Annual Report 1986

Aquaculture Department
Southeast Asian Fisheries Development Center

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FOREWORD

While the SEAFDEC Aquaculture Department (AQD) is essentially a non-political scientific agency, the establishment of a new political order in the Philippines as a result of the historic "People's Revolution" in February 1986 also ushered administrative changes in the Department. Wanting to have a fresh start along the policy of reform introduced by the New Government, majority of AQD personnel pressed for the management revamp with mass action. The desired change in administration was successfully effected and obtained the strong support of the SEAFDEC Council and Member Countries of the Center.

Thus, 1986 was a year of renewal equally for the SEAFDEC Aquaculture Department. With the establishment of a new government regime in the country, an environment more conducive was created not only for socio-economic development but also for scientific research such as that mandated upon the Department to pursue.

The year under review, however, was a transition and reconstruction period for the new AQD management. In addition to the momentary work interruption during the early part of the year, the Department inherited problems left by the past administration. But thanks to the renewed dedication to duty of its staff and the support of the SEAFDEC Council, important AQD projects went on and most of the problems are now resolved.

This AQD Annual Report for 1986, therefore, is a summary of work done in a transition period. It describes the accomplishments of the SEAFDEC Aquaculture Department in research, training, and information dissemination. It may be modest in scale compared to what the Department foresees to achieve in the succeeding years, but we believe AQD had not failed to meet the normal quantity and quality of work expected by its numerous beneficiaries in Southeast Asia.

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Chief
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OVERVIEW

The new administration of the SEAFDEC Aquaculture Department (AQD) took over on 8 April 1986. To correct the distortions and inefficiencies of the previous management, institutional reforms and a new and revitalized Plan of Operation and Program of Work were immediately formulated. Upon approval of the SEAFDEC Council, during its nineteenth meeting on 22-26 November 1986, AQD was reorganized into five functional divisions: Research, Training, Administration, Finance, and Information. These were envisioned as the effective organizational structure to implement the new directions and thrusts of AQD. To rationalize the research functions, management concentrated the research activities in Tigbauan Research Station, Leganes Brackishwater Station, and Binangonan Freshwater Station. Corresponding changes in the leadership of the various units were undertaken. In response to the perennial problems of personnel management, several committees were formed: the committees on the retirement fund plan, medical benefit plan, compensation review, staff development, and rules and procedure. This approach minimized the often debilitating sources of irritants between management and employees. All these organizational changes were realized without impairing the continuity of the ongoing research projects and other vital tasks of AQD.

The major scientific achievement for the year was in the breeding of milkfish. The Igang Substation developed an effective method of collecting milkfish eggs with high recovery. This milkfish egg collector is a boost to the large-scale production of hatchery-bred milkfish fry. It was developed by SEAFDEC AQD researchers after continuously conducting studies on various egg-collecting devices and methods since the first spontaneous maturation and spawning of captive milkfish broodstock was realized in 1980.

The eggs are collected by seining or by using an "egg sweeper" and by installing a fine-meshed hapa net cage inside the milkfish broodstock cage to prevent entry of egg predators and to retain eggs which may sink through the bottom of the cage. By utilizing this egg sweeper combined with a hapa net, the number of milkfish eggs collected from June until November 1986 significantly increased from 300,000 eggs from nine spawnings of 35 *sabalos* in a cage without the collecting gear to 25 million eggs collected from 18 spawnings from the same floating cage.

Feed development researches were geared toward the development of nutritionally effective and economical fish and prawn diets for the industry. Research projects focused on the following: nutrient requirement, practical diet development, evaluation of indigenous feed resources, feedstuff digestability, and digestive physiology.

Fish health studies concentrated on improving fish production through identification of disease agents and their control methods. Pesticide contamination has been found to cause mortalities and body curvatures in milkfish fingerlings. In

addition to environmental pollution, mortalities of milkfish fry may be caused by *Vibrio* strains autochthonous to some phytoplankton species. Secondary bacterial infection by *Aeromonas hydrophila* has likewise been observed in the recurring ulcerative fish disease in Laguna Lake, affecting snakehead, Thai catfish, crucian carp, and goby.

Exposure to very low concentrations of a chemical pesticide has also been found to cause mortalities and the chronic soft-shell syndrome in penaeid prawns. The disease which may also be due to nutritional deficiency could be controlled by incorporating a 1:1 calcium/phosphorus ratio in the diet.

In aquaculture economics, studies were conducted on the economic and financial viability of prawn hatcheries to provide information on: a) economic and financial evaluation not only for researchers but also for potential investors; b) causes of hatchery failures in order to assess investment opportunities in a more realistic manner; and c) the merits of backyard, low-investment type, large-scale, and high-investment type hatcheries to aid future investors to decide on the scale of operation they may pursue.

AQD conducted seven training sessions covering four aquaculture short courses which were attended by 149 participants from different countries. Participants were entrepreneurs, hatchery and pond technicians, and fish farmers. AQD also held consultative meetings with the aquaculture industry sector and policy-makers and administrators of related fishery agencies; conducted *in-situ* seminars in collaboration with the Department of Agriculture/Bureau of Fisheries and Aquatic Resources, and pond-owners' associations; and trained graduating students from Philippine fishery schools in off-campus practicum in various aquaculture operations.

AQD also conducted the sixth session of the one-year Training Course for Senior Aquaculturists in Asia and the Pacific in collaboration with UNDP/FAO Network of Aquaculture Centres in Asia (NACA) and University of the Philippines in the Visayas (UPV).

Despite various disturbances in AQD operations, the regular publication programs went on unhampered. Similarly, the collaboration in aquaculture with various national and international agencies proceeded normally.

RESEARCH

Research management underwent a major change with the delineation of research activities into four categories: Breeding, Farming Systems, Feed Development, and Fish Health. The first two categories represent phases of aquaculture production while feed development and fish health are essential support sections. Ongoing research studies were thus classified with the onset of the new AQD management in April.

The streamlining of research was welcomed by the staff who saw in the new classification a more realistic and practical approach in the development and refinement of aquaculture production technologies. The new approach easily identifies production problem areas, resulting in the faster solution of technology gaps.

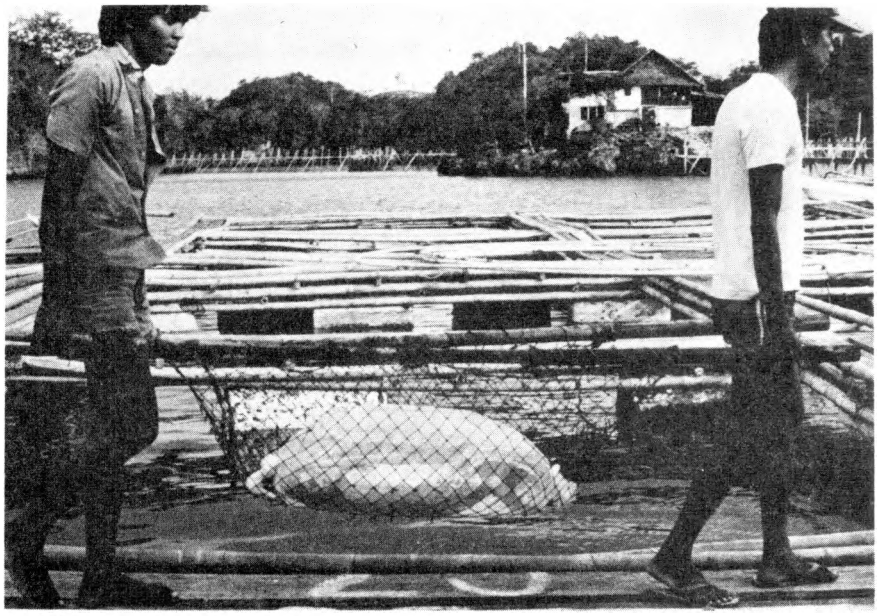
This report contains the significant findings and indications from the studies under the four categories.

Breeding

One of the main goals of AQD is to develop techniques to mass produce the seed of important fish and shrimp food species and make these available to the fish farmer. While past research efforts concentrated on the establishment of quality broodstock of several finfishes and shrimps, present efforts were now aimed to further develop and refine existing methods of controlling reproduction of these species. Larval rearing techniques likewise continued to be developed and refined to ensure the availability and quality of the resulting seed.

Finfish Broodstock

This year's research studies on fish breeding mainly dealt with the hormonal induction of gonadal maturation and of single and/or multiple spawnings in milkfish, sea bass, and siganids. The effectiveness of LHRHa's



Milkfish broodstock for induced spawning.

(luteinizing hormone releasing hormone analogues) compared to gonadotropin hormones as spawning agents was evaluated in the milkfish. Methods of administering LHRHa to mature broodstock were investigated and have been initially refined. The use of testosterone and LHRHa to advance gonadal maturation in the milkfish was also tested. Results of these studies together with an abundant collection of milkfish and sea bass eggs from both natural and/or induced spawnings will significantly contribute to mass production of seed supply of these economically important fish food species in the region.

Milkfish

The hormonal induction of gonadal maturation and of spawning in milkfish was investigated.

Chronic administration of testosterone and LHRHa failed to trigger the first maturation event of 5- and 6-year old milkfish nor to remature 6- to over 9-year old spent/regressed fish. Following a similar treatment, 4-year old milkfish reared in concrete tanks significantly advanced gonadal maturation and spawning. This is the first reported case of induced precocious maturation and spawning of 4-year old milkfish stocks in concrete tanks, indicating that sexual maturation can be advanced earlier than the reported 5 years. Likewise, this case supports the possibility that milkfish in the Philippinescan be artificially bred in land-based impoundments in addition to spontaneous sexual maturation and spawning of milkfish in floating net cages.

Maturing milkfish reared in floating net cages at Igang Substation were induced to spawn by injection or implantation of various analogues of GnRH (gonadotropin releasing hormone) or HCG (human chorionic gonadotropin). While GnRH analogues and HCG injections were equally effective in inducing maturing fish to spawn, fish implanted with GnRH analogues showed responses which varied from ovarian hydration to complete spawning. Spawnings by hormone-treated fish produced fertile eggs with fertilization rates ranging from 14 to 88%.

Various methods of egg collection and egg collecting gears were tried in a search for more efficient egg collection techniques for naturally spawned eggs from floating cages. A total of 30.3 million naturally spawned milkfish eggs were collected from several floating net cages from May to November 1986. Hatching rates of collected eggs ranged from 51.5 to 67.2%. Together with a fine mesh hapa net installed within cages to retain spawned eggs, the use of an egg sweeper collector considerably increased the number of eggs recovered from floating net cages.

