue-interaction with small fishermen/fish farmers around Laguna de Bay) was launched on June 22, 1987 at AQD's Binangonan Freshwater Station. The project aims to actively involve everyone concerned in the proper management of the lake and its potentials for aquaculture. Among the topics discussed during the series of meetings were the problems related to illegal fishing, fish diseases, pollution, flood control, decrease in clam production, and site selection for fish culture.

Technology Verification. AQD conducted a technology verification study to prove the efficiency of a SEAFDEC-formulated feed which uses cheap raw materials. The formulation, costing half the price of commercial feeds, will greatly benefit small prawn farmers who cannot afford the high cost of commercial prawn feeds presently available in the market. The study was done with the cooperation of the Iloilo Fish Producers Association, DA/Aquaculture Development Project, and University of the Philippines in the Visayas Brackishwater Aquaculture Center.



AQD Deputy Chief, Mr. **Satoru Fukumoto** *awarding certificates of completion to trainees (left), and "Ugnayan sa Lawa" session (right).*

INFORMATION

Library and Documentation Services

Library Services. The present library collection consists of 8,356 monographic volumes, 4,307 pamphlets, 1,718 SEAFDEC publications; and 3,346 journal volumes. During the year, library users were counted at 20,883 readers, or an average of 9 readers per hour.

Current Awareness, a weekly issue of photocopies of the table of contents of scientific journals received by the library, was revived. Researchers have likewise been provided easier access to the latest scientific journals through the "New Arrivals" table at the library.

Documentation Services. Documentation activities were intensified to develop and provide quality and effective information services on aquaculture, particularly brackishwater aquaculture. The Brackishwater Aquaculture Information System (BRAIS), a specialized information analysis project with funding support from IDRC, continued to provide **Brackishwater Aquaculture Abstracts** and other special abstracts. Among these are the **Mussel Abstracts** (already published) and **Grouper Abstracts, Milkfish Abstracts, and Mud Crab Abstracts** (now under preparation). Also underway is the preparation of a **Directory of Scientists** and **Directory of Institutions.**

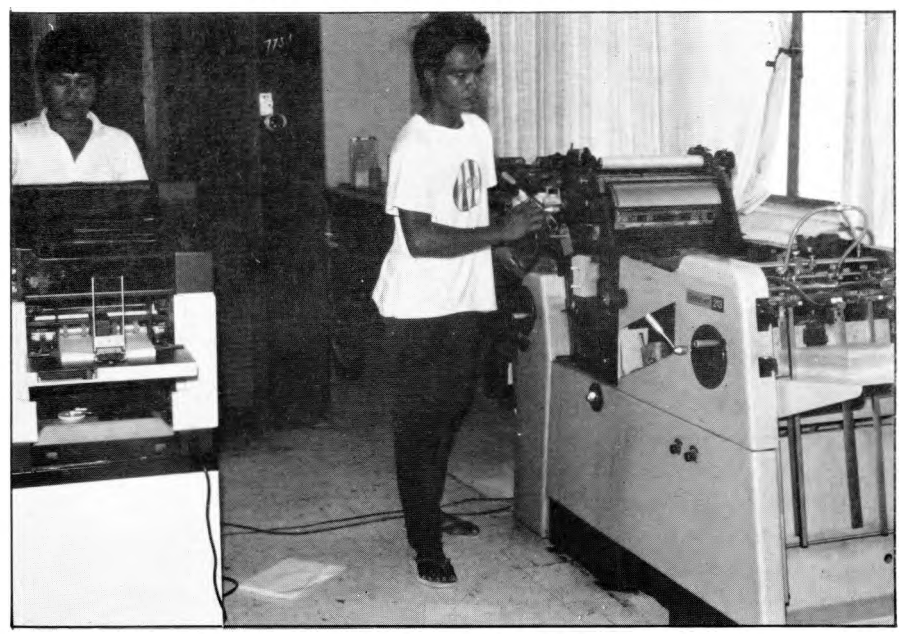
There are now 3,864 entries in the BRAIS database for regular and special bibliographies and abstracts. For the scientists' directory database, 168 entries are available, while for the institutions' directory 48 responses have been received. Some 202 inquiries and referrals have also come from 44 countries.

Publications

Activities under this heading include the publication of newsletters, manuals, pamphlets and brochures. AQD regular publications are the 1) quarterly **SEAFDEC Asian Aquaculture,** 2) monthly **Aqua Farm News,** 3) fortnightly **Aqua Dep't. News** (house organ), and monthly **Information Alerts.**

AQD has an in-house printing facility which produces newsletters, extension manuals, modules, brochures, certificates, programs, etc. Among the printed materials produced during the period under review were the following:

AUTOMATION of aquaculture information.



STAFF manning the printing machines at Tigbauan.

1) Extension Manual (EM) No. 5 – Farming of prawns and shrimps (with accompanying document entitled: "Recent Developments in Prawn Pond Culture")

2) EM No. 9 – Prawn hatchery design and operation

3) EM No. 10 – Important fish and shrimp fry in Philippine waters: identification, collection and handling

4) Aquaculture Technology Module (ATM) No. 2 – How to transport and acclimate prawn fry

5) Abstracts of Serial Publications – Abstracts of publications (1978-1987) on milkfish, prawn, tilapia, rabbitfish, sea bass and bivalves (200 pages)

6) ADSEA '87 abstracts, brochures, documents and working papers – Prepared for use in the ADSEA Seminar held September 8-12 and for the Tenth Meeting of the SEAFDEC Program Committee on September 15-18, 1987.

7) ADSEA '87 Report – Published as reference for the SEAFDEC 20th Council Meeting in Manila on November 17-20, 1987.

8) Aquaculture of Siganids: State of the Art – Published in October 1987 (51 pages)

9) BRAIS quarterly newsletter

10) Collected Reprints – AQD papers published in scientific journals. Vol. IA – FINFISHES; Vol. I-B – CRUSTACEANS and BIVALVES (1903 pages).

11) Information Alerts – A monthly reference list for AQD researchers.

12) New AQD brochure

13) Training brochure

14) Brochure for Poster 1, Important Penaeid prawns/shrimps of the Philippines

15) List of publications

16) Publications catalogue

17) List of AQD Senior Staff

18) Brochure on Business Opportunities in Aquaculture

19) Training certificates, programs, etc.

ADMINISTRATION

Management Organization

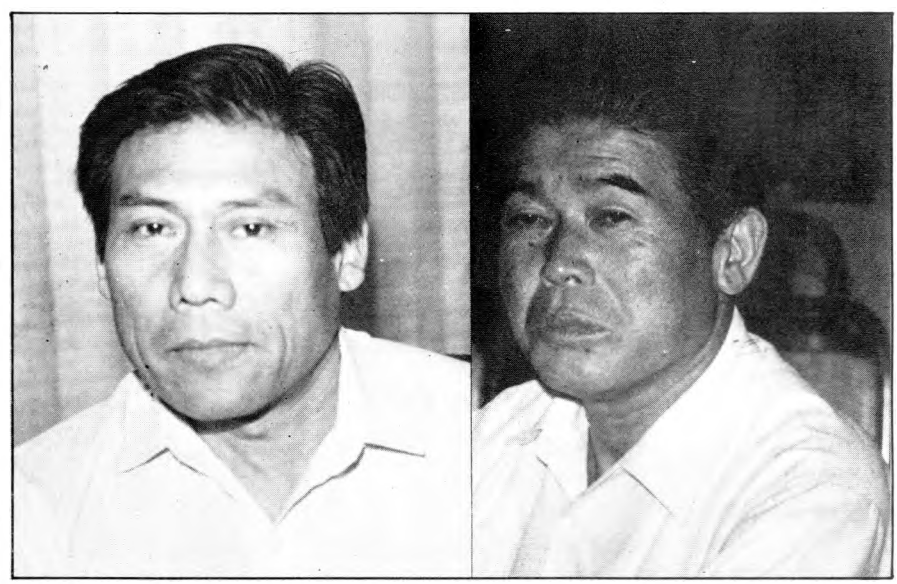
Streamlining of the functions and operations of the Aquaculture Department and other cost-effective measures were implemented during the year under review, in accordance with the AQD Revised Plan of Operation and Program of Work approved at the Nineteenth Meeting of the SEAFDEC Council in Tokyo, Japan, November 18-21, 1986. As restructured, the Department is now organized into five divisions, namely: Research, Training, Information, Administration, and Finance divisions.

Sections under each division are: Research Division – Breeding, Farming Systems, Feed Development, and Fish Health sections; Training Division – Trainee Affairs, Training Courses, and Instructional Materials sections; Information Division – Documentation, Publications, and Techno-Transfer sections; Administration Division – General Services, Personnel, and Engineering sections; and Finance Division – Accounting and Cashiering sections.

AQD maintains three principal research stations, i.e., Tigbauan Research Station (TRS) in Iloilo Province, Visayas, which also serves as headquarters of the Department; Leganes Brackishwater Station (LBS), also in Iloilo; and Binangonan Freshwater Station (BFS) in Rizal Province, Luzon.

TRS deals primarily with the basic aspects of aquaculture technology, seed production, and feed development. The station also offers international and national training programs on the culture of finfish, crustaceans, and molluscs. At LBS, activities focus on the generation, verification, and refinement of aquaculture technology for both seed production and grow-out of finfish and shrimps. Studies on mass production of *Artemia* are also done at LBS. On the other hand, BFS undertakes studies on milkfish and other freshwater fish species such as carps and tilapia. Development of seed production and pen/cage culture technology is the main objective of these studies. Training courses on freshwater aquaculture are also conducted at the station.

All these stations have been opened



AQD Chief **F. J. Lacanilao** *(left), and Deputy Chief* **Satoru Fukumoto** *(right).*

DIVISION HEADS

C. L. Marte
Research Division

J. H. Primavera
Training Division

V. T. Sulit
Information Division

R. E. Cuevas
Administration Division

R. V. Alger
Finance Division

as sites of various AQD projects, following the aim of the reorganization plan for more flexibility in project implementation.

To further support the management of AQD, President Corazon C. Aquino issued Executive Order No. 116 on January 1987, creating the Philippine Technical and Administrative Committee for SEAFDEC. Replacing the former National Board for SEAFDEC, the Committee will monitor and assess the implementation of AQD research projects on the basis of the policies and standards established by the SEAFDEC Council and the Philippine government's Department of Agriculture. The Committee is composed of the Secretary of Agriculture as chairman and the DA Undersecretary for Attached Agencies, the Dean of the College of Fisheries of the University of the Philippines in the Visayas, the Director of the Bureau of Fisheries and Aquatic Resources, and the Chief of AQD, as members.