Partial analyses of data on genetic variability of milkfish population in Philippine waters suggest that milkfish fry gathered nearshore are produced from one genetically related breeding stock. Since there appears to be little population differentiation among milkfish samples collected from

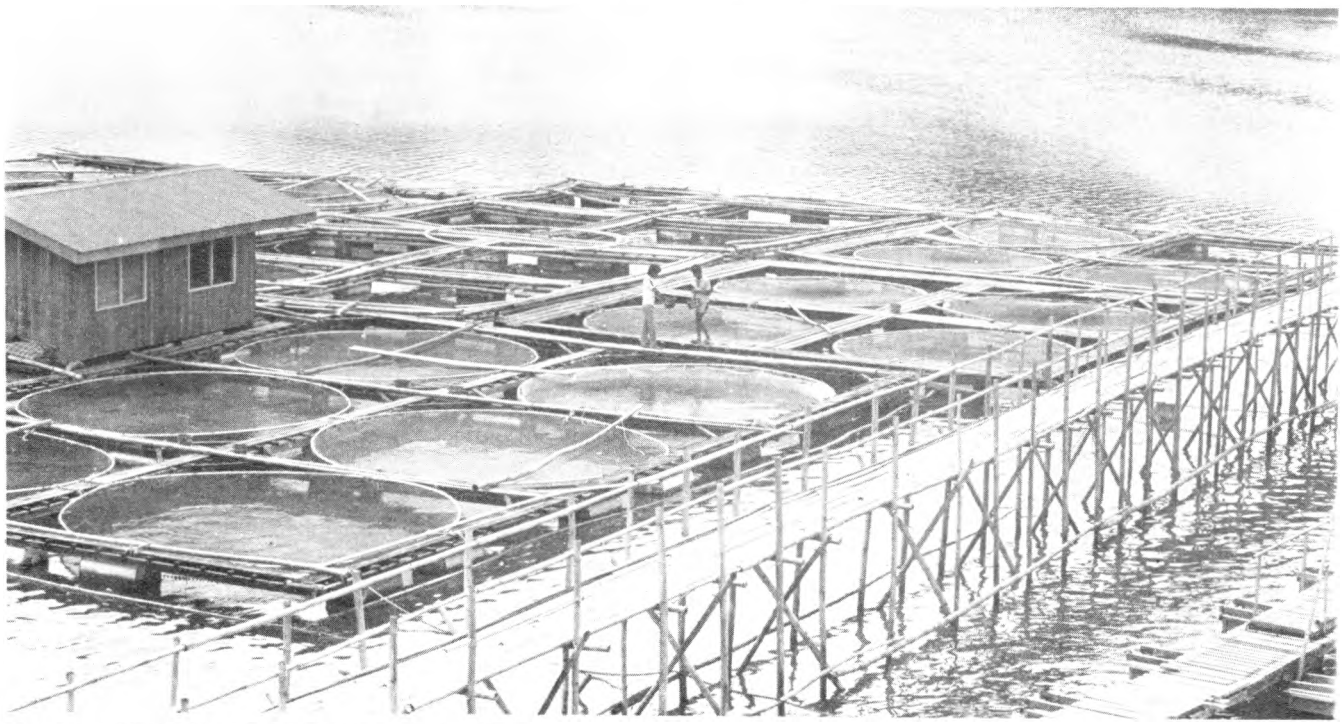
several sites in the Philippines, intensifying effort to artificially and or naturally propagate milkfish can potentially lead to in-breeding depression resulting in low quality seedstock. Thus, management of the Philippine regional milkfish hatcheries within the National Bangus Breeding Program should in the near future include a system for periodic determination of genetic variability of hatchery-bred milkfish seedstock.

Sea Bass

Controlled release of LHRHa in an osmotic pump implant induced a maximum of four sequential spawnings of mature female sea bass. A less expensive, less intrusive and possibly more reliable means of triggering sequential and multiple spawnings of mature female sea bass was observed after pellet implantation of salmon GnRHa or LHRHa embedded in a matrix consisting of various proportions of cholesterol and cellulose. Female and apparently male sea bass can also be induced to remature and spawn by LHRHa pellet implantation during the middle and latter part of the breeding season. The spawning responses of female sea bass to LHRHa treatment indicated no correlation with the lunar phases. These results show that the final phases of the reproductive process of sea bass can be artificially manipulated by hormonal means, thus, enabling one to procure eggs on demand. Artificially and naturally spawned sea bass eggs totalled more than 101 million. These could provide a reliable source for the large-scale production of sea bass fry in the Philippines.

Siganids

Highly variable results were



Feeding milkfish broodstock at Igang Substation.

Egg sampling by cannulation.

obtained with siganids induced to spawn with LHRHa. Treatment of hatchery-bred or of wild siganids with pelleted LHRHa or salmon GnRHa did not significantly reduce the spawning response time of these siganids compared to their sham control groups. Since fertilization rates of spawned eggs from these hormone-treated fish were considerably lower, research studies addressing this particular problem are currently being undertaken.

Carp

Bighead (ave. wt. 2.96 kg) and silver (ave. wt. 3.8 kg) carp broodstock were stocked in 5 x 10 x 3-m cage in Laguna Lake to determine rate of gonadal maturity. Observations were made from January to August 1986.

The highest percent maturity rate for bighead carp broodstock was 78% female (F) and 71% male (M) obtained in March. Zero percent maturity was recorded in July. For silver carp, the maturity rate was highest during the month of May with 52% (F) and 50% (M). The lowest was recorded in July with 4% (F) and 3% (M). Zooplankton and phytoplankton biomass were highest during the months of July (19.33 g/cm^2) and June (37.69 g/cm^2), respectively.

Sexually mature silver carp and bighead carp were reared in polyculture in ponds. Silver carp attained earlier gonadal development. Six were found gravid and spawned artificially by hormone injection. Average fecundity, fertilization rate, and hatching rate were 250,000; 70.7%; and 20.3%, respectively. Gonadal development of bighead carp was observed to begin in October.

In studying the biochemical genetic variation in Asiatic carps, five enzymes, sarcoplasmic protein, and hemoglobin were investigated by starch gel electrophoresis. The buffer system used was citric acid-tris (hydroxymethyl) aminomethane (C-T), pH 7.0. Other buffer systems, however, will be tried to establish definite loci and allelic frequencies.

Two experimental runs were conducted to evaluate the food value of *Brachionus* sp. grown on *Chlorella* alone, *Chlorella* and yeast, yeast alone, and enriched yeast for rearing bighead carp larvae. Growth was best among larvae fed with *Brachionus* grown on enriched yeast; the poorest growth was obtained among larvae fed with *Brachionus* grown on either *Chlorella* or yeast. Results from yeast alone and enriched yeast did not differ greatly from each other. Averages of two trials show highest (83.56%) and lowest (76.89%) percent survival among fry fed with *Brachionus* grown on enriched yeast and *Brachionus* grown on *Chlorella* and yeast, respectively.

Tilapia

Taiwan-Singapore strain, Israeli strain, and two local commercial stocks of *Oreochromis niloticus* are being evaluated for early growth and survival in aquaria and cages. Stress tolerance is also being evaluated. Data are very preliminary and the study is in progress.

Finfish Seed Production

Comparative studies on the early growth and developmental phases of finfishes (milkfish, sea bass, and siganids) were con-

ducted. The food preference and response of milkfish and sea bass larvae to variations in salinity levels were also investigated. Results of these studies further contributed to the refinement of existing larval rearing methods of economically important finfishes.

Milkfish and Sea Bass

Survival rates of milkfish and sea bass larvae reared at various salinity levels (16 to 32 ppt) indicated that both species generally survive better at lower salinities. Survival rates were improved when milkfish and sea bass larvae were reared at reduced salinities at a stocking rate of 20 milkfish larvae and 17-38 sea bass larvae per liter.

Sea bass larvae reared at a stocking density level of 45 per liter had the lowest body weight and length compared to larvae stocked at either 15 or 30 per liter. Survival rates of sea bass larvae at these stocking rates were similar after a 21-day rearing period in half-ton circular fiberglass tanks. Crowding apparently resulted in the poor growth performance of sea bass larvae reared at high stocking rate.

In addition, tests showed that there was an exponential increase in the amount and type of food consumed by sea bass larvae during their early growth and developmental phases.

Siganids

Compared to milkfish and sea bass which undergo a shorter phase of early growth and development, siganid undergo seven periods of early growth and development (Figure 1). This prolonged phase and the existence of a small mouth opening have contributed to the difficulties of rearing siganid larvae. Notably, siganid larvae consume their yolk and oil globule reserves at a shorter period and at a faster rate than milkfish and sea bass larvae (Figure 1).

Tilapia

Experiments to evaluate various techniques of harvesting tilapia fry were conducted in nine 320-sq m freshwater ponds. Three methods were tried: harvesting by seining the fry (Treatment I), daily harvesting of fry in ponds using fine-mesh scoop net (Treatment II), and harvesting of fry from hapa net cages installed in ponds (Treatment III). All broodstock ponds were prepared, maintained uniformly, and sustained through fertilization. Results of two experiments indicated that the recovery of fry in hapa net installed in ponds (Treatment III) was superior compared to the other two techniques being practised. Mortality in all treatments was not statistically significant.

Crustacean Broodstock Development and Gonadal Maturation

Prawn (*Penaeus monodon*)

The ever increasing demand for *P. monodon* spawners had led to the lack of supply of both wild spawners and wild broodstock. To bridge this gap in the industry, studies were conducted on the standardization of criteria for classifying ovarian stages and on the refinement of rearing and maturation techniques using pond-reared broodstock.

Sea bass eggs spawned at Igang Substation are stocked in a rearing tank at Tigbauan Research Station.

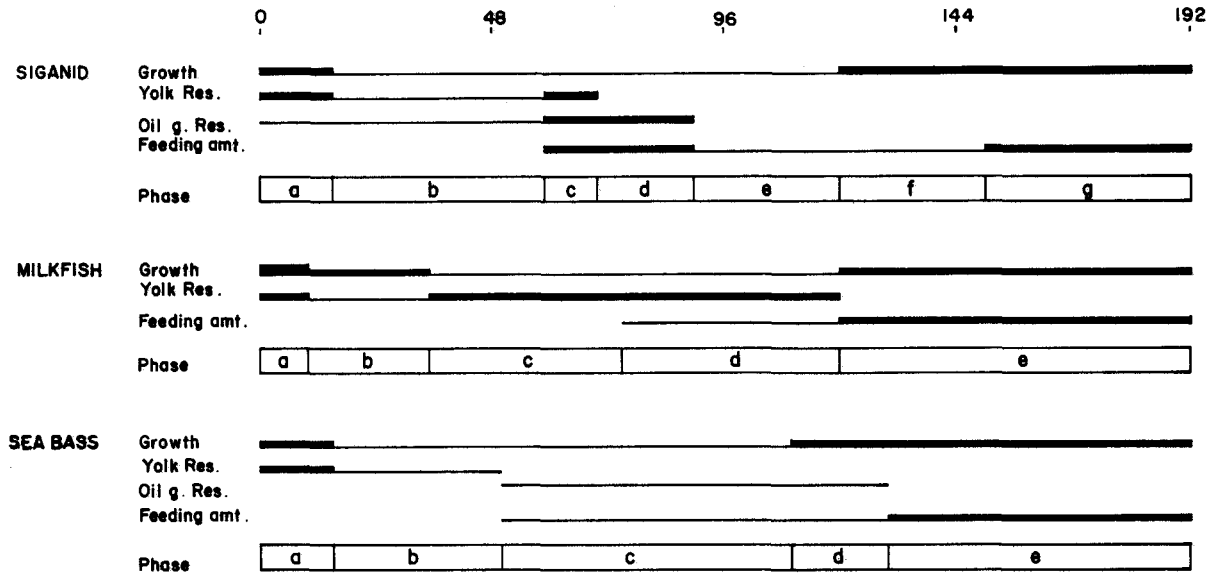


Fig. 1. Relationship between growth, yolk and oil globule resorptions, and feeding amount in siganid, milkfish, and sea bass.

a-g: phases, see text. Thicker line represents faster rates of increase in growth and feeding amount and faster rates of yolk and oil globule resorptions.

Various tags (eyestalk tag and/or carapace tag) and tank colors (black and unpainted) were tried to assess their effects on the reproductive performance of 8-month old pond-stock ablated *P. monodon*. Preliminary results showed that hatching and nauplii production were obtained from both tagged and untagged females. These indicate that tagging does not affect normal mating behavior. Also, females in the black tank gave better hatching and nauplii production rates compared to females in the unpainted tanks.

Investigation of the maternal influence on the biological components of the reproductive process in *P. monodon* showed that, for wild stock spawners, egg size increases with body weight. There is also a definite positive relationship between egg size, hatching rate, and survival at zoea I. Significant positive correlations exist between body weight and number of eggs per female and between body weight and percentage survival at zoea I. These suggest that larger females produce more eggs that will have greater percentage survival at zoea I. Therefore, size selection of spawners is important for maximum egg and larval production.

A qualitative and quantitative study of the ovarian maturation stages of wild *P. monodon* was conducted to refine existing arbitrary method of staging. Based on histology, the maturation stages can be classified into four, namely: Previtellogenic, Vitellogenic, Cortical Rod, and Spent. Table 1 summarizes the characteristics of each stage. Histochemical staining showed the absence of glycoproteins and lipids in perinucleolar oocytes, and presence of these inclusions in yolky oocytes, and of glycoproteins, but not lipids, in cortical rods. Uniformity in number, stage, and composition of oocytes in the four regions of the ovary in each stage show that ovarian development is synchronous. In stages 1 to 3, there was a significant increase in

Table 1. Characteristics of the ovarian maturation stages of wild *Penaeus monodon*

Revised Staging	Equivalent Stage (existing method)	Distinguishing Characteristics Description (based on histology)	Ave. Oocyte Diameter (mm)	Maximum Oocyte Diameter (mm)
Stage 1 – Previtellogenic	Stage 0	oogonia and oocytes in the chromatin nucleolus & or perinucleolus stage	0.06 ± 0.01^a	0.10 ± 0.00^a
Stage 2 – Vitellogenic	Stages I, II	yolky oocytes	0.25 ± 0.01^c	0.35 ± 0.01^c
Stage 3 – Cortical Rod	Stages III, IV	yolky oocytes with spherical or rod-like bodies at the peripheral cytoplasm	0.34 ± 0.02^d	0.44 ± 0.03^d
Stage 4 – Spent	Stage V	few oocytes with yolky substances &/or cortical rods; thicker layers of follicle cells; few darkly-stained, irregularly shaped perinucleolar oocytes	0.17 ± 0.00^b	0.26 ± 0.03^b

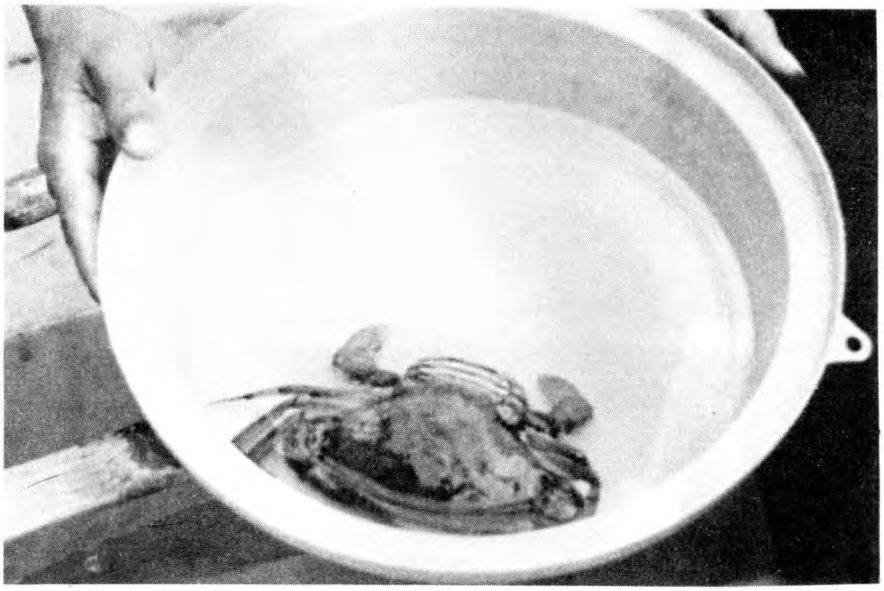
Numerical values represent means ± 1 SEM. Significant differences are indicated by different superscripts.

Sampling *P. monodon* broodstock.

gonad weight but not in body length or weight. Differences in the mean values of average or maximum oocyte diameter between the four stages (Table 1) show that these parameters are good indicators of maturation stages in wild *P. monodon.*

Mudcrab (*Scylla serrata*)

Maturation and rematuration process of *Scylla serrata* was also studied. Ablated and unablated animals were fed with either trash fish or annelids. After five months, ovarian maturation (unberried state) was observed in ablated and unablated animals fed with annelids and ablated crabs fed with trash fish. Ablated animals rematured (unberried state) after an average of 4.5 months but unablated crabs did not remature even after five months of culture.



Mudcrab, *Scylla serrata.*

Crustacean Larval Rearing

Prawn *(Penaeus monodon)*

To further improve survival, basic studies leading to determination of optimal conditions for rearing of *P. monodon* larvae were conducted. The effects of various environmental factors and water treatment on the survival, growth, and other physiological processes of these animals were investigated.

Salinity tolerance experiments showed that of the salinity levels tested, 12, 16, 20, 24, and 50 ppt were lethal to *P. monodon* nauplii and zoea. These levels, except for 20 and 24 ppt were also lethal to the mysis stage. Other tested salinities were 28, 32, 36, and 40 ppt. Ammonia excretion rate per dry weight was found to be negatively correlated to larval stage. This is consistent with the general principle that metabolic rate is inversely related to the size of the organism.

To assess the effect of water treatment with NaEDTA, frequency and rates of application were varied. In Experiment 1, 2.0, 5.0, and 10.0 ppm NaEDTA was applied on Days 1, 4, and 7. Daily application at the rates of 5.0 and 10 ppm was tried in Experiment 2. Survival was greatly improved at 5.0 and 10.0 ppm application in Experiment 1 (Figure 2). However, best survival was obtained in daily application (Experiment 2) of 10 ppm NaEDTA (Figure 3). It is believed that NaEDTA improved survival rates by chelating toxic elements in the culture medium. Growth or metamorphosis was not greatly affected with the addition of NaEDTA except from nauplii to zoea where the highest percent molts were observed with the 10 ppm treatment.

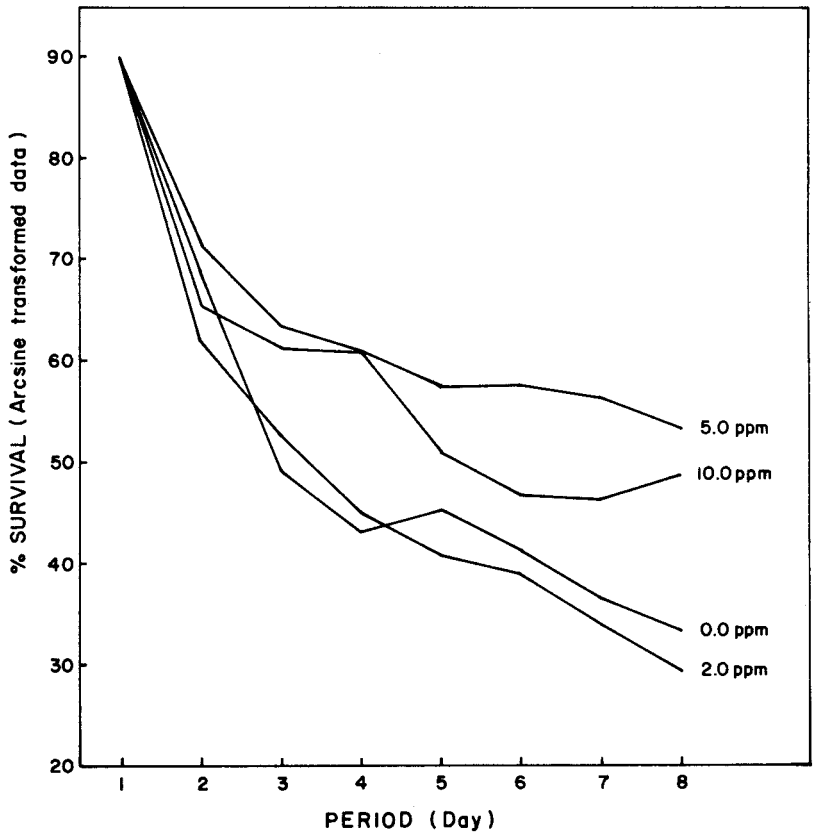


Fig. 2. Survival of *Penaeus monodon* larvae with Na EDTA applied at Day 1, 4 and 7. Points represent means of 10 replicates.

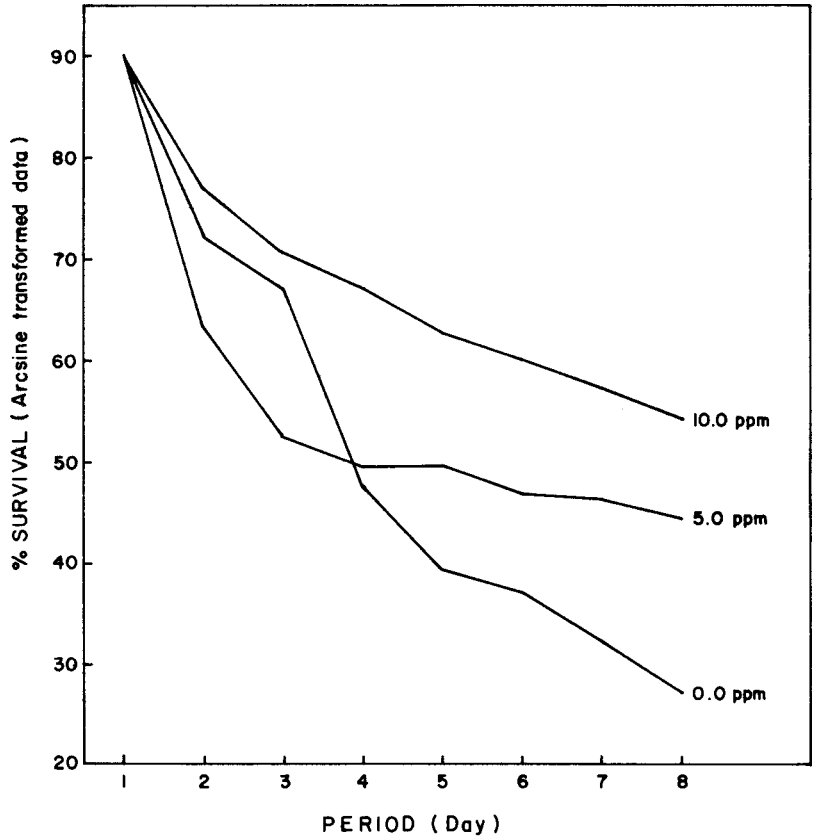


Fig. 3. Survival of *Penaeus monodon* larvae with daily application of Na EDTA. Points represent means of 10 replicates.

Farming Systems

FARMING SYSTEMS

Studies conducted under Farming Systems were related to verification of techniques and methods of pond, pen and cage culture of finfishes and prawn. The economic feasibility of various culture techniques was investigated. Different fertilization schemes were examined in relation to biomass production in brackishwater and freshwater ponds. Preliminary studies to assess the relationship between growth of cultured fish in cages and ecological changes occurring in Laguna Lake were done.

Pond maintenance is a routine activity at LBS.

Finfish Brackishwater Culture

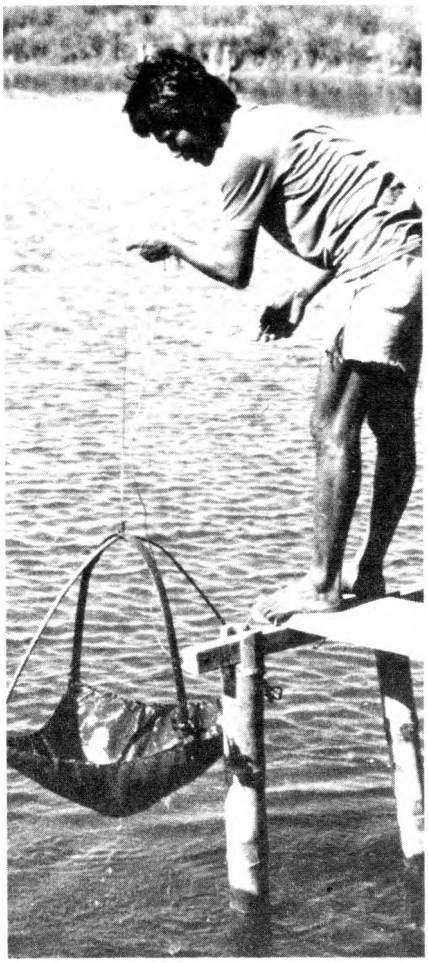
Siganids

The effect of stocking density on the growth and survival of siganids from fingerlings to marketable size was evaluated. Siganid fingerlings (mean weight of 4.8 g) were stocked in 300-sq m ponds at 0.25, 0.50, 0.75/sq m, feeding on natural food, mainly *lablab* (benthic algal mat) and *lumut* (filamentous green algae). High average weight gains after 90 days were obtained at lower stocking levels 0.25 and 0.50/sq m (54 g and 49.34 g, respectively), compared to only 14. .4 g when stocked at 0.75/sq m. Survival rates were also high, 100 and 97% for those stocked at 0.25 and 0.50/sq m, respectively.