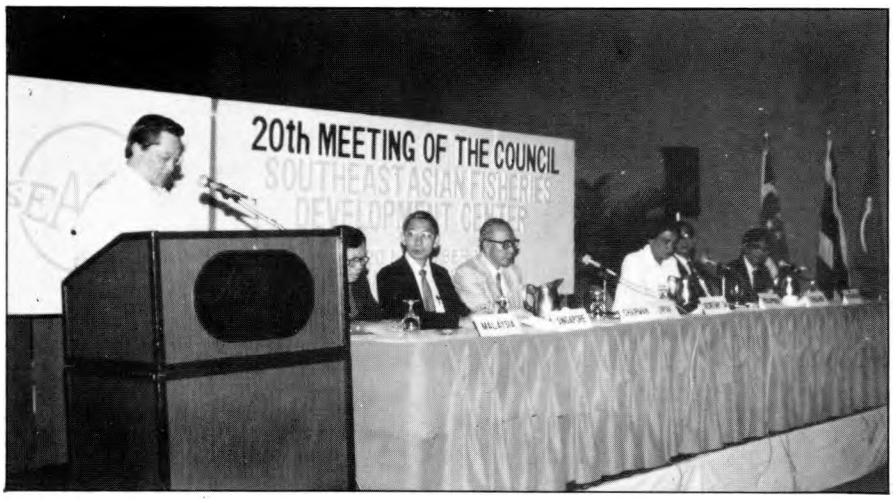
Inside the Department, a Management Information Services Group was created to review and document all existing systems and procedures, identify the information needs of the different offices, produce systems manuals, ensure that new systems are properly followed, and evaluate their efficiency.

Personnel

As of December 31, 1987, personnel of AQD totaled 581 regular employees distributed as follows: 330 in the Research Division; 21 in the Training Division; 38 in the Information Division; 146 in the Administration Division; 20 in the Finance Division; and 26 in the Office of the Chief.

The Department also avails of the services of foreign and local experts. Expatriate personnel at AQD include Dr. Hiroshi Kohno, who is staying up to February 1988 to complete a study on the biology of groupers; Mr. Philippe Dhert, research associate of the *Artemia* Reference Center (ARC), Ghent, Belgium, who was commissioned by the Department to implement studies under the collaborative AQD-ARC project from March 4,

The Program Committee of SEAFDEC reviews and evaluates the activities, and examines future programs of activity of the SEAFDEC Departments.



THE SEAFDEC Council held its 20th Meeting in Manila with Secretary **Carlos G. Dominguez** *of the Department of Agriculture as keynote speaker. At the session, the Council confirmed the reappointment of AQD Chief* **F. J. Lacanilao** *for two years beginning April 1988.*

1987 to March 3, 1989; Dr. Hiralal Chaudhuri, as visiting scientist since April 16, 1987; and Mr. Yoshibumi Yashiro, Japanese expert on shrimp culture, who is assigned at AQD for two years beginning September 15, 1987 (he also serves as JICA coordinator assisting the Japanese AQD Deputy Chief.

Staff Development. To enhance the knowledge and expertise of its technical personnel, AQD has sent or approved the attendance of members of its research staff to various postgraduate studies and training programs. Among AQD personnel who benefited during the year from these educational and training opportunities are the following:

- *E. Amar and J. Ladja* — one-year NACA Sixth Training Course for Senior Aquaculturists in Asia and the Pacific Region, NACA Training Centre, SEAFDEC, Iloilo, March 13, 1986-March 6, 1987.
- *M. Parazo and E. Rodriguez* — M.S. degrees under Monbusho scholarships, June 1987 (M.S. in Fisheries from Kagoshima University, Japan, for Parazo and Master of Fisheries Sciences from Nagasaki University, Japan, for Rodriguez).
- *E. Gonzales* — four-month fellowship as visiting scholar sponsored by the British Council, University of Cambridge, United Kingdom, from March 20, 1987.
- *B. Acosta* — FAO Regional Training Course on Mass Seed Production of Chinese Carps, sponsored by IDRC, Guanzhou and Wuxi, People's Republic of China, April 18-May 28, 1987.
- *J. Llobrera* — four-month research fellowship, Institute for Animal Production in the Tropics and Sub-Tropics, University of Hohenheim, Stuttgart, Federal Republic of Germany, from April 15, 1987.
- *O. Millamena* — two-month *Artemia* Training, *Artemia* Reference Center, State University of Ghent, Belgium, from May 26, 1987.
- *Z. Basiao* — two-month training on statistical analysis and genetics, Dalhousie University, Halifax, Canada, from June 1, 1987.
- *I. de Mesa* — UNESCO-MAB Regional Training Course on Microcomputer-based Application of Statistical Programs and Packages for Environmental Scientists, Manila, from June 15, 1987.
- *D. Estenor* — two-year degree grant, September 1987 to September 1989, in Master of Science in Fundamental and Applied Marine Ecology, Free University of Brussels, Belgium (sponsored by AQD and the Belgium Administration for Development Cooperation).
- *D. Javellana* — three-month training on qualitative/quantitative analyses of plankton in benthos communities in brackishwater, Nansei Kaiku Fisheries Laboratory, Hiroshima, Japan, from July 6, 1987.
- *M. de la Pena* — four-month training on culture and physiological studies on larval food organisms culture, phytoplankton and zooplankton, Fisheries Experimental Station, Nagasaki, Japan, from August 10, 1987.
- *D. Chavez and E. Borlongan* — Fifth *Artemia* International Training Course, *Artemia* Reference Center, State University of Ghent, Belgium, August 16-October 1, 1987.
- *M. Bautista* — Six-month training on larval feed technology with emphasis on microencapsulation, Kagoshima University, Japan, from September 1, 1987.
- *P. Subosa* — Six-month training on environmental physiology (water quality parameter), Kyoto University, Japan, from September 1, 1987.
- *E. Ledesma* — DTCP Course on Extension AV-Aids, sponsored by FAO/UNDP, Bangkok, Thailand, October 5-30, 1987.
- *W. Gabuelo and D. Zamora* — Desktop Publishing Software, sponsored by BRAIS, Dynalink, Iloilo City, October 19-30, 1987.
- *R. Luhan* and *N. Guanzon* — Seaweeds Research Training-Workshop for Project Leaders, sponsored by the University of the Philippines Marine Science Institute and Philippine Council for Agriculture and Resources Research and Development (PCARRD), University of the Philippines, Diliman, Quezon City, November 23-December 15, 1987.

FACILITIES

Service Laboratories

Larval Food Laboratory. This laboratory routinely analyzes the quality of commercial *Artemia* strains as a service to the private sector and all users of *Artemia* at SEAFDEC. It produces enriched, newly hatched *Artemia* nauplii and biomass for siganid, sea bass, milkfish, and prawn fry. Another facility, the Phycology Laboratory, also services the needs of private enterprises and the different SEAFDEC projects for phytoplankton and zooplankton starters.

Centralized Analytical Laboratory (CAL). Submitted to CAL for analysis are water and feed samples. Water parameters frequently requested are pH, ammonia-nitrogen, nitrite-nitrogen, dissolved oxygen. For feeds, most analyses involve crude protein, moisture, and crude fat contents. In 1987, some 3,742 water and 466 feed samples were examined at the laboratory. Among the beneficiaries of CAL services are small fish farmers who are charged a very minimal fee to help defray the cost of chemicals used in the analysis.

Fish Health Laboratory. This laboratory performs diagnostic services for detection of fish diseases, as well as examination of water samples for bacterial count. Diseases found in finfishes were mostly caused by bacterial infection, parasitic infestation, and nutritional and environmental factors. Prawn mortalities, on the other hand, were mostly due to environmental disorders and a few were attributed to bacterial infection. A total of 85 cases were diagnosed in 1987, 60% of which was for pathological examination of finfish (19) and prawn (32), while 40% was for total bacterial count. Of these, 52 (61%) diagnostic tests were performed at the request of the private sector while the rest came from various projects of AQD.

Microtechnique Service Laboratory. The laboratory does histological processing of fish tissue and larval samples. During the period under review, 1910 samples were processed for histological slide and whole mount preparations.

Computer Facilities

To optimize AQD's computer resources, improved softwares have been developed for its HP 3000 minicomputer and microcomputers. The HP 3000 is being used for all the Brackishwater Aquaculture Information System (BRAIS) and Aquaculture Information System (AQUIS) work requirements.

A database for a directory of scientific institutions and scientists, together with a research databank system, has been developed using the MINISIS software package. Also adopted are a computer-based property inventory system and a custom-made program for the implementation of the new AQD employees' compensation scheme.

The acquisition of a Laser Jet printer, an IBM-compatible microcomputer, and the Advanced Link 2392 Emulator donated by IDRC through the BRAIS Project, completed the plan to link the microcomputers to the HP 3000 minicomputer, thus allowing the former to access the mass storage capacity of the latter. Information to be included in an AQD microcomputer user's manual have been compiled. The manual will serve as a guide in obtaining access to stored data and information on:

1) Computerized information systems, e.g., SEAFDEC Provident Fund Plan and literature information system;

2) Research information systems, e.g., research study monitoring and management, scientific publications, and staff personnel profiles; and

3) Management information systems, e.g., personnel management system and finance management system.

AQD's computer services also provide individualized computer training sessions and statistical consultations.

Infrastructure Development

To improve AQD's research capabilities and infrastructure, the following projects were undertaken during the period under review:

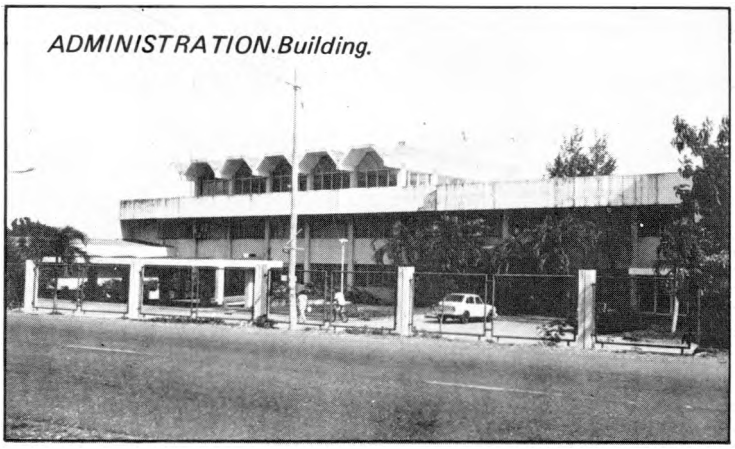
1) At the Tigbauan Research Station (TRS), these projects include: installation of aeration and water systems; fabrication of improved milkfish egg sweepers and installation of facilities at Igang Substation; installation of two units pre-filtered saltwater system, 300 gpm, to augment the capacity of the existing system; construction of concrete breeding tanks at the Genetics Laboratory and roof of the 50-120 ton hatchery; strengthening of freshwater lines located at the nearby Guimbal River; and upgrading of electrical installations within the TRS compound. The station also acquired a radio telephone system. This vital communication facility now links TRS with the AQD Liaison Office in Metro Manila.