Results of this study are expected to guide fish farmers on the optimum stocking density on the culture of siganids in ponds.

Sea Bass

A preliminary study was carried out to determine optimum stocking density and feeding levels for sea bass in order to generate a technology for culturing sea bass at the nursery stage in ponds. Thirty-day old sea bass were stocked in 144-sq m ponds at stocking densities of 3, 5, 7, and 10/sq m and were cultured for one month. There were three feeding levels: 6, 8, and 10% of biomass for each level of stocking density. Highest survival of 50% was obtained when fish were stocked at 3/sq m and fed with frozen



Tray-feeding of prawn.

Broadcasting of feed at LBS ponds.

trash fish at 10% of body weight. With a stocking density of 10/sq m and 10% feeding rate, a survival of 44.2% was obtained. However, when fish were fed at 6 or 8% of biomass, survival was low. Weight gains were generally low.

Prawn Culture

In the study which pilot-tested a SEAFDEC-formulated practical diet, analyses of plankton present in the pond were conducted for 11 weeks. *Lablab* was abundant throughout, hence, the ponds were not fertilized prior to stocking and during the culture period. Water was changed for a period of 3 to 4 days during the spring tide and was facilitated by a water pump during neap tide. Water exchange was done from under rather than from the surface of the pond. pH ranged from 8.0 to 8.3, salinity from 2 ppt to 30 ppt, and temperature from 25.7 to 30.2°C. Copepods dominated the plankton community while mollusc and shrimp larvae occurred in small quantities. *Lumut* and other algae samples were composed mostly of *Enteromorpha* spp; *Spirogyra* sp; *Spirulina* sp; *Oscillatoria* spp; *Lyngbya* sp; *Rhizochlonium* spp; *Nostoc* sp; and *Ulothrix* sp. Diatoms, rotifers, and copepods adhered to the filamentous algae.

Present in the gut of subadult prawns were diatoms, some filamentous algae, rotifers, and copepods. Nematodes were dominant in the gut of harvestable prawns. *Nostoc* sp., *Spirogyra* sp. and *Spirulina* sp. were not found in the gut of the prawns examined during the entire culture period.

In a related study, gut

content of *P. monodon* juveniles grown in ponds was analyzed. The prawns were cultured in ponds where the dominant natural food was either *lablab, lumut* or *digman* (bushy pondweed). Analysis showed that the food ingested by the prawns consisted of crustacean larvae, nematode, benthic copepod, and filamentous algae. Small quantities of phytoplankton detritus, plant debris, and sand particles were also found.

An attempt was made to determine the most ideal pond preparation scheme for optimum growth and survival of potential *P. monodon* spawners. *P. monodon* juveniles weighing between 18 to 25 g were stocked in 500-sq m ponds at 2,000/ha. Three schemes were used: (A) traditional method with no cultivation and no application of lime and organic fertilizer; (B) lime and organic fertilizer application after pond cultivation; and (C) organic fertilizer and lime application before pond cultivation. Cultivation meant tilling the soil with a hoe up to a depth of 6 to 7 cm.

After two months of culture, high survival rates were obtained, 92.5 and 93.5%, respectively, in schemes B and C, with 56% survival for scheme A. The difference in the mean final weights were not statistically significant, (58.9, 54.1, and 53.7 g) for the three schemes. Polychaetes were observed in schemes B and C. Rotifers, copepods, and diatoms dominated the pond production of natural food during the first month of culture.

Studies were also conducted to determine the optimum level of nitrogen or phosphorus combination in prawn ponds. *P. monodon* juveniles (mean weight of 0.36 g) were reared in 1,000-sq m ponds fertilized with nitrogen and phosphorus at four different levels, and a constant level of 1.0 ton of chicken manure/ha. Diammonium phosphate (18-46-0) and urea (46-0-0) were used as sources of nitrogen and phosphorus at a ratio of 1:2. Levels of nitrogen and phosphorus per hectare were 15 kg N and 30 kg P for Treatment I; 20 kg N and 40 kg P, Treatment II; 25 kg N and 50 kg P Treatment III; and 30 kg N and 60 kg P Treatment IV. The fertilizers were added during pond preparation and every two weeks thereafter.

Survival rates, mean final weights, and gross production after two months did not significantly differ in all the schemes. Increasing the levels of diammonium phosphate and urea beyond the amounts in Treatment I, 15 kg N to 30 kg P, did not affect gross production. Survival rates of the prawns were better at lower levels of fertilizer than at higher levels. Lower levels of inorganic fertilizer together with chicken manure should, thus, be applied to lower the cost of production.

A feeding experiment using commercial pelleted feed containing 35% crude protein (Treatment I), trash fish (Treatment II), combination of pelleted feed and trash fish at 50:50% ratio (Treatment III), and 75:25% ratio (Treatment IV) was conducted to determine the response of *P. monodon* juveniles (PL_{50} mean body weight of 0.26 g) to different feeding regimens. Twelve 320-sq m earthen ponds were utilized for a culture period of 105 days.

Results (Table 2) show that

Table 2. Response of *P. monodon* juveniles to different feeding regimens

Treatment	Mean Wt. Gain (g)	Survival (Rate %)	Production kg/ha/crop	Feed Conversion
I – Pelleted Feed	16.36	86.95	558.98	2.43
II – Trash Fish	17.22	79.8	543.24	1.94
III – Pelleted Feed/Trash Fish (50:50)	25.03	79.77	787.93	2.14
IV – Pellet/ Trash Fish (75:25)	23.96	88.53	839.7	1.80

pelleted feed (75%) mixed with trash fish (25%) is the best combination.

Finfish Freshwater Culture

A two year study to determine the conversion factor between natural food and growth of selected fish in Laguna de Bay was started. Experiments on fish growth in relation to the lake's biomass or standing crop are in progress.

In the ecomonitoring study, selected physico-chemical and biological parameters were monitored in West Cove, West Bay, Central Bay, and East Bay of Laguna Lake from January to December.

In West Cove, high transparency values were first noted in May. Lower temperature was observed in January, increasing in May. Chemical parameters such as dissolved oxygen and pH did not reach the critical levels; however, chloride and conductivity levels increased in late April indicating sea water intrusion. Subsequently, higher values of gross primary production and phytoplankton biomass were exhibited starting June. Zooplankton biomass also increased in July while zooplankton biomass maxima was noted in the months of June and July.

In the other stations, sampling was started in May. Chloride values showed increasing trend, indicating seawater intrusion in the lake. The appearance of *Brachionus plicatilis* was observed.

Brachionus plicatilis, a marine zooplankton, was successfully grown on *Chlorella* in fresh water at a density of 5.5×10^3 animals per ml. *Moina macrocopa* was grown in three types of media: chicken manure, water hyacinth, and rice straw. Highest population growth was achieved in the water hyacinth medium with an average population density of 10,400 animals per liter. Highest *Moina* production was obtained in this medium with

Water sampling to determine Laguna Lake primary productivity.

the adult stages comprising the greatest biomass (29 ug/ml/day). *Moina* grown in chicken manure and rice straw medium had an average population density of 7,700 and 6,900/l, respectively.

Carp

Two experiments were conducted on the effect of varying stocking densities (35/sq m and 70/sq m) on growth and survival of bighead and silver carp fry in ponds. In the first experiment, stocking rates did not significantly affect the mean weight and survival of bighead carp fry grown in ponds fertilized with *Sesbania* or chicken manure. On the other hand, mean weight was significantly high at a stocking density of 35/sq m when bighead carp fry were grown in the pond where inorganic fertilizer was applied during the last two weeks of rearing only. Results for silver carp fry were comparable to those obtained in the first experiment. However, percent survival of fry was significantly low at 70/sq m. Statistical analysis of the interaction of stocking density with types of fertilization is in progress.

Natural food production in the different ponds with different fertilizer applications (chicken manure, *Sesbania* and Ammophos, 16-20-0) was also monitored. Green manuring with dried, finely ground *Sesbania* leaf meal enhanced production of both phytoplankton and zooplankton. This might explain why the mean weights of silver carp fry were comparable in the three types of fertilizer treatments (third experiment).

The effects of inorganic (21-0-0 or ammonium sulfate, 0-18-0 or solophos) and organic (chicken manure) fertilizers on the production of marketable-sized bighead carp and tilapia in freshwater ponds were also evaluated. Growth of bighead carp fingerlings was best in ponds fertilized with 0-18-0 and chicken manure, followed by those grown in ponds fertilized with chicken manure alone; the poorest growth was obtained in ponds that received 21-0-0 and chicken manure. After five months of culture, highest weight and length of tilapia were obtained in ponds that received 0-18-0 and chicken manure and 21-0-0 and chicken manure,

respectively. Total final fish biomass was highest from ponds applied with 0-18-0 and chicken manure and lowest from ponds fertilized with combination of fertilizers, 21-0-0 and 0-18-0 and chicken manure.

Tilapia

Integrating tilapia (*O. niloticus*) farming with crops which included the biofertilizer *Sesbania sesban* was tried. After 10 weeks, weight and length of tilapia were higher in ponds with *Sesbania* than those without *Sesbania.*

Polyculture

Four combinations of three different species — *O. niloticus*, hybrid Chinese carp, and sea bass — were evaluated in 9-sq m cages installed in 577-sq m freshwater pond of Bay Fishfarm Project, Laguna from December 1985 to July 1986 using the following treatments: (I) five tilapia with three carp and one sea bass/sq m; (II) five tilapia with three carp/sq m; (III) five tilapia with one sea bass/sq m; and (IV) five tilapia/ sq m. Highest total production was obtained from Treatment I (5,022.15 g), followed by Treatments II (4,598.35 g), IV (3,368.10 g) , and III (2,479.88g). Production from Treatment III (2,479.88 g) was significantly the lowest. The polyculture of tilapia, carp, and sea bass gave a higher production than the two-species combination and the monoculture. The highest mean weight gain both for tilapia and carp was obtained from Treatment II. This was significantly higher than those of Treatments I and IV for tilapia, and apparently higher but not significantly different from that of Treatment III. Thus, it is more advantageous to combine carp, sea bass, and tilapia than to combine only two of the species.

AQUACULTURE ECONOMICS

A comparative economic analysis of different scales of prawn (*P. monodon*) hatchery production systems was carried out with Western Visayas (Region VI) as study area and 1985 as base year. Data utilized were taken from hatchery operators, aquaculture scientists, available literature on hatcheries, and traditional institutional sources.

Analyses show that all scales of hatchery operations, be they backyard, small-scale medium-scale or large-scale, are highly profitable. In addition, results show that when ranked and compared, smaller hatcheries in general, generate better profitability performance than larger hatcheries.

Table 3 presents the profitability indicators for the different scales of hatcheries. Smaller hatcheries have shorter payback periods, higher benefit-cost ratios, and higher internal rate-of-returns than larger hatcheries.

Corollary to the study on hatcheries, another comparative study was conducted on the costs and returns between individual and integrated prawn (*P. monodon*) hatchery, nursery, and grow-out production systems. This second study used the same methodology as the hatchery study.

Analyses indicate that all production systems are profitable, with integrated production systems generally more profitable than individual production systems. Also, the integrated

Table 3. Profitability indicators of different scales of prawn hatcheries

	HATCHERIES			
	Backyard	Small	Medium	Large
1. Payback period (yr)	1.1	2	4	3.1
2. Benefit-cost ratio (B/C)	1.47	1.44	1.13	1.36
3. Internal rate-of-return (IRR %)	123	60	29	55

hatchery-nursery system proves to be the most profitable of all systems considered and that the extensive polyculture of prawn and milkfish is the most profitable grow-out culture method.

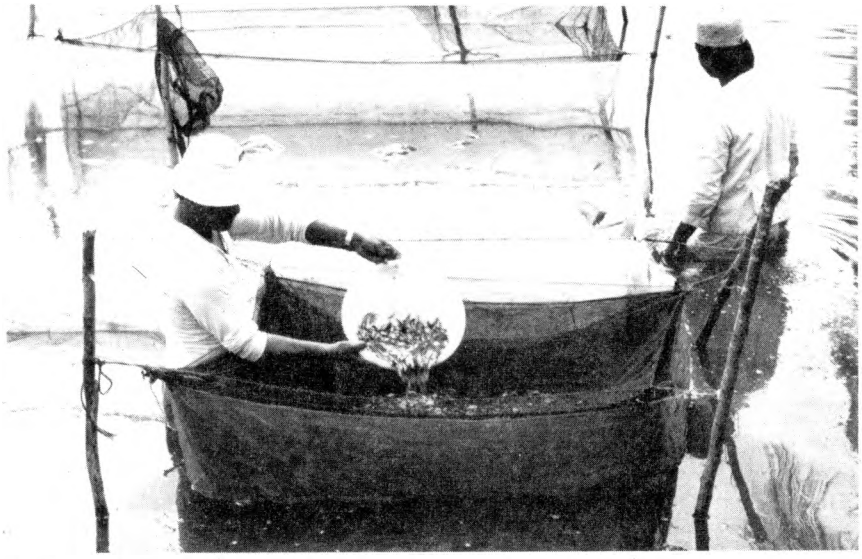
Table 4 presents the profitability indicators for all individual and integrated systems covered in the study.

In another development, growth, survival, production, and economic feasibility of culturing milkfish and prawns (*P. monodon*), monoculture and polyculture, were evaluated after 109 days of rearing in earthen ponds. A stocking density of 2,000 milkfish fingerlings or 20,000 prawn juveniles/ha was used in monoculture and in polyculture (a combination of the same stocking densities). Production of milkfish in monoculture (526 kg/ha/crop) was significantly higher than in polyculture (398 kg/ha/crop. Prawn production was not significantly affected. In monoculture, 590 kg/ha/crop was produced while 524 kg/ha/crop was produced in polyculture. Return on investment (ROI) for polyculture was 45.2% while that of monoculture was 38.7% with a payback period of 2.2 and 2.5 years, respectively.

On the other hand, four sets of modular ponds were used to culture *P. monodon* juveniles at two stocking densities (15,000 and 20,000/ha) with frozen trash fish as supplementary feed. Pond areas were 550; 1,100; and 2,200 sq m, respectively. After three months, mean growth, survival, and final body weight did not differ significantly. Total production was 533 kg/ha in ponds stocked at 20,000/ha and 404 kg/ha in ponds stocked at 15,000/ha. Return on investment was 72.6% and 69.5% for ponds stocked at 20,000/ha and 15,000/ha, respectively, with payback period of 1.4 and 1.3 years for 15,000/ha and 20,000/ha, respectively.

The economic feasibility of milkfish fingerling production with feeding in freshwater ponds was determined in 1985 and 1986. In 1986, the use of formulated diet as feed gave the highest ROI of 43%. The combination of formulated diet and *Spirulina* powder gave an ROI of 42.3% while rice bran alone had 25%. In 1985, the combination of formulated diet and *Oscillatoria*, formulated diet alone, and *Oscillatoria* alone gave ROI values of 39.4, 26, and 8.5%, respectively.

A survey of tilapia farms at Bo. Kalinawan, Binangonan



BFS's impact in the immediate community is evidenced by the proliferating tilapia farms in Binangonan. Above, tilapia fry are being harvested at the Station.

showed a total of 97 farms with 2,134 cages, 22 average number of cages by farm; 373 sq m average farm size; and 2.2 average number of years in operation.

Table 4. Profitability indicators of individual and integrated prawn production systems

	Payback period (yr)	B/C ratio	IRR (%)
1. Backyard hatchery	1.1	1.47	123
2. Pond nursery	2.2	1.08	54
3. Extensive monoculture	4.5	1.14	29
4. Semi-intensive monoculture	4.5	1.11	28
5. Extensive polyculture of prawn and milkfish	3	1.27	45
6. Extensive polyculture of prawn and shrimp	5.5	1.08	23
7. Integrated hatchery-nursery system	0.5	1.58	225
8. Integrated hatchery-nursery-grow-out system	1.2	1.38	86

Feed Development

Researches under this section are geared towards the development of biologically effective and economical fish and prawn diets for the industry. Research projects focus on the following major areas: nutrient requirements, practical diet development, evaluation of indigenous feed resources, feedstuff digestibility, and digestive physiology.

Finfish Nutrition

Larval Diet

Practical larval diets have been developed with reasonable stability and acceptability by larval fish. The diets were tested in the laboratory and by a fry dealer. Acceptability of the diet was reported in feeding trials with milkfish fry conducted by the fry dealer. Water management practices, however, were not adequate and pollution could have caused most of the observed mortalities. In the laboratory, good growth and survival were maintained in the first weeks. Mortalities after the second week were attributed to inherently weak fry.

Fry/Fingerling Diets

Studies on lipid nutrition confirmed earlier findings on the ability of milkfish to grow for five months on a lipid-free diet suggesting that essential fatty acids are highly conserved. The experiments showed no significant growth improvements from the addition of 1% n-3 or n-6 fatty acids. A consistent growth depression was observed in fish fed diets containing 0.5% each of n-3 and n-6 fatty acids. Highest survival and growth rates, however, were observed among fish fed diets containing 7% cod liver oil. Poorest growth rate was obtained from the diet with a 1:1 ratio of n-3 to n-6 fatty acids.

Milkfish with mean initial weight of 7.0 g were fed diets containing graded levels of lysine at 0.9, 1.3, 1.7, 2.0, 2.3, 2.6 g/100 g dry weight diet. Results after 12 weeks showed that growth rate increased proportionately with increasing levels of lysine in the diet. However, no further weight gain was observed with the increase in lysine level beyond 2.0 g/100 g diet suggesting that lysine requirement for milkfish is about 2.0 g/100 g diet.

Acclimated wild milkfish fry with initial mean body weight of 0.0048 g, total length of 1.4 cm were stocked in 12 uniformly prepared 50-sq m freshwater ponds. The fish were given the following feeds for seven weeks: 1) combination of *Spirulina* powder and formulated diet; 2) formulated diet; and 3) rice bran. Milkfish fed with the formulated diet alone gave the fastest growth in body weight and total length (1.5 g and 5.57 cm) followed by those given the combination of *Spirulina* and formulated diet (0.886 g and 4.66 cm). Milkfish given rice bran alone had the lowest growth (0.754 g and 4.36 cm). Results of a six-week experiment conducted under laboratory conditions were consistent with those obtained in ponds. Results further showed that growth rather than survival rate was directly in-

Feeding experimental animals in nutrition and feed development studies.

fluenced by the feeds given to the milkfish in the laboratory as well as in the ponds.

The need for ascorbic acid was determined by using milkfish with initial mean weight of 1.5 g. Milkfish were fed purified diets, one containing about 300 mg ascorbate/100 g diet, and another with no ascorbate at all. A commercial fish pellet was used as control. Results showed that the fish fed for 15 weeks diets containing no ascorbate grew as well as those fed with diets of 300 mg of ascorbate/100 g diet, or with commercial fish pellet. The results suggest that the depletion rate of tissue ascorbate may be extremely low. It is highly possible that ascorbate requirement could be provided by natural food organisms introduced into the rearing tank via the flow-through system. The interference caused by these extraneous food organisms posed technical difficulties in the conduct of the experiment.

Crustacean Nutrition

Larval Diet

The possibility of adopting a new feeding system using K-Carrageenan Microbound Diet (C-MBD) which may help alleviate problems currently limiting prawn hatchery production was assessed on *Penaeus monodon* larvae in a laboratory scale. Results indicate that with proper management techniques, survival rates and metamorphosis of larvae fed C-MBD (0.32 to 0.64 mg/larvae/day, four times daily with various particle sizes depending on the larval stage) was comparable to those fed natural food (*Chaetoceros calcitrans/Skeletonema costatum* at 10-50 x 10^3 cells/ml; *Tetraselmis chuii* at 2-5 x 10^3 cells/ml; *Artemia salina* nauplii at 2-5 individuals/ml fed twice daily at different larval stages). Survival from nauplii to postlarvae was 50-70%. Metamorphosis from zoea to postlarvae took 9 to 11 and 10 to 12 days for natural food and C-MBD-fed larvae, respectively. C-MBD could therefore be a partial or total replacement of the traditional natural food for *P. monodon* larvae. The diet contained 50.28% crude protein, 14.24% crude fat, 3.18% crude fiber, 20.42% nitrogen free extract

Preparing culture media for natural food production.

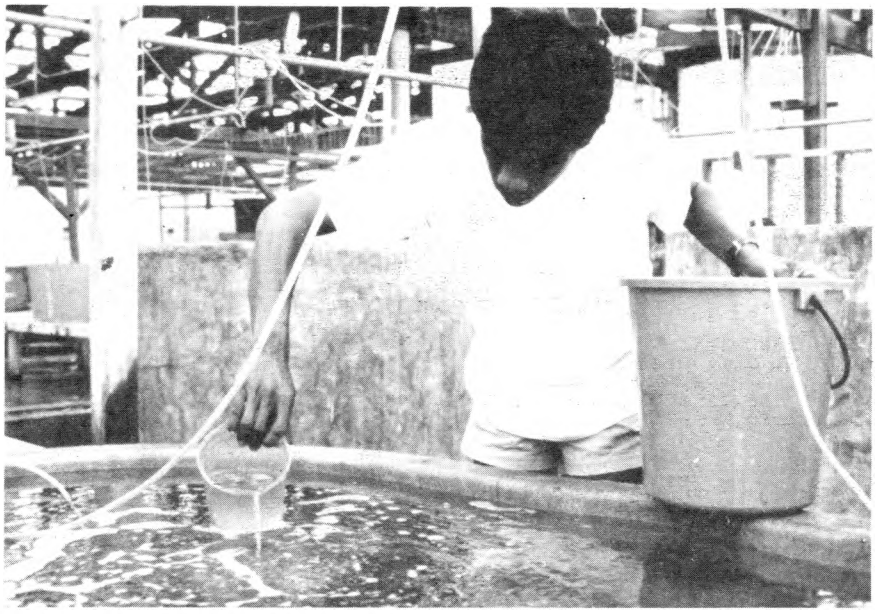
(NFE), and 11.86% ash.

Grow-out Diet

P. monodon juveniles (mean weight of 0.38 g) were fed 12 diets of 30, 20, or 16% Peruvian fish meal, 15 or 35% defatted soybean meal (DSM), 10% ipil-ipil meal (*Leucaena leucocephala*) and 15% shrimp meal with and without vitamin and/or minerals. The diets contained around 45% crude protein and 13% crude fat. After eight weeks of feeding, results showed that weight gains were below 200% in prawns fed diets of ipil-ipil and more than 200% in prawns fed diets without ipil-ipil regardless of the amount of DSM in the diet. Survival and feed conversion ratios were not affected by the type and amount of protein source but by the addition or omission of vitamin or mineral mixtures. Survival was highest when the diets were complete and lowest in diets without added vitamins and minerals. When either vitamins or minerals were omitted from the diet, mean survival rates did not differ from one another. Feed conversion ratios were better for complete diets and those where only vitamins were added. Poorest feed conversion ratios were obtained when no vitamins and minerals or only minerals were added to the diets.