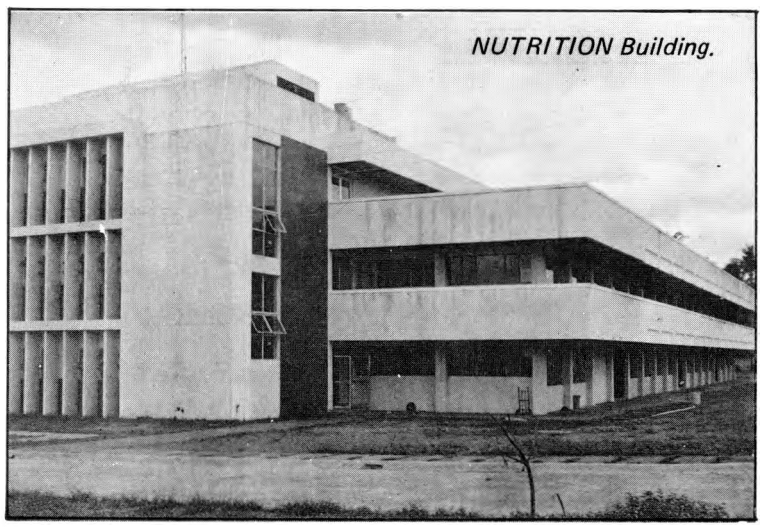
2) At the Leganes Brackishwater Station, construction and renovation works include: deepening of the main water supply and drain canal; pond upgrading to meet the requirements of the various studies, including the conversion of some ponds into *Artemia* ponds; and renovation/repair of buildings.

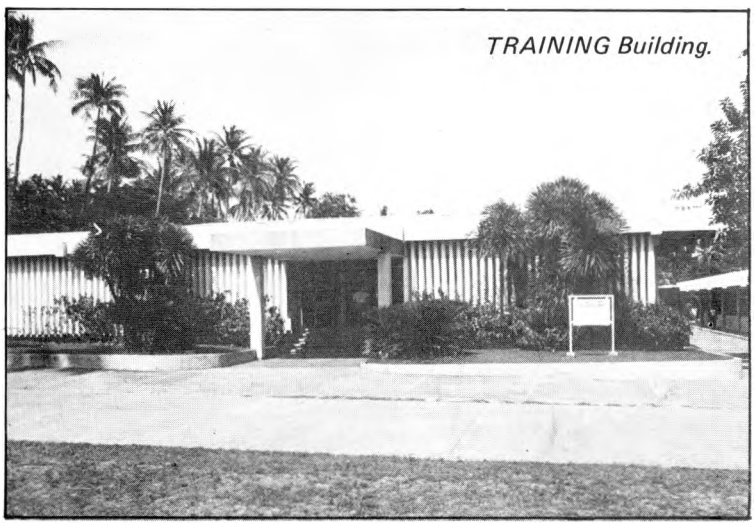
3) At the Binangonan Freshwater Station, additional facilities installed include laboratory room for carp project, tilapia genetics room, floating cages, breeding tanks, and recirculating system for water distillation.

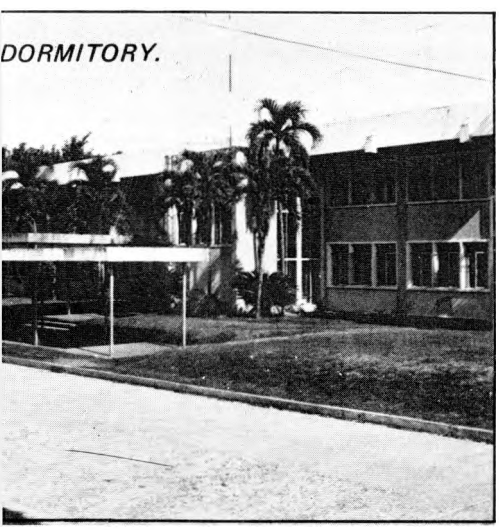
PICTORIALS
Tigbauan Research Station
Tigbauan, Iloilo

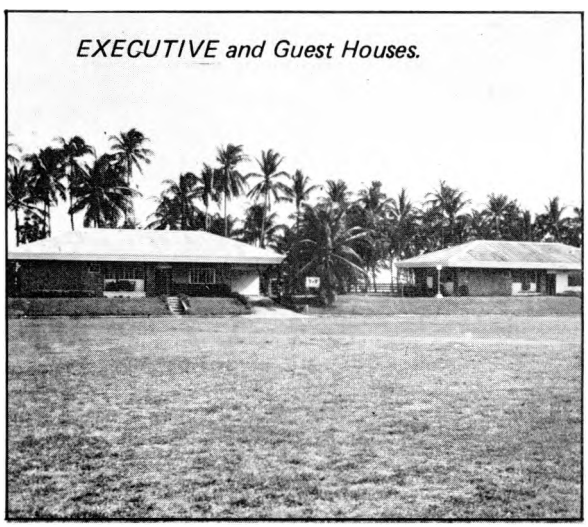

FINFISH Nursery Tanks/Wet Laboratory.

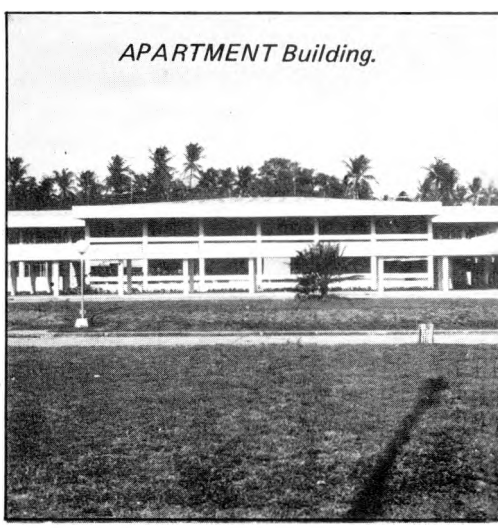

ADMINISTRATION Building.


NUTRITION Building.

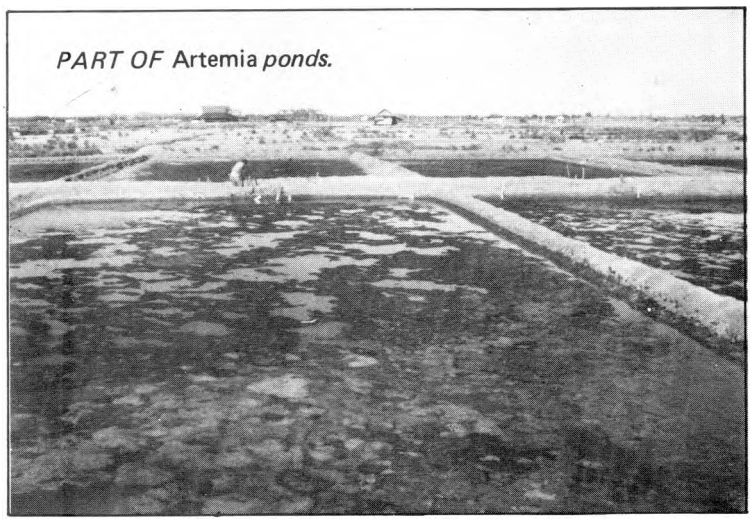

TRAINING Building.


DORMITORY.

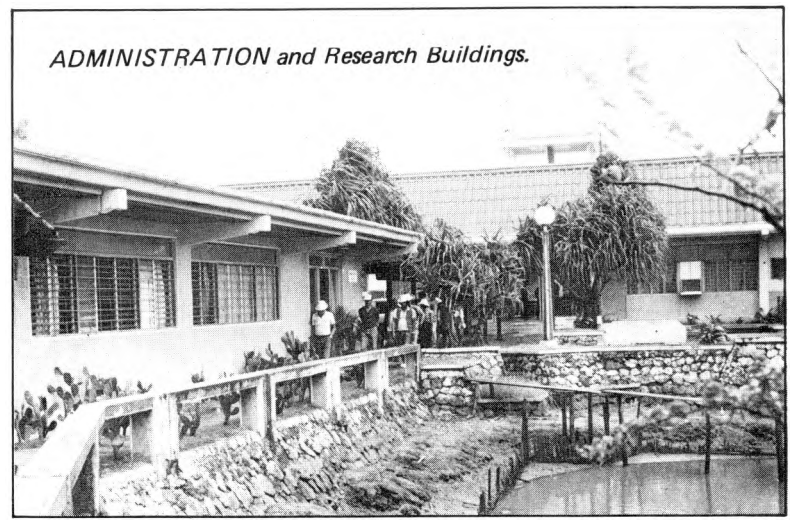

EXECUTIVE and Guest Houses.


APARTMENT Building.

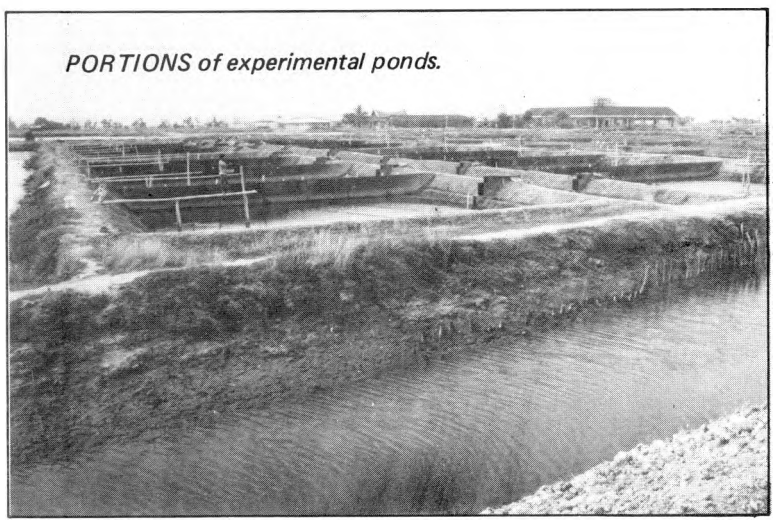
Leganes Brackishwater Station
Leganes, Iloilo



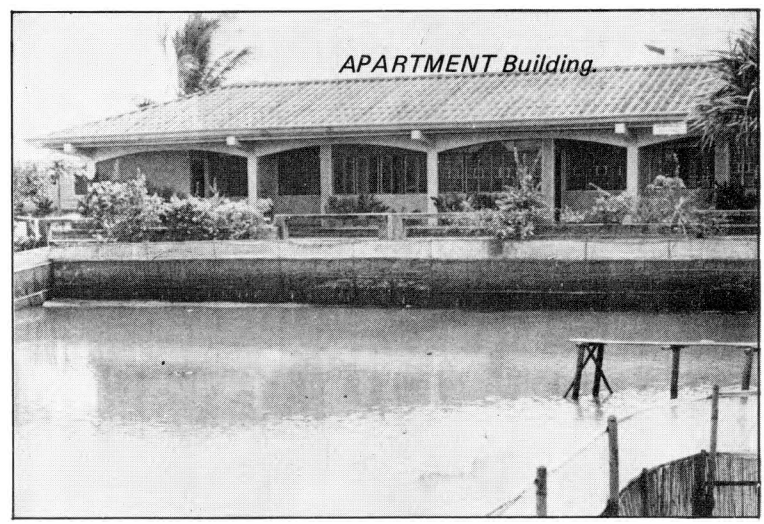
PART OF Artemia *ponds.*



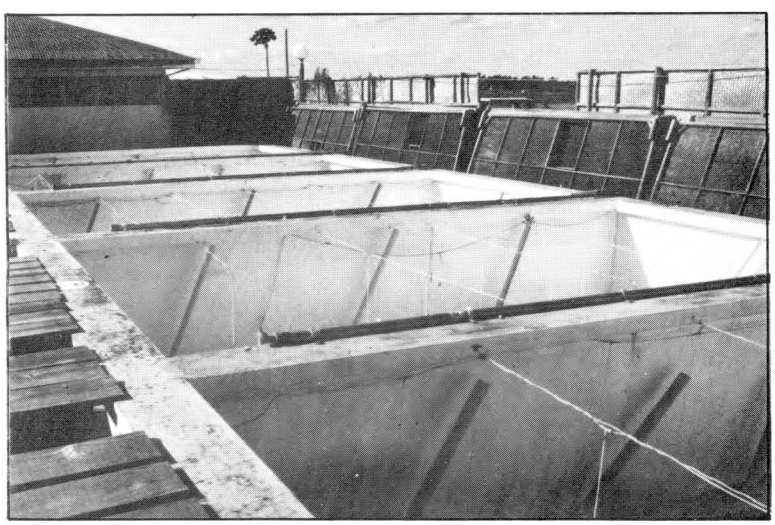
ADMINISTRATION and Research Buildings.



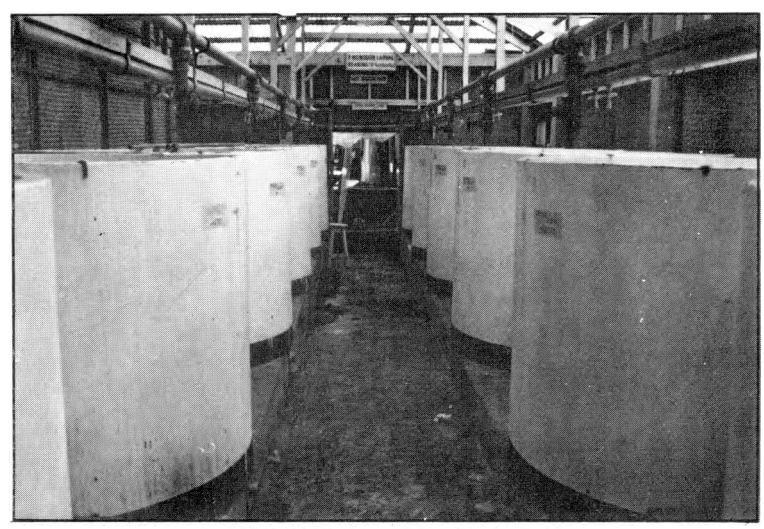
PORTIONS of experimental ponds.



APARTMENT Building.

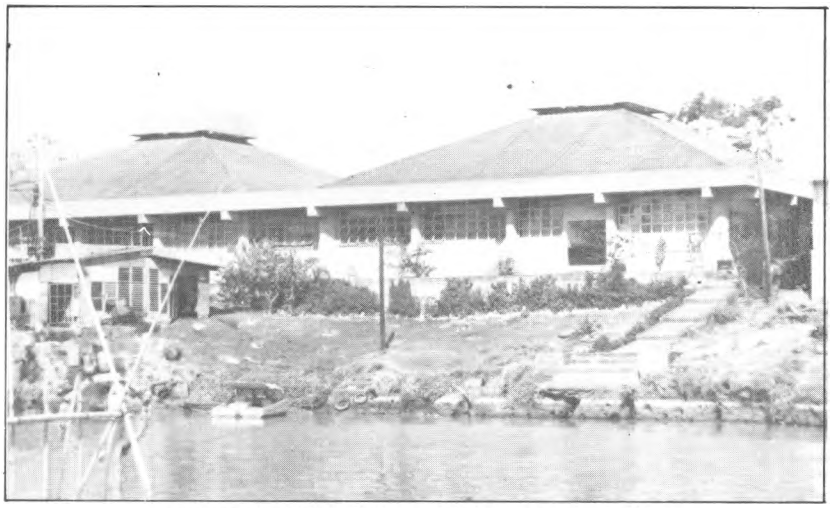


OUTDOOR hatchery/nursery tanks.

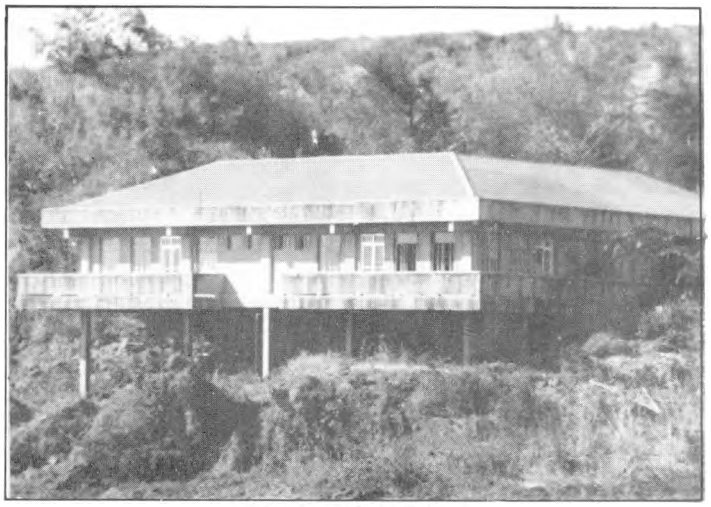


INDOOR prawn hatchery tanks.

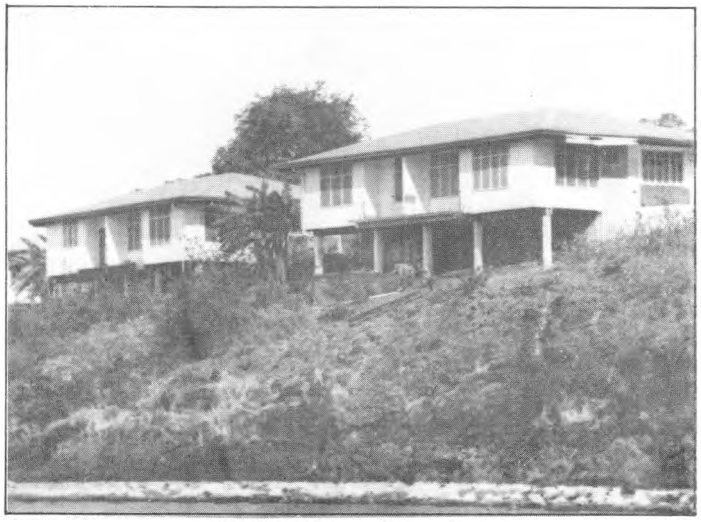
Binangonan Freshwater Station
Binangonan, Rizal



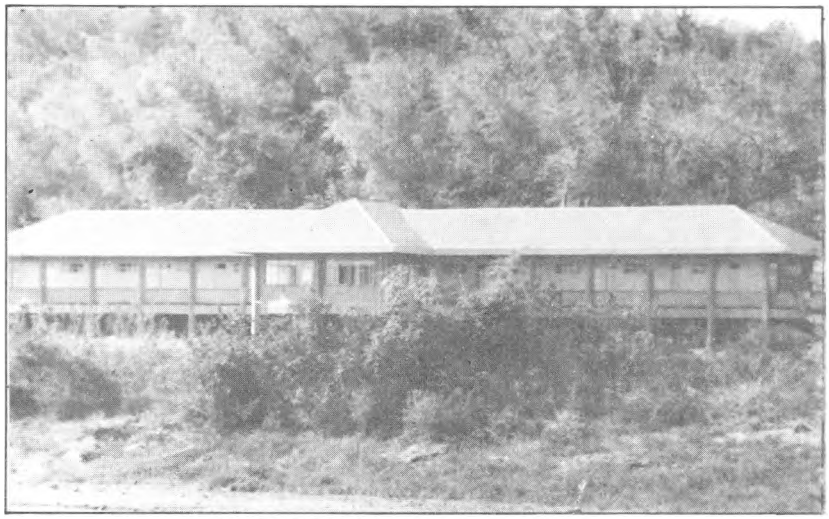
HATCHERY Building with laboratories/offices.



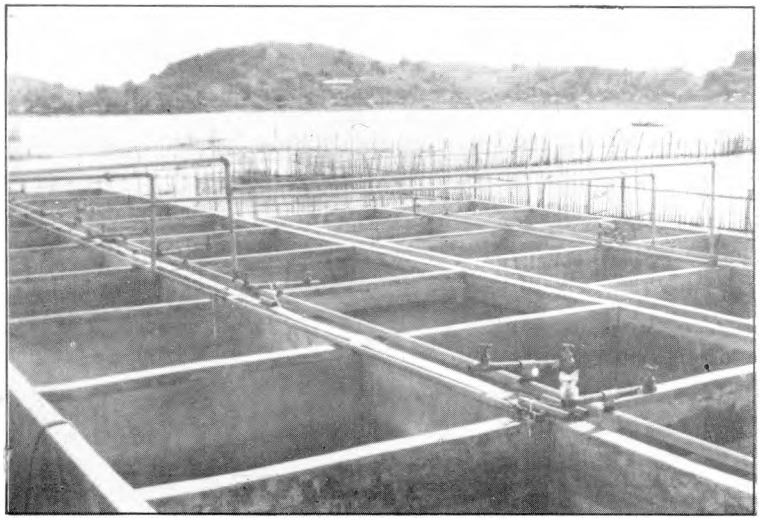
TRAINING Building.