In order to determine the essential fatty acid requirements of *P. monodon*, prawn juveniles (mean weight of 0.3 g) were fed purified test diets containing the following fatty acids: 18:2n-6 and 18:3n-3 at 0.5%, 1.0% and 2.0%; 18:1n-9 at 7% and n-3 highly unsaturated fatty acid (HUFA) at 1%. Culture period was 28 days with lipid-free diet as control. Results show that survival rates of the prawns increased with increasing levels of 18:2n-6 and 18:3n-3. Highest survival rate (52%) was obtained for prawns fed 2% of 18:3n-3 and lowest (6%) with prawns fed diets with no lipid.

The arginine requirement of *P. monodon* was evaluated using semi-purified diets containing six levels of arginine: 2.3, 4.2, 6.1, 8.0, and 9.0 g/100 g dry diet. After 28 days of culture in the laboratory, weight gains were 18.6 to 39.5% while survi-



Feeding natural food to fish larvae.

val rates ranged from 50 to 95%. The diet with the highest arginine content gave the lowest survival rate. Best results were obtained in the diet with arginine content close to the level of arginine (5.76 g) in the prawn muscle.

In the search for various potential protein sources, results of amino acid analyses of various feedstuffs were evaluated using EAAI (essential amino acid index) *of P. monodon*. The EAAI of an indigenous shrub "Kamantulan" (0.98) was comparable with ipil-ipil leaf meal while tamarind and acacia leaf meals showed EAAI of 0.80 and 0.75, respectively. Arginine and methionine appeared to be the limiting amino acids for the leaf meals analyzed. The EAAI of defatted scallop meal was 0.93 while that of "karajo" meal was 0.98. These are close to the amino acid profile of *P. monodon,* thus they appear to be potential sources of protein in the diets.

A SEAFDEC-formulated practical diet (Table 5) was produced on commercial scale and pilot-tested in three brackishwater ponds at Leganes Research Station, University of the Philippines Brackishwater Aquaculture Center, and Bureau of Fisheries and Aquatic Resources Molo Station. *P. monodon* postlarvae (about 0.2 g mean initial weight) were stocked at 25,000 pcs/ha. After four months, the total yield of marketable-sized prawns averaged 556 kg/ha with an average feed conversion ratio of 1.9 and average survival rate of 83%. The cost of feed was US $ 1.00/kg.

Broodstock Diet

The relative effects of diet on reproductive performance of pond-reared *P. monodon* were assessed. Diets A, B, and C were formulated to contain the same basal components but supplemented with different lipids. The diets contained 52.8 to 56.5% crude protein, 12% crude fat, 3.8 to 4.9% crude fiber, 16.5 to 18.4% ash, and 9.9 to 13.4% NFE. Diet A was supplemented with cod liver oil, Diet B with 1:1 combination of cod liver oil and soybean lecithin, and Diet C with soybean lecithin. Results show that diet quality has a considerable effect on reproduction, egg hatching efficiency, and larval quality. Diet A was observed to be suitable for the promotion of successful maturation and spawning of pond-reared *P. monodon* and supported the survival of larvae.

Table 5. Composition of SEAFDEC-formulated diet for *P. monodon* grow-out

	%
Fish meal	32.0
Shrimp meal	15.0
Soybean meal, defatted	15.0
Rice bran	13.8
Bread flour	15.0
Cod liver oil	3.0
Lecithin	2.0
Vitamin mix	1.5
Mineral mix	1.5
Polymethylol carbamide	1.0
Butylated hydroxy toluene	0.2
Proximate analysis:	
Crude protein	43.7
Crude fat	7.8
Crude fiber	4.9
Ash	11.1
Nitrogen-free extract	32.5

Fish Health

A major problem that reduces aquaculture production is disease which could either be microbial, nutritional or environmental in origin. Hence, fish health management is one of the major concerns in an aquaculture facility. In the Fish Health Section, studies were geared toward 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 soft-shell syndrome through dietary manipulation, and investigation of the ulcerative fish disease in Laguna Lake.

Finfish

Chemical control of pests is a common practice in fishponds. Usually, however, such pesticides can have adverse effects on the cultured species. The chemical pesticides most often used are Aquatin, Brestan, and Gusathion A, but the tolerance level of fish to these pesticides have not been established. To determine the effects of such pesticides on milkfish fingerlings, static bioassays were conducted for 96 h using 0.1 to 3 ppm Aquatin, 0.025 to 0.25 ppm Brestan, and 0.1 to 0.75 ppm Gusathion A. These concentrations were much lower than the manufacturer's recommended rate of application and those commonly used in ponds. Gusathion A was found to be the most toxic and Aquatin the least toxic to 2-g milkfish. The acute toxicity of these pesticides ceased towards the end of 96 h. Exposure to higher concentrations of the pesticides caused reversible body curvature (lordosis and scoliosis). Thus, these pesticides must be used with great caution in milkfish culture.

Aside from diseases due to poor environmental conditions, bacterial infections are also prevalent in aquaculture systems. One possible source of contamination is the natural food given to the fish. A study on the bacterial flora associated with some phytoplankton species was conducted. Four bacterial strains of *Vibrio* were isolated from the phytoplankton *Tetraselmis chuii*. The bacteria were found to decrease in number in *T. chuii* cultures left unaerated. All four strains were also demonstrated to be pathogenic to milkfish fry at salinities of 15, 20, and 25 ppt. The most pathogenic of these (coded *Vibrio* TC-9) was tested for its ability to cause mortality in milkfish using a modified hyperosmotic infiltration method. It was found to be pathogenic at densities of 5×10^1 colony forming unit per ml (CFU/ml) to 5×10^8 CFU/ml to fry exposed for three minutes to 5% sodium chloride solution. These results demonstrate that phytoplankton cultures can be a source of bacteria pathogenic to fish being cultured.

A bacterial species has likewise been found to be associated with the recurring ulcerative fish disease in Laguna Lake. The epidemiology of the ulcerative fish disease observed in 1985-86 in Laguna Lake had many striking similarities with the most recent (late 1986) occurrence of the disease. In both instances, the disease occurred in late November, reached its peak in

Inoculating bacteria into various media for identification.

December and January, and started to disappear toward the end of March. The prevalence of infection, however, is relatively lower in the recent occurrence. The bacteria, *Aeromonas hydrophila,* were consistently isolated from body ulcers and lesions of snakehead (*Ophiocephalus striatus*), Thai catfish (*Clarias batrachus*), crucian carp (*Carassius carassius*), and goby (*Glossogobius giurus*), 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, 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* was believed to be secondary to some predisposing factors existing in Laguna Lake such as low water temperature.

Prawns

Pesticide contamination has also been identified as a causative factor of the chronic soft-shell syndrome in penaeids. To find out the effects of Gusathion A on shell quality and survival of 10-15 g *P. monodon*, static bioassays were conducted for 96 h using levels 1.5 to 150 ppb which were way below those used in prawn ponds. The lowest survival rate resulted from exposure to 150 ppb while the highest incidence of soft-shelling was observed among prawns exposed to 75 ppb, the second highest pesticide level. Results establish that Gusathion A, an organophosphate, is a significant factor in soft-shelling and mortality of prawns, indicating that such pesticides must be used discriminately.

To control the chronic soft-shell syndrome, an in-depth investigation on the appropriate calcium and phosphorus content in the diet was undertaken in collaboration with the Feed Development Section. Various calcium/phosphorus ratios in the diet were tested on *P. monodon.* An optimum Ca:P ratio of 1:1 was found to be most effective in reversing soft-shelling and improving shell quality in prawns in 4 weeks.

Service Laboratories

The service laboratories accommodate analyses of samples from the various research projects of the Department as well as from the private sector.

Pathology Laboratory

Diagnostic services involved 28 disease cases of which 11 were diseased milkfish, sea bass, siganid, and tilapia. The diseases in finfishes were caused by bacterial infection, parasitic infestation, and nutritional and environmental disorders. Twelve cases involving *P. monodon* were processed. Prawn mortalities were mostly caused by environmental factors and a few by bacterial infection. Water samples were also analyzed for bacterial examination consisting of one case for bacterial count and four for potability.

Microtechnique Service Laboratory

A total of 1,845 tissue samples were processed by routine slide preparation. The peak months for requests for slide preparation were observed in August and October.

Centralized Analytical Laboratory (CAL)

A total of 3,784 (92%) water and 343 (8%) feed samples were analyzed. The parameters analyzed for the water analyses were ammonia-nitrogen, nitrite-nitrogen, pH, and dissolved oxygen. For feed samples, the following parameters were analyzed: crude protein, moisture, crude fat, and crude fiber. In addition to its main function, the supervision of the Scientific Supply House was transferred to CAL.

Natural Food Laboratory

A total of 407,250 liters of quality larval food starters (algae and zooplankton) were produced and served to various studies at AQD, private sector, graduate students, research institutions, and trainees.

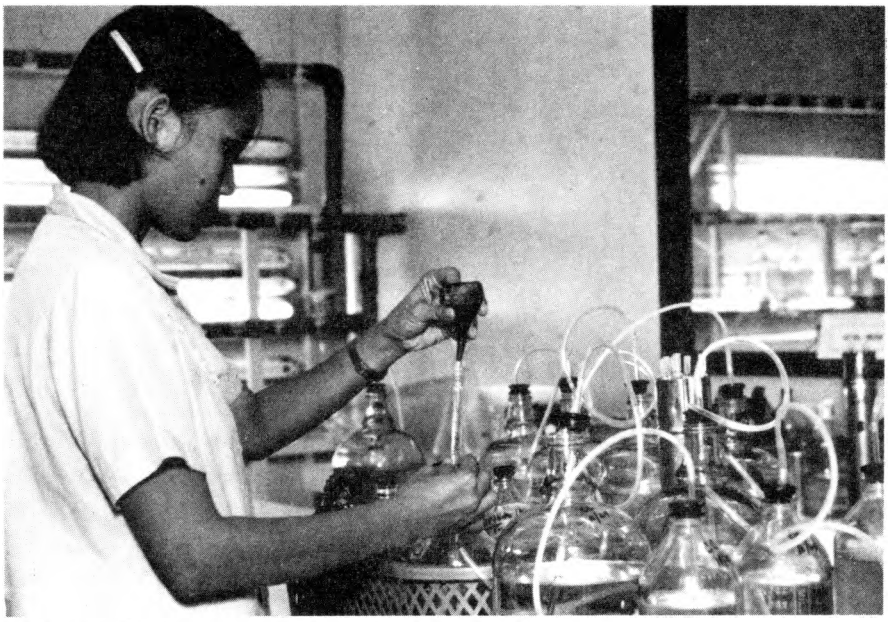
An average of 2 kg pre-adult *Artemia* biomass was produced which served the needs of AQD's research projects. This reduced the yearly consumption of costly imported *Artemia* cysts by at least 20%.

Chem-Bio Lab of Leganes Brackishwater Station

Total samples analyzed during the year were: water — 3,584; soil — 510; fertilizer — 3; and feeds — 5. Parameters analyzed for water samples included pH, salinity, D.O., alkalinity, phosphate, nitrite, ammonia, total hardness, total solids, and chloride. For feed samples, the following parameters were analyzed: crude protein, moisture, crude fat, and crude fiber. For social analysis the following parameters were recorded: pH, potential acidity, texture, total phosphate, lime requirement, organic matter, and total nitrogen.

Central Chem Lab of Binangonan Freshwater Station

A total of 3,614 analyses were performed of which 99% was water analyses, the remaining 1% was soil analyses. Fourteen water quality parameters were analyzed: pH,



Culture media are prepared for natural food production.