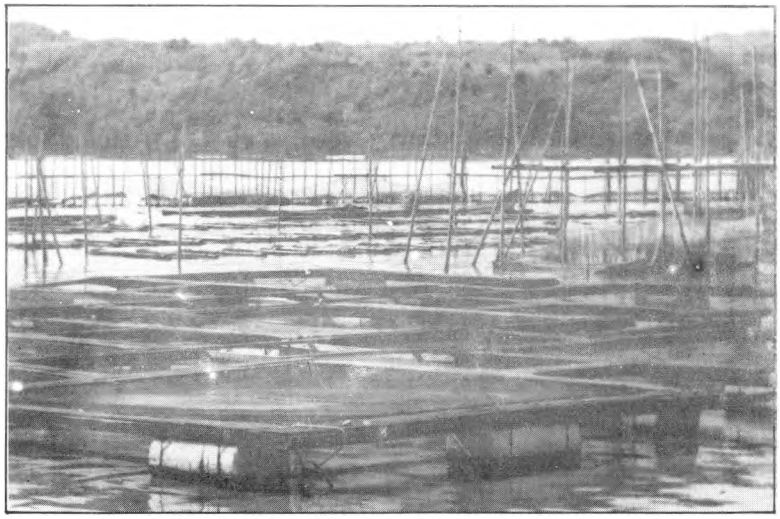
DUPLEX housing units.



DORMITORY Building for trainees.

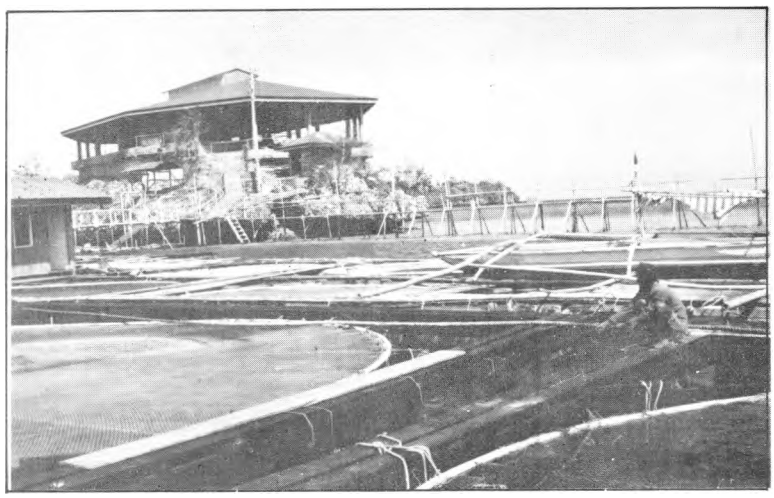


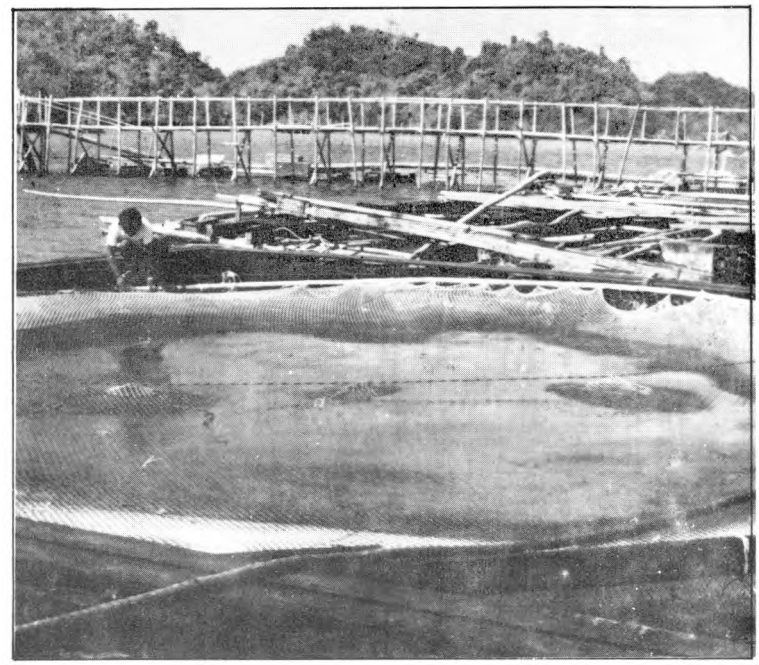
TILAPIA breeding tanks.

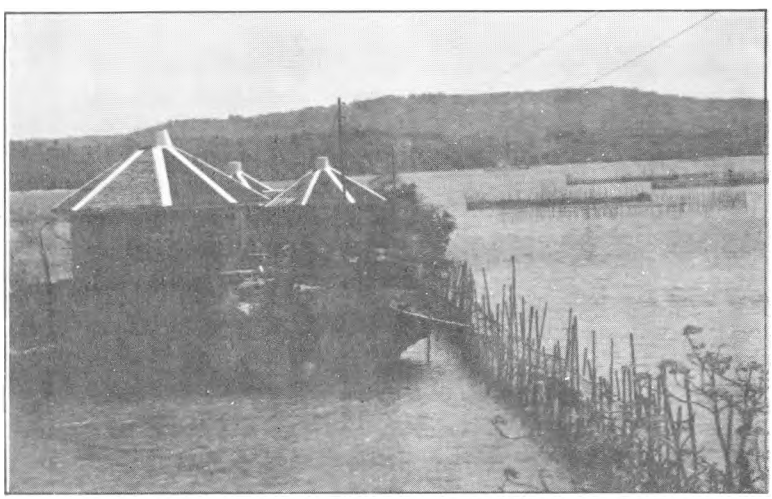


FLOATING cages for carp broodstock.

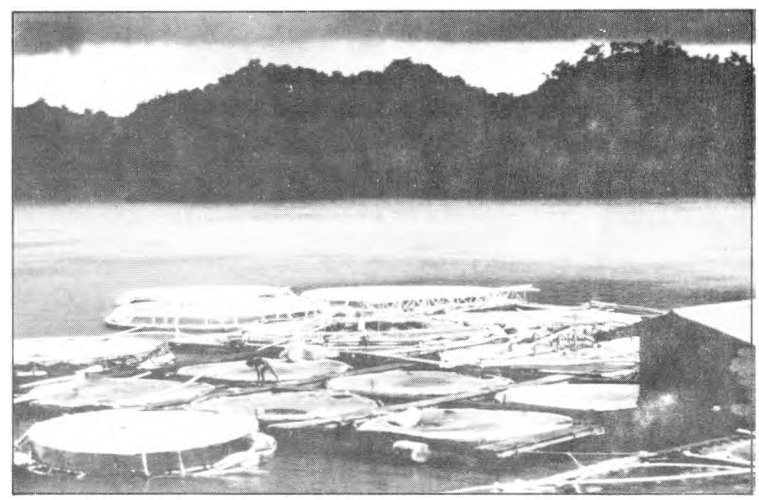
Igang Research Substation
Igang, Guimaras Is.



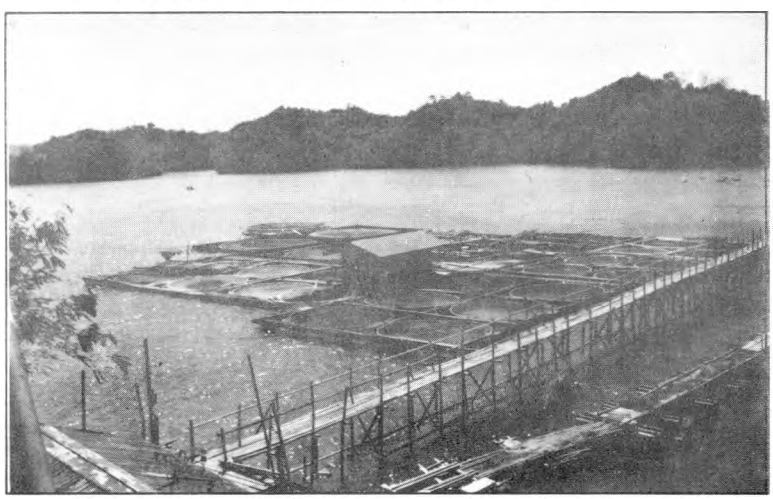




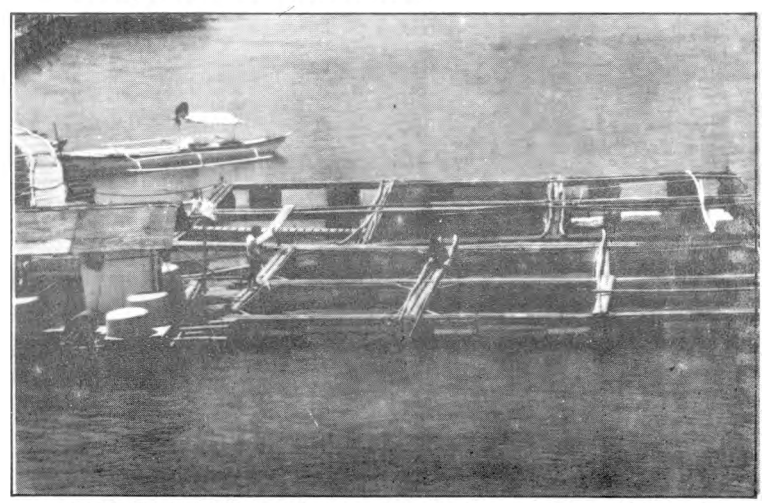
TOP: Wooden cage frames supporting floating net cages (foreground). In the background is the Marine Finfish Hatchery Building. BOTTOM: Island Guest Houses.



TOP: Closer view of the wooden cage frame and floating net cage. BOTTOM: Circular floating net cages for milkfish broodstock.



10-M diameter floating net cage with wooden cage frame support.



SQUARE floating net cages for sea bass and siganid broodstock.

OTHER ACTIVITIES

COOPERATION WITH NON- MEMBER GOVERNMENTS/ ORGANIZATIONS

Non-Member Governments

Belgium. Implementation of a three-year *"Artemia* Applied Technology Program" was agreed upon between AQD and the *Artemia* Reference Center (ARC), Belgium Administration for Development and Cooperation (BADC). The project started in February 1987. Also concluded was an agreement with the Flemish Association for Educational Programs Abroad (VVOB) for the assignment of *Artemia* experts to AQD.

France. The *Institute Francais de Recherche pour L 'exploitation de la Mer — Centre Oceanologique du Pacifique* (IFREMER/COP) extended a grant for a 14-month research project on the improvement of sea bass *(Lates calcarifer)* larval rearing techniques. Began in August 1986, the project was completed last September.

International Organizations

International Development Research Centre (IDRC). The following are the IDRC-assisted projects:

1) Study on fish gametes, scheduled for three years beginning October 1986.

2) Genetic evaluation and selective breeding of *Oreochromis niloticus* for broodstock development, for three years beginning June 1986.

3) National Bangus Breeding Program, for three years from 1986.

4) Training in aquaculture, for three years from 1985.

REPRESENTATIVES of non-member governments/organizations sit as observers during the 10th Meeting of the SEAFDEC Program Committee in Manila.

5) Brackishwater Aquaculture Information System (BRAIS), for three years (March 1984-April 1987) but later extended up to April 1989.

International Foundation for Science (IFS). Projects under funding by IFS involve: 1) Improvement of extensive prawn production using aquatic macrophytes as food organisms in brackishwater ponds (one year); and 2) isolation and characterization of a female-specific serum protein (vitellogenin) in milkfish *(Chanos chanos),* which was given favorable consideration by IFS for implementation in 1988.

Food and Agriculture Organization (FAO). FAO is co-sponsor of the NACA-AQD one-year Training Course for Senior Aquaculturists in Asia and the Pacific Region. The course marked the conclusion of its sixth session in March 1987. FAO also collaborated on the implementation in 1987 of the project on the "Effects of Farming Phase and In-Plant Processing on the Microbial Quality of Prawn."

ICLARM/Asian Fisheries Social Science Research Network (AFSSRN). During the period under review, a grant from these agencies supported the study on "Cost and return analysis of newly developed aquaculture production systems in the Philippines".

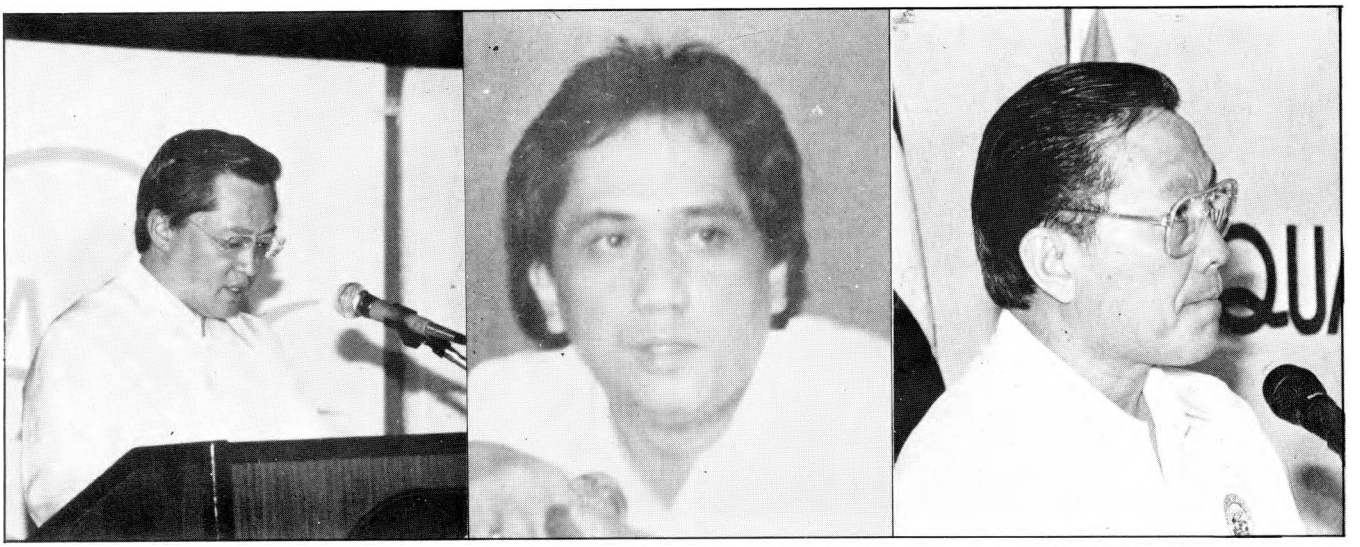
Philippine Agencies

Department of Agriculture (DA). The Department has extended strong support to various AQD extension services, e.g., Aquaculture Technology Outreach Program, Farmers' Profitability Campaign, and Agri-Aqua Caravan Fair.

Bureau of Fisheries and Aquatic Resources (BFAR). The bureau has participated in the National Bangus Breeding Program since 1980 to the present.

Technology and Livelihood Resource Center (TLRC). Arrangements were made for the implementation of the SEAFDEC/AQD-TLRC Aquaculture Technology Outreach Program (ATOP) effective June 1987.

University of the Philippines Marine Science Institute (UP-MSI). The Institute has collaborated with AQD from October 1982 to December 1987 on the research project dealing with the determination of genetic variation in milkfish.



GOVERNMENT officials extending active support to AQD activities include (from left to right) DA Secretary **Carlos G. Dominguez,** *DA Undersecretary and SEAFDEC Council Director for the Philippines* **Conrado C. Gozun,** *and OIC Governor of Iloilo Province* **Simplicio Griño.**

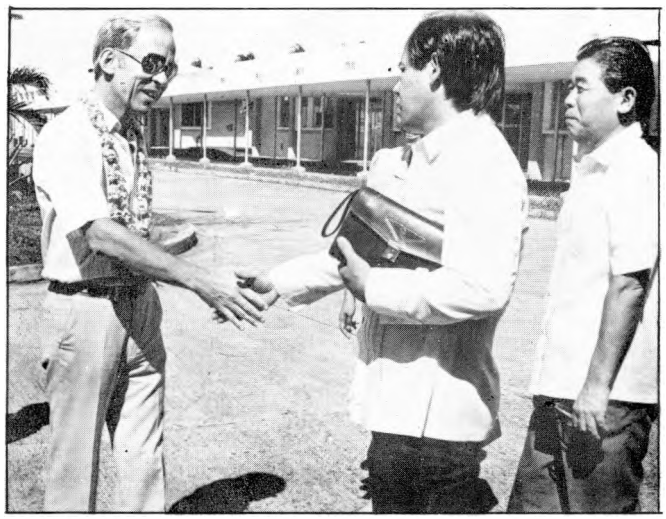
AQD Visitors/ Guests

Foreign and local dignitaries, scientists, researchers, and private entrepreneurs have been among the prominent visitors and guests of AQD. In the first half of the year (January-June 1987), they include:

Dr. Veravat Hongskul, Secretary-General of SEAFDEC, together with the crew of M.V. PAKNAM and trainees of the SEAFDEC Training Department; *Mr. Kazuo Inoue,* Deputy Secretary-General of SEAFDEC; *Messrs. Jaime Raneses, Jose Mari Ponce, Paramon Furigay, Sanku Diamoy, Mario Carino, and Ms. Gloria de Peralta,* Cagayan Integrated Agricultural Development Project; *Dr. Ulrich Grieb,* Country Representative, FAO, Manila; *Dr. H. Moller,* University of Kiel, Federal Republic of Germany; *Ms. Sylvia Ordonez* and *Mr. Vedasto Jose,* Technology and Livelihood Resource Center, Manila; *Dr. F. Brian Davy,* IDRC, Singapore; *Mr. Chen Foo Yan,* NACA, Bangkok, Thailand; *Mr. Brian Crawford,* University of Rhode Island, U.S.A.; *Mr. James Rakocy,* University of Virgin Islands; *Mr. W.G. Alters,* International Fund for Agricultural Development; *Mr. Constancio Canete,* NSTA, Davao City; *Messrs. Romulo Zipongan* and *Gregorio Barretto,* Local Government Finance Office, Tuguegarao, Cagayan; *Mr. Reynaldo Cuaderno,* National Police Commission, Makati, Metro Manila; and *Messrs. Rogelio Cuyno, Rex Navarro* and *R. Orozco,* University of the Philippines at Los Baños.

Visitors listed during the second half of the year (July-December 1987) include the following:

Ms. Isabel Bulcke and *Mr. Willy Block,* both of the Flemish Association Educational Project Abroad, Belgium; *Mr. Shamsuddin Qureshi* of the Marine Fisheries Department, Karachi, Pakistan; *Mr. John Robertson* of SEA Hatcheries Ltd., Australia; *Mr. George B. Ditching,* Engineering Manager, Philippine Refining Co., Metro Manila; *Dr. J. Bruce Hillcoat* and *Dr. Paul Quinlan,* both specialists of the Agribusiness Division, Unilever, United Kingdom; *Mr. Gunther Lang,* Project Coordinator, Mariculture Project, Lutheran Development Services, Silberweg 7 Boeblingen, Federal Republic of Germany; *Mr. Angel B. Koch, Jr.,* General Manager, Negros Navigation, Co., Cagayan de Oro City; *Mr. Francisco Concillo,* Regional Director, Department of Education and Culture, Fishery School, Region VII, Cebu City; *Mr. Camillo Gray,* Prawn Aquaculture Manager, Fishfarm Development International, Scotland, United Kingdom; French Ambassador to the Philippines *Jacques Le Blanc; Dr. Louis Van Den Akker* of the Ministry of Foreign Affairs, Netherlands; *Dr. Youssouf Ali* of the Bangladesh Center for Advance Studies; *Mr. David P. Roy,* Program Officer, Department of Fisheries, Bangladesh; *Mohammed Ahsanullah,* Director, Department of Fisheries, Bangladesh; *Liaquat Ali,* Principal Scientific Officer, Department of Fisheries, Bangladesh; *M.A. Rahman,* Assistant Chief, Ministry of Fisheries and Livestock, Bangladesh; *Qasi Khase Alam,* Senior Program Coordinator, Department of Fisheries, Bangladesh; *Exequiel Gonzales,* Project Specialist, ICLARM, Makati, Metro Manila; *Waheed Ahmed,* Deputy Director, Directorate of Fisheries, Pakistan; *Ghulam Mohammad Mahar,* Deputy Director, Sukkur Division, Pakistan; *Dr. Kees Soels,* Head, Research Project of the Directorate for International Cooperation, Netherlands; *Denise Cotanea* of IFREMER, Tahiti; and *Arlo W. Fast,* Coordinator, Marine Shrimp Research Program, University of Hawaii.