A water sample is analyzed.

dissolved oxygen, ammonia, nitrogen, nitrate-nitrogen, nitrite-nitrogen, phosphate-phosphorus, chloride, hardness, alkalinity, total suspended solids, turbidity, conductivity, volatile organic matter, and chlorophyll-A. For soil samples, pH and organic matter were analyzed.

Lab Equipment Maintenance Unit

During the year, a total of 1,290 equipment were repaired and maintained. The services of the unit included year-round preventive maintenance, routine check-up, and emergency repair. Monthly averages were 63 units for research equipment maintenance, 29 units for check-up, and 18 units for repairs.

Research Seminars

Date	*Topic*	*Speaker*
January 16	Ammonia excretion in the horse-shoe crab (*Limulus polyphemus*) and the pupfish (*Cyprinodon variegatus*)	J. Almendras
February 12	Morphology: Fundamentals and applications to aquaculture	H. Kohno
March 12	Egg size and larval size among teleosts: significance to fisheries and aquaculture	T. Bagarinao
March 24	Prawn broodstock a) Production of broodstock in ponds b) Field survey and monitoring of wild spawners and environmental conditions c) Lipid and protein requirements	G. Nezaki
April 2	Bacterial purification of oysters using different sterilization methods for sea water	A. Gallego
April 16	a) The effect of supplemental lecithin and lipid sources on the growth and survival of *P. monodon* juveniles b) Defatted soybean meal as substitute for fish meal in diets of tiger prawn *P. monodon* raised in earthen ponds	F. Pascual
April 23	Comparative economic analysis of hatchery systems	D. Israel
June 4	Metabolism in tilapias	K. Becker*
June 10	Fishpen development in Laguna de Bay: the social implications	M. Delmendo*
August 21	Studies on the soft-shell syndrome in the tiger prawn *Penaeus monodon* Fabricius from brackishwater ponds	M.C. Baticados

RESEARCH SEMINARS

September 25	Research and publications	H. Bern*
September 29	Population dynamics of *Acartia* in ponds of Japanese red sea bream	A. Ohno*
October 10	Fishfarming in Singapore	L. Landesman*
October 25	The energetics of swimming in fishes	M. Gordon*
November 3	The craft of technical editing	A. Lambert
November 4	Chromosome engineering: its application	H. Ida*
November 12	Food availability of lab-lab in milkfish ponds	R. Kado*

*Department guests.

TRAINING

Long-term Training

NACA trainees seining milkfish at harvest time.

Twenty-one participants of the 5th NACA-SEAFDEC-UPV Training Course for Senior Aquaculturists in Asia and the Pacific completed the one-year course on 13 March 1986. On the same day, the 6th session of the training course opened with 19 participants from eight countries (Philippines, Indonesia, Thailand, Malaysia, India, Sri Lanka, Pakistan, and China) with funding support from NACA, International Development Research Centre (IDRC), and the Asian Development Bank. The course will end on 7 March 1987.

Short-term Training

Brackishwater Pond Culture
(28 April to 5 June)

The training course conducted mainly in Leganes Brackishwater Station had 20 participants consisting of 17 local trainees, mostly from the private sector, and 3 foreign trainees from Malaysia, Egypt, and Thailand. Four of the trainees were sponsored by IDRC.

Small-Scale Prawn Hatchery and Nursery Operations
(7 May to 2 July)

This session was originally scheduled to start 3 March but had to be deferred due to the February Revolution. The course was conducted at Leganes Brackishwater Station with 15 local participants.

Hatchery of Marine Finfishes
(9 June to 1 August)

Fourteen trainees, five of which were IDRC-sponsored, completed the two-month course held at Tigbauan Research Station and Igang Sub-station. Seven BFAR personnel assigned to the National Bangus Breeding Project (NBBP) also participated with IDRC assistance. The rest of the trainees came from various local and international research establishments. The group visited three IDRC-funded projects in Bohol, Zambales, and Pangasinan during the post-training tour.

Small-Scale Prawn Hatchery and Nursery Operations
(4 August to 25 September)

The 17th session of this

Trainees apply lime to ponds as part of practicals in pond preparation.

training course was conducted simultaneously at Tigbauan and Leganes Stations. Of the 39 participants, 22 came from the Philippines and Southeast Asia and 10 from other Asian and South Pacific countries. Half of the participants was sponsored by their governments through grants from IDRC, NACA, and UNDP.

Freshwater Aquaculture
(15 September to 17 October)

Twenty-two participants coming from the Philippines, Indonesia, and Thailand attended the 9th session of the training course held at Binangonan Freshwater Station. Three of the trainees were sponsored by IDRC and five by FAO.

Brackishwater Pond Culture
(6 October to 14 November)

Attended by 21 participants from the Philippines, India, Thailand, Indonesia, Malaysia, Sri Lanka, China, and Caroline Islands, the training course was conducted at Leganes Brackishwater Station. At the end of the six-week course, the group visited private farms, feed mills and processing plants in Capiz, Aklan, and Negros for their post-training tour.

Small-Scale Prawn Hatchery and Nursery Operations
(6 October to 28 November)

This special session was scheduled for the Prawn Hatchery Course applicants who were not accommodated in the regular sessions. A total of 19 participants attended the course held in Leganes Brackishwater Station. Of the 18 local participants, 15 were from the private sector while three were sponsored by the Bureau of Fisheries and Aquatic Resources Aquaculture Development Project.

Other Training Activities

Secondment of Junior Scientists

Two Indonesian junior research scientists are undergoing training on brackishwater pond culture at Leganes Brackishwater Station under the NACA Program for Secondment of Junior Scientists. They also had training in nutrition and feed development and fish health at Tigbauan Research Station.

Consultative Meeting with Fishfarmers

Three meetings were held from January to June. A special meeting was held on 27 January to discuss the standardized definition of terminologies often used in technology verification. The meeting was attended by members of the Iloilo Fish Producers Association and representatives from the Bureau of Fisheries and Aquatic Resources.

A regular meeting was held on 29 January at Tigbauan Research Station. Highlight of the meeting was a report on the high production result achieved for prawns at 843.3 kg/ha in semi-intensive culture with 25,000 juveniles/ha and supplemental feeding of commercial pellet and trash fish. Other topics discussed included extensive prawn culture results and the modular monoculture and polyculture of prawns.

Another regular meeting was held at Tigbauan Research Station on 30 April 1986. The discussion focused on soft-shelling of pond-reared prawns and shrimps.

In-situ Seminar

An in-situ seminar was held on 12-14 March in Naga City with 28 participants. The seminar was sponsored by the Naga Chamber of Commerce and Industry, and the Bicol River Basin Development Program.

A one-day seminar was also conducted on 21 March in Ajuy, Iloilo, with fishpond owners/operators and caretakers from the municipality of Ajuy as participants. There were also half-day seminars on nutrition and feeding of *sugpo* in Pilar, Capiz and Dumangas, Iloilo in collaboration with Bureau of Fisheries and Aquatic Resources.

Internship Training

At Tigbauan Research Station and Leganes Brackishwater Station, a total of 34 participants availed of the Department's internship program. The participants undertook training in prawn broodstock development, phycology, and *Artemia* as well as in prawn hatchery operations. Two foreign participants from the Overseas Fisheries Cooperation Foundation of Japan and the National Aquatic Resources agency of Sri Lanka underwent internship training both at Tigbauan Research Station and Leganes Brackishwater Station.

Twenty-two participants from the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) undertook a two-day observation tour of Binangonan Freshwater Station and attended special lectures in freshwater aquaculture.

Off-campus Industry Training (Practicum)

A total of 62 students from different fishery schools throughout the country undertook off-campus training in the different research stations of the Department. Among the schools represented were: Iloilo State College of Fisheries (16 students), Samar Regional Institute of Fishery Technology (13), Davao Agro-Industrial Foundation (8), and Northern Iloilo Polytechnic State College (8). The students assisted in the various activities of the research projects ranging from natural food production, prawn broodstock development, larval rearing, nutrition, and pond culture.

Several students availed of the program at Binangonan Freshwater Station: three from the Malolos Marine Fishery School, and six from the Don Mariano Marcos Memorial State University. They assisted research staff in the different activities of the station, mainly in carp and tilapia culture, chemistry, natural food, and nutrition. Another five students from the Tomas Claudio Memorial College participated in the program specifically for office management.

Documentation Services

Brackishwater Aquaculture Information System (BRAIS)

BRAIS, a specialized information analysis project with funding support from IDRC, has its Project Lead Center at AQD's Tigbauan Research Station. National centers were organized in Indonesia, Malaysia, and Thailand.

Established in 1984, BRAIS has acquired a total of 188 aquaculture materials from the national centers: 89 came from INDOBRAIS, four from MALAY-BRAIS, and 95 from THAI-BRAIS. BRAIS data base now contains 1,906 entries. In addition, 716 aquaculture materials already published in the Brackishwater Aquaculture Bibliography are yet to be entered in the data base. This activity has been facilitated by computer facilities which enabled automated information storage and retrieval, and computer generation of bibliographies and abstracts.

A training on SEAFIS (Southeast Asian Fisheries Information System) methodology was conducted in Bangkok in April-May. SEAFIS input sheet was adopted as common input facility for all information-related projects in fisheries and aquaculture supported by IDRC. A MINISIS User's Group meeting and training session conducted in Singapore in October-November enabled the immediate creation of the SEAFIS data base in the Lead Center.

Two issues (Vol. II, Nos. 1 and 2/3) of the *Brackishwater Aquaculture Abstracts* were published, and another two issues (Nos. 4/5 and 6) are still in press. The *Sea Bass Abstracts* with 259 entries was published while *Mussels Abstracts* with 181 entries is in press.

A forthcoming publication, *Groupers Abstracts* with about 136 entries, is being prepared, the *State-of-the-Art Review on Siganid* is being reviewed while the *State-of-the-Art Review on Prawn (Sugpo)* is still being written. Other publications of BRAIS Project are BRAIS News-

BRAIS publications.

letter with its first issue for the period April-June 1986 and BRAIS brochure which was distributed during the year.

For its clearing house activities, BRAIS Project closely coordinates with the Department's Library. During the year, 99 user queries were received by mail. Four came from Africa, 54 from Asia and the Pacific including the Philippines, 14 from Australia, 9 from Europe, 9 from South America, and 9 from the U.S.A.

Library Services

The present collection consists of 8,061 monographic volumes; 4,068 pamphlets; 1,604 SEAFDEC publications; and 3,285 journal volumes. Accessioned during the period were 224 monographic volumes, 266 pamphlets, 76 SEAFDEC publications, and 301 journal volumes. Checklisted were 1,606 journal issues (808 gifts and exchanges and 798 subscriptions).

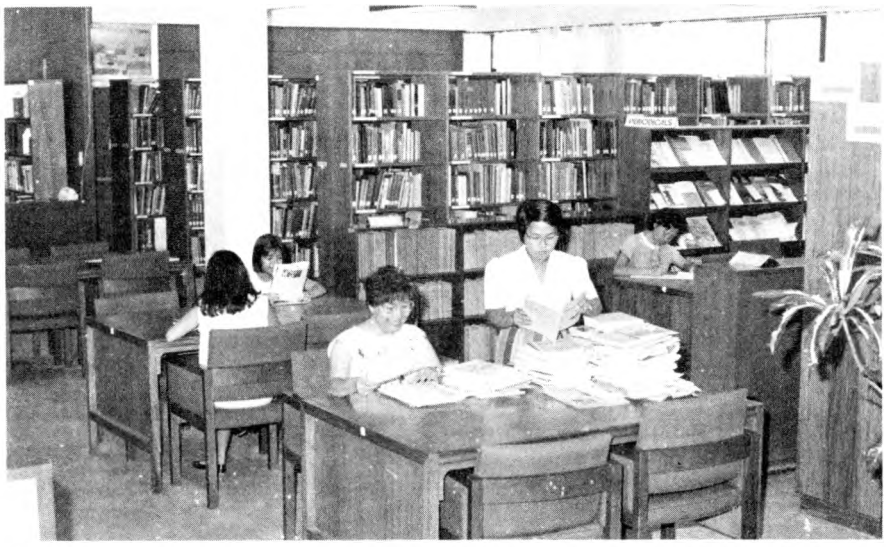
A total of 29,838 readers were registered for 2,478 hours of library service making an average of 12 persons per hour. Four issues and 12 numbers of *Acquisitions List* were distributed; these were for October to December 1985 and January to December 1986.