AQD Deputy Chief **Satoru Fukumoto** *and Administration Division Head* **Rufil Cuevas** *welcome French Ambassador to the Philippines* **Jacques Le Blanc** *on his visit to TRS. Right photo shows other AQD guests on their arrival.*

Awards for AQD

AQD paper won in the 1987 Dr. Elvira O. Tan Memorial Awards sponsored by PCARRD. The following paper was selected the best paper in the Aquaculture/Inland Fisheries category:

Baticados, M.C.L., Coloso, R.M. and Duremdez, R.C., 1986. Studies on the chronic soft-shell syndrome in the tiger prawn, *Penaeus monodon* Fabricius, from brackishwater ponds. *Aquaculture*, 56:271-285.

Prawn culture is becoming more widespread in the Philippines. In recent years, prawn production in brackishwater ponds has been adversely affected by a chronic soft-shell syndrome. A field survey of prawn ponds in the island of Panay showed that occurrence of soft-shelled prawns could be predicted with 98% accuracy under poor soil and water conditions in the ponds. Some management practices were also highly correlated with the soft-shell syndrome.

Soft- and hard-shelled prawns collected during the survey were analyzed for calcium and phosphorus levels. In soft-shelled prawns, calcium and phosphorus levels were significantly higher in the hepatopancreas, and phosphorus was significantly lower in the exoskeleton than in hard-shelled prawns. Chitinoclastic bacteria, *Vibrio* and *Aeromonas*, were isolated from soft-shelled prawns but experimental infection with these species to induce soft-shelling gave largely negative results. Laboratory experiments using an organostannous pesticide revealed that a 96-h exposure to at least 0.0154 ppm of the pesticide could result in soft-shelling of 47-60% of the prawns.

Soft-shelled prawns were fed various quantities of frozen mussel meat for 4 weeks to find out if soft-shelling could be reversed by dietary manipulation. Successful reversal of soft-shelling, general improvement of shell quality, and best growth and survival rates were observed in prawns fed a 14% mussel meat diet.

AQD also received two awards for BEST BOOTH during the Agri-Aqua Livestock and Poultry Caravan Fair '87 sponsored by PHILCITE and the Department of Agriculture. At the Fair's first lap in PHILCITE Manila (22-29 March 1987), AQD's participation was judged second best. In Cebu City (25 April - 2 May 1987), and in Cagayan de Oro City (17-24 May 1987), AQD received the Best Booth awards from a total of more than forty participations. The criteria for selection were: attractiveness of exhibits, visitor's information acceptance, information dissemination effectiveness, and compliance with the Fair's rules and regulations.

TROPHY given to AQD for winning the **Best Booth Award** *at the Cagayan de Oro City leg of the 1987 Agri-Aqua Livestock and Poultry Caravan Fair.*

APPENDICES

Bibliography of Research Publications

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Camacho AS. An overview of the Philippine fishpond industry. Workshop on National Strategy for the Sustainable Development of Forestry, Fisheries and Agriculture; Manila, 30-31 March.

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Corre KG. Prawn nursery and grow-out rearing operations. Seminar on Aquaculture Development in Southeast Asia; Iloilo City, Philippines, 8-12 September.

Cruz ER, De la Cruz MC, Suñaz NA. Histophathological and nematological changes in *Tilapia mossambica* intoxicated with pesticides. Second International Symposium on Tilapia in Aquaculture; Bangkok, Thailand, 16-20 March.

Duray M, Juario JV. SEAFDEC AQD contribution to broodstock development and seed production of the siganid, *Siganus guttatus* (Bloch), and sea bass, *Lates calcarifer* (Bloch). Seminar on Aquaculture Development in Southeast Asia; Iloilo City, Philippines, 8-12 September.

Estepa F, Primavera JH. SEAFDEC AQD contribution in maturation and seed production of *Penaeus monodon.* Seminar on Aquaculture Development in Southeast Asia; Iloilo City, Philippines, 8-12 September.

Fermin AC. Broodstock development and management and seed production of carp and tilapia. Seminar on Aquaculture Development in Southeast Asia; Iloilo City, Philippines, 8-12 September.

Gonzales-Corre K. Polyculture of the tiger prawn *Penaeus monodon* Fabricius) with Nile tilapia *(Tilapia nilotica* Linnaeus) in brackishwater fishponds. Second International Symposium on Tilapia in Aquaculture; Bangkok, Thailand 16-20 March.

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Lacanilao F. Seafarming: key to sustained fish self-sufficiency. 1st Int'l. Agro Equipment/Technology Exhibition and Conference; Manila, 4-8 November.

Lio-Po GD, Billiones R, Villegas CT. Induction of bacterial infection in *Oreochromis mossambicus.* Pacific Science Congress; Seoul, Korea, 20-30 August.

Marte C. Induced gonadal maturation and rematuration of milkfish — Limited success with chronic administration of testosterone and gonadotropin-releasing hormone analogues (GnRH-A). Fish Breeding Workshop; Singapore, 7-10 April.

Marte CL. Milkfish culture and artificial propagation. Third International Symposium on Reproductive Physiology of Fish; New Foundland, Canada, 2-7 August.

Marte CL. Broodstock development and management and seed production of milkfish. Seminar on Aquaculture Development in Southeast Asia; Iloilo City, Philippines, 8-12 September.

Marte CL, Lam TJ. Hormonal changes accompanying sexual maturation in milkfish *Chanos chanos* Forsskal. The First Congress of the Asia and Oceania Society for Comparative Endocrinology; Nagoya, Japan, 4-7 November.

Primavera JH. Aquaculture training program of the SEAFDEC Aquaculture Department. Seminar on Aquaculture Development in Southeast Asia; Iloilo City, Philippines, 8-12 September.

Primavera JH, Posadas R, Aquino N. Feeding rhythm of *Penaeus monodon.* Guayaquil, Ecuador, 18-23 January.

Romana MRR. Electrophoretic studies on induced gynogenetic diploids and triploids in tilapia *(O. niloticus* and *O. aureus).* Second International Symposium on Tilapia in Aquaculture; Bangkok, Thailand, 16-20 March.

Santiago AE. Feasibility study on a waste-water treatment fish farming system for cola wastes. Second International Symposium on Tilapia in Aquaculture; Bangkok, Thailand, 16-20 March.

Santiago CB, Aldaba MB, Reyes OS, Laron MA. Response of young Nile tilapia to diets containing Azolla meal. Second International Symposium on Tilapia in Aquaculture; Bangkok, Thailand, 16-20 March.

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Tuburan IB, Gerochi DD. Milkfish hatchery and grow-out culture. Seminar on Aquaculture Development in Southeast Asia; Iloilo City, Philippines, 8-12 September.

List of AQD Senior Staff

(As of December 1987)

MANAGEMENT STAFF

1.	Flor Lacanilao Ph. D. (Fish Physiology) University of California at Berkeley 1971	Chief
2.	Satoru Fukumoto Bachelor of Fisheries Kagoshima College of Fisheries 1949	Deputy Chief
3.	Clarissa L. Marte M. S. (Zoology) University of the Philippines 1971	Head Research Division
4.	Jurgenne H. Primavera M. A. (Zoology) Indiana University 1969	Head Training Division
5.	Rufil E. Cuevas B. S. (Agricultural Economics) University of the Philippines 1970	Head Administrative Division
6.	Virgilia T. Sulit M. A. (Statistics) University of Bombay 1974	Head Information Division
7.	Ben A. De Los Reyes B.S. Com. (Accounting-CPA)/ Bachelor of Laws Western Institute of Technology/ University of San Agustin 1971/1985	OIC Finance Division
8.	Arsenio S. Camacho Ph. D. (Fisheries Management) Auburn University 1974	Head Binangonan Freshwater Station
9.	Dante D. Gerochi M. Aquaculture University of the Philippines 1984	Head Leganes Brackishwater Station
10.	Jesus V. Juario Ph. D. (Marine Biology) University of Hamburg 1974	Coordinator Collaborative Projects

RESEARCH STAFF

		Field of Research
1.	Acosta, Belen M. S. Fisheries (Aquaculture) University of the Philippines 1984	Fish Hatchery
2.	Agbayani, Renato M. B. A. (Business Management) University of the Philippines 1972	Aquaculture Economics
3.	Alava, Veronica M. S. Fisheries (Aquaculture) University of the Philippines 1979	Aquaculture Nutrition
4.	Almendras, Jesus M. S. (Marine Biology) University of the Philippines 1982	Fish Hatchery
5.	Antiporda, Jocelyn M. S. (Zoology) University of the Philippines 1984	Crustacean Culture
6.	Apud, Florentino M. S. Fisheries (Aquaculture)/ M. Aquaculture University of the Philippines 1979/1983	Pond Culture
7.	Avila, Enrique Ph. D. (Biology) University of Heidelberg 1987	Fish Hatcheery
8.	Bagarinao, Teodora M. S. Marine Biology (Marine Oceanography) University of California-San Diego 1982	Larval Ecology
9.	Baldia, Jose M. S. (Microbiology) University of the Philippines 1984	Fish Health

10. Baldia, Susana — Larval Food Culture
M. S. (Biology)
University of the Philippines
1984

11. Banno, Jessie* — Pond Culture and Fish Hatchery
M. S. Fisheries (Aquaculture)
University of the Philippines
1980

12. Basiao, Zubaida — Aquaculture Genetics
M. S. (Zoology)
University of the Philippines
1975

13. Baticados, Ma. Cecilia — Fish Health
M. S. (Biology)/
M. Aquaculture
University of the Philippines
1980/1983

14. Bautista, Myrna — Aquaculture Nutrition
M. S. (Food Science)
University of the Philippines
1980

15. Benitez, Lita — Aquaculture Nutrition
Ph. D. (Biochemistry)
University of California-
San Diego
1974

16. Bombeo, Ruby — Larval Food Culture
M. S. Fisheries (Aquaculture)
University of the Philippines
1983

17. Borlongan, Ilda — Aquaculture Nutrition
M. S. (Biochemistry)
University of the Philippines
1982

18. Camacho, Arsenio — Aquaculture Nutrition
Ph. D. (Fisheries Management)
Auburn University
1974

19. Carlos, Manuel — Lake Ecology
M. S. (Aquaculture)
Central Luzon State University
1985

20. Castro, Ma. Teresa — Shellfish Farming
M. S. (Environmental Engineering)
University of the Philippines
1982

21. Catacutan, Mae — Aquaculture
M. Fisheries (Marine Animal Nutrition, Fisheries)
Kagoshima University
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22. Coloso, Relicardo* — Aquaculture Nutrition
M. S. (Biochemistry)
University of the Philippines
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23. Corre, Kaylin — Pond Culture
M. S. Fisheries (Aquaculture)
University of the Philippines
1983

24. Cruz, Erlinda — Fish Health
M. S. (Marine Biology)
University of the Philippines
1983

25. Cuvin, Ma. Lourdes — Lake Ecology
M. S. (Biology)
University of Glasgow
1985

26. Cruz, Margarita de la — Fish Health
M. S. Fisheries (Fish Pathology)
Hiroshima University
1986

27. Dhert, Philippe — Artemia Culture
M. S. (Aquaculture)
Universiy of Ghent, Belgium
1986

28. Dueñas, Corazon — Fish Hatchery
M. S. Zoology (Physiology)
University of British Columbia
1981

29. Duray, Marietta — Fish Hatchery
M. S. (Biology)
University of San Carlos
1977

30. Estepa, Fe Dolores — Crustacean Physiology and Hatchery
M. S. Fisheries (Aquaculture)
University of the Philippines
1982

31. Fermin, Armando — Fish Hatchery
M. S. (Aquaculture)
Central Luzon State University
1985

32. Fernandez, Roselyn — Fish Health
M. S. Fisheries (Aquaculture)
University of the Philippines
1982

33. Ferraris, Ronaldo* — Fish Physiology
Ph. D. (Zoology)
University of Hawaii
1982

34. Gacutan, Rogelio — Fish Health
M. S. (Botany)
University of the Philippines
1973

35. Gallego, Amalia — Fish Hatchery
M. S. Fisheries (Aquaculture)
University of the Philippines
1986

36. Garcia, Luis Maria — Fish Breeding
M. S. (Zoology)
University of Alberta
1986

37. Gerochi, Dante — Pond Culture
M. Aquaculture
University of the Philippines
1984

38. Gonzales, Ernesto — Aquaculture Economics
M. S. (Economics)
Asian Social Institute
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39. Israel, Danilo* — Aquaculture Economics
M. A. (Economics)
University of the Philippines
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40. Javellana, Gilda — Crustacean Hatchery
M. S. (Zoology)
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41. Juario, Jesus — Fish Hatchery
Ph. D. (Marine Biology)
University of Hamburg
1974

42. Kohno, Hiroshi — Fish Hatchery
Ph. D. (Agriculture)
Tokyo University
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43. Lacanilao, Flor — Fish Breeding
Ph.D. (Fish Physiology)
University of California
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44. Lacierda, Rodrigo — Cage Culture
M. Aquaculture
University of the Philippines
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45. Lijauco, Melchor* — Pond Culture
B. Fisheries (Fishing Culture)
Tokyo Fisheries University
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46. Licop, Ma. Suzette — Crustacean Hatchery
M. S. (Zoology)/
M. Aquaculture
University of the Philippines
1980/1982

47. Llobrera, Alcestis — Post Harvest
Ph. D. Food Science and
Technology (Microbiology- Post-
harvest handling)
Texas A&M University
1983

48. Llobrera, Jose — Fish Physiology
Ph. D. Fisheries Science
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Texas A&M University
1983

49. Marte, Clarissa — Fish Breeding
M. S. (Zoology)
University of the Philippines
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50. Mesa, Imelda de — Statistics
M. Statistics/M. A. (Economics)
University of the Philippines
1980/1985

51. Mesa, Romeo — Pond Culture
M. S. Fisheries (Aquaculture)
University of the Philippines
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52. Millamena, Oseni — Aquaculture Nutrition
M. Engineering (Public Health
Engineering)
Asian Institute of Technology
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53. Palisoc, Fermin — Fish Health
M. S. (Zoology)
University of the Philippines
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54. Parazo, Monina — Fish Breeding
M. S. Fisheries (Marine Resource Chemistry)
Kagoshima University
1987

55. Pascual, Felicitas — Aquaculture Nutrition
Ph. D. (Nutrition)
Iowa State University
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56. Peña, Milagros Dela — Larval Food Culture
M. S. (Marine Biology)
University of the Philippines
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57. Peñaflorida, Veronica — Aquaculture Nutrition
M. A. Agriculture (Animal Science)
West Visayas State College
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58. Perez, Teresita — Lake Ecology
M. S. (Botany)
University of the Philippines
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59. Pitogo, Celia — Fish Health
M. S. (Marine Biology)
University of the Philippines
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60. Po, Gilda — Fish Health
M. Public Health (Microbiology)
University of the Philippines
1973

61. Posadas, Ruth — Crustacean Breeding
M. S. Fisheries (Aquaculture)
University of the Philippines
1986

62. Primavera, Jurgenne — Crustacean Breeding
M. A. (Zoology)
Indiana University
1969

63. Rodriguez, Eduard — Aquaculture
M. Fisheries Sciences
Nagazaki University
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64. Romana, Ma. Rowena — Aquaculture Genetics
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65. Quinitio, Emilia* — Crustacean Hatchery
M. S. Fisheries (Aquaculture)
University of the Philippines
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66. Quinitio, Gerard* — Fish Breeding
M. S. Fisheries (Aquaculture)
University of the Philippines
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67. Sanchez, Arthur* — Soil Chemistry
Ph. D. (Oceanography)
University of Washington
1983

68. Santiago, Alejandro — Lake Ecology
M. A. (Zoology)
Indiana University
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69. Santiago, Corazon — Aquaculture Nutrition
Ph. D. (Fisheries and Allied Aquaculture)
Auburn University
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70. Solis, Noel — Ecology and Pond Culture
M. S. (Biology)/
M. Aquaculture
University of San Carlos/
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71. Suayan, Zenaida — Fish Health
M. S. (Plant Pathology)
University of the Philippines
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72. Tabbada, Reynaldo — Lake Ecology
Ph.D. (Biology)
University of Chicago
1971

73. Tabbu, Marlo — Shellfish Farming
M. S. Fisheries (Aquaculture)
University of the Philippines
1981

74. Tabbu, Nilda — Pond Culture
M. S. Fisheries (Aquaculture)
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1983

75.	Tamse, Catherine* M. S. Fisheries (Aquaculture) University of the Philippines 1979	Fish Health
76.	Tan, Josefa M. S. (Zoology) University of the Philippines 1982	Fish Breeding
77.	Tiro, Lillian* M. S. (Marine Biology) University of the Philippines 1980	Aquaculture Nutrition
78.	Triño, Avelino M. S. Fisheries (Aquaculture) University of the Philippines 1986	Pond Culture
79.	Tuburan, Isidra M. S. Fisheries (Aquaculture) University of the Philippines 1980	Pond Ecology
80.	Valera, Pepito M. Aquaculture University of the Philippines 1984	Cage Culture
81.	Ver, Leo Michael* M. S. (Marine Biology) University of the Philippines 1981	Shellfish Culture
82.	Villaluz, Antonio M. S. (Zoology) University of Guelph 1979	Crustacean Hatchery
83.	Villegas, Cesar Ph. D. Agriculture (Plant Breeding) Iowa State University 1970	Fish Breeding and Genetics
84.	Young, Paciencia* M. S. (Biology) University of San Carlos 1978	Fish Physiology

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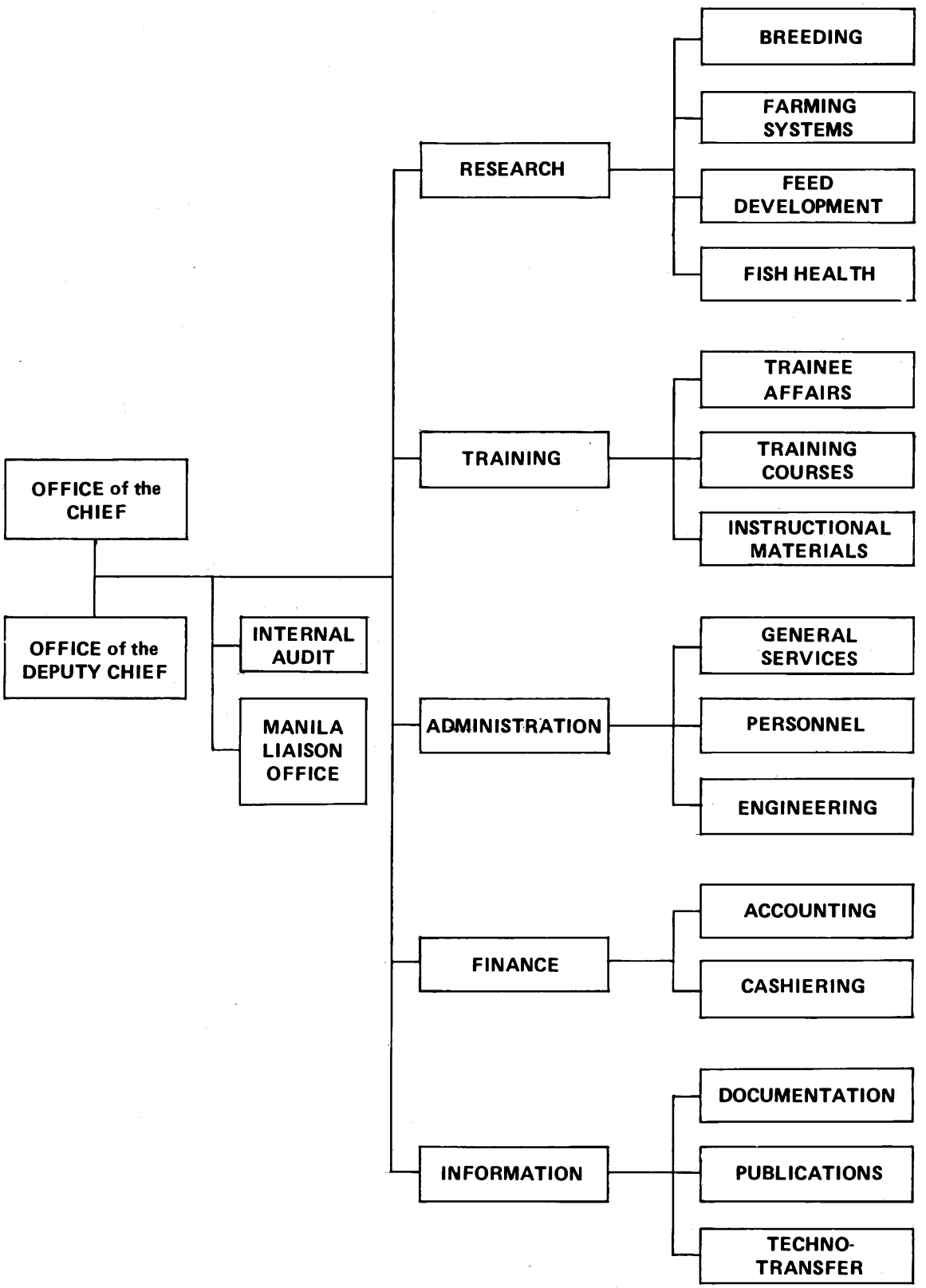
AQD Organization Chart



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