Information Alerts, a current awareness bibliography, came out with six issues with the maiden issue printed in July. This bibliography, being collated and distributed by Data Bank, brings to the attention of the researchers of AQD current and relevant publications on fisheries.

Computer Services

In June, the Apple Microcomputer at Leganes Brackishwater Station was transferred to Tigbauan Research Station. An IBM PC/ST-compatible microcomputer system was acquired for Tigbauan Research Station in August and another two units in October.

Lectures and computer hands-on sessions for AQD researchers were conducted in September and October. The training sessions covered computer fundamentals, word processing, and statistical analysis on the microcomputer. In addition, statistical analyses of 27 research studies conducted at AQD were undertaken.



The Library at the Tigbauan main station services the staff as well as students from the local colleges and universities.

AQD also continued to implement FAO's Aquaculture Information System (AQUIS) using the HP3000 computer system.

Publications

Regular publications of AQD newsletters were undertaken. *SEAFDEC Asian Aquaculture* had five monthly issues from January to May after which the newsletter became a quarterly publication. *Aqua Farm News* had eight issues released while *Aqua Dep't News* had 7 issues of in-house news. In addition, communication materials were printed for the Rainfed Resources Development Project (RRDP).

Techno-Transfer

Aquaculture Technology Module (ATM) No. 4, *Site Selection for Brackishwater Ponds;* and ATM No. 5, *Soil Sampling for Laboratory Analysis* were printed in the first quarter. The following materials were also produced: *Technotips for radio* — 9 on natural food; 3 on biology, species identification, and collection; 6 on soil sampling; 7 on growing *lablab*/plankton; and 6 on liming of brackishwater ponds. *Devplug for TV* — one English version and one Visayan version each for *Artemia as Live Food in Hatcheries; Advantages of Hatchery-Bred Prawn Fry; Distinguishing Live from Dead Sea Bass Fry; Sanitizing Mussels and Oysters for the Table;* and an instructional video in *Artemia Decapsulation.*

Communication materials were developed under the Rainfed Resources Development Project in collaboration with the Bureau of Fisheries and Aquatic Resources, the University of the Philippines in the Visayas, and the Philippine Council for Agriculture and Resources Research and Development. Among those developed and distributed were three fisheries primers, two fliers, one poster, and one wall newspaper, all written in the language spoken by the fish farmers in Panay. In addition, two barangay consultancies were held. These were attended by the fish farmers with resource persons from AQD and collaborating agencies.

ADMINISTRATIVE MATTERS

Streamlining of Department Operations

The revised Plan of Operation and Program of Work of the Department was approved by the SEAFDEC Council at its nineteenth meeting in Tokyo, Japan, 18 to 21 November.

In the revised Plan of Operation and Program of Work, the Department has five divisions, namely: Research, Training, Administration, Finance, and Information.

The Research Division comprises four sections: Breeding, Farming Systems, Feed Development, and Fish Health. The Training Division comprises the Trainee Affairs, Training Courses, and Instructional Materials Sections. The Administration Division comprises the General Services, Personnel, and Engineering Sections. The Finance Division has the Accounting and Cashiering Sections while Information Division has Documentation, Publications, and Techno-Transfer Sections.

There are three research stations: Tigbauan Research Station which also serves as the headquarters of AQD, Binangonan Freshwater Station and Leganes Brackishwater Station. These research stations and their substations serve as project sites and are managed by Station Heads who report to the Department Chief in coordination with the Research Division. Under the Office of the Chief are the office of the Deputy Chief, Internal Audit, and the Manila Liaison Office.

Personnel Management

Personnel

As of 31 December, personnel complement of the Department totalled 624 with 348 in Research, 195 in Administration, 24 in Training, 17 in Finance, and 40 in Information. At least 65 employees resigned from the service, 28 were either hired or regularized, and at least 80 were transferred from one unit to another.

Designations

Major designations made for heads of offices were the following: R. Cuevas for Administration Division, J. Primavera for Training Division, B. de los Reyes for Finance Division, V. Sulit for Information Division. The Department Chief heads the Research Division in a concurrent capacity.

Other designations for heads of offices were: J. Juario for Tigbauan Research Station and as Coordinator for Collaborative Projects, D. Gerochi for Leganes Brackishwater Station, and A. Camacho for Binangonan Freshwater Station.

Staff Development

E. Amar and J. Ladja joined the one-year training for Senior Aquaculturists of the NACA Training Program. J. Antiporda completed in September a one-year training at the National Inland Fisheries Institute, Bangkok, Thailand under the

Administrative Division Head Rufil Cuevas is master of ceremonies at AQD's 13th anniversary celebration. Listening are AQD Deputy Chief Satoru Fukumoto; Dr. Veravat Hongskul, SEAFDEC Secretary-General; SEAFDEC Council Chairman Vanich Varikul; and Dr. Flor Lacanilao, AQD Chief.

NACA secondment of junior scientists program. J. Toledo undertook a six-week training in marine fish net cage culture in Singapore beginning 1 September under an FAO grant. F. Palisoc attended the Expert Consultation on Ulcerative Fish Diseases in Asia and the Pacific Region held in Bangkok, Thailand, 5 to 9 August. S. Baldia attended a two and a half-month training on composite carp fish farming in the NACA Regional Lead Center in Bhubaneswar, India starting 1 September. T. Bagarinao left for a doctoral degree program in Marine Biology at the University of California, San Diego, under a Fulbright-Hays grant. Another Fulbright-Hays grantee, R. Coloso is pursuing a Ph.D. in Nutritional Sciences at Cornell University, New York.

Foreign Experts

Services of foreign experts availed of included that of G. Nezaki who worked on prawn broodstock development in ponds and field survey of prawn spawners from the wild until March, S. Hara on the feeding biology and sperm preservation of milkfish until June, and H. Kohno on finfish larval development until February 1987. Several foreign scientists who visited the Department also gave seminars/lectures on specific aquaculture topics. Among those who lectured were K. Becker, H. Bern, A. Ohno, L. Landesman, M. Gordon, H. Ida, R. Kado.

Infrastructure & Facilities Development

Infrastructure and support facilities development at Tigbauan Research Station were the following: fabrication of atmospheric instruments and installation of water cooler for 1-ton tank with thermostat control at the Nutrition Building, improvement of the exhaust system for fume hood at the Centralized Analytical Laboratory, completion of pre-filtered new seawater supply system of the siganid rearing tanks, and construction of broodstock culture tanks and laboratory.

At Igang Research Substation, repairs were made on the bridge from the hatchery to the Guest House, floating bridges (Pontoon Bridge), 55 and 35 KVA Generators and engines of pumpboats, catwalks, and hatchery roofings. Fabrication of milkfish egg - collection gears, construction of tanks, and improvement of the milkfish laboratory and spawning cages boosted Igang support facilities.

Research infrastructure at Leganes Brackishwater Station comprised largely pond repair and maintenance. Major repairs were also made on the electric motors, centrifugal pumps, and hatchery electrical system. The Station Cafeteria was renovated, two guard houses were constructed, and the roofs of the Research and Administration Buildings were waterproofed.

At Binangonan Freshwater Station, life support facilities in the carp hatchery/roots blower house were improved. Different buildings in the station and other land and lake-based facilities underwent either repair or renovation. A new water tank was installed to serve the different station facilities and a deep-well was constructed for the station's staff houses.

General Services

Dormitory and Apartment occupancies averaged at 91 and 85, respectively, while Staff House occupancy averaged at 88. A total of 97 guests were billeted at the two Tigbauan Guest Houses with an average length of stay of 2.5 days.

A total of 2,138 visitors were accommodated at the various stations of the Department broken down into 47 dignitaries, 43 researchers/scientists, 338 from the general public, including fish farmers and 1,719 students and teachers.

The Income Monitoring and Recording Activities registered an initial Department income of P1,245,223.19 for the year comprising station income, housing rentals, research produce, training fees, publication sales, and photocopying.

The messengerial services, radio communications services, and Central Records continued to handle messengerial, mailing, mimeographing, photocopying, and recording activities. The Property and Supply Unit continued to supervise the purchasing and recording of supplies and equipment.

Reorganization

After a year without a Deputy Chief, a new Deputy Chief for AQD was appointed, Mr. Satoru Fukumoto, here stressing a point to SEAFDEC Council Chairman Vanich Varikul.

Two most significant events during the year led to the reorganization of the Department: the ouster of former AQD Chief Dr. Alfredo C. Santiago, Jr. and the appointment of Dr. Flor J. Lacanilao as new AQD Chief on April 8.

Another significant event was the appointment of a new Deputy Chief for AQD, Mr. Satoru Fukumoto, on June 10. For one year from June 1985, AQD did not have a Deputy Chief. With his appointment, the Government of Japan released to AQD its fund contribution which was withheld in 1984 and 1985.

Other Matters

Major Drawbacks

One major drawback in the progress of AQD research and development activities was the mass mortality of fish and prawn spawners in broodstock tanks and hatcheries at Tigbauan Research Station on April 6. The incident was investigated by the National Bureau of Investigation (NBI), Criminal Investigation Service (CIS), and the Region VI Philippine Constabulary Command.

Results of the investigation revealed that the cause of death of the fishes and prawns was toxin from a poisonous vine. The culprits, however, have not been identified.

Another major setback was the aborted take-over of SEAFDEC AQD led by a Navy Captain in November. Armed with a nomination letter from the Ministry of Foreign Affairs, the intruder invaded Tigbauan Research Station on November 21 with an entourage of armed bodyguards and security guards, and some present and former AQD employees. Another group assumed control of the Manila Liaison Office on that same day.

Agriculture Minister Ramon Mitra being shown around AQD facilities by Dr. Lacanilao, 8 May 1986.

The Tigbauan group was, however, repelled by the employees. The take-over attempt failed after one week of power struggle. It ended when the Supreme Court issued a restraining order preventing the group from taking over AQD facilities.

Other Administrative Matters

Various committees were either reconstituted or organized anew to assist in the efficient implementation of Department policies.

These committees are the
(1) Provident Fund Plan,
(2) Medical Benefit Plan,
(3) Compensation Review,
(4) Staff Development, and
(5) Rules and Procedure.

Scientific Publications

The following papers were published during the year:

Avila, E.M. 1986. Evaluation of practical diets in the culture of the rabbitfish, *Siganus guttatus* (Bloch) (Pisces: Siganidae) using liver ultrastructure method. *Zool. Anz.* 217:178-191.

Bagarinao, T.U. 1986. Yolk resorption, onset of feeding and survival potential of larvae of the tropical marine fish species reared in the hatchery. *Mar. Biol.* 91: 449-459.

Bagarinao, T.U. and P. Kungvankij. 1986. An incidence of swimbladder stress syndrome on hatchery-reared sea bass *(Lates calcarifer)* larvae. *Aquaculture* 51: 181-188.

Bagarinao, T.U. and K. Thayaparan. 1986. Length-weight relationship, food habits and condition factor of wild juvenile milkfish in Sri Lanka. *Aquaculture* 55:241-246.

Baliao, D.D., R.B. Ticar, and N.G. Guanzon, Jr. 1986. Effect of stocking density and duration on stunting milkfish fingerling in ponds. *J. Aquacult. Trop.* 1:119-126.

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

Bautista, M.N. 1986. The response of *Penaeus monodon* juveniles to varying protein/energy ratios in test diets. *Aquaculture* 53:229-242.

Cruz, E.R. and C.T. Tamse. 1986. Histopathological response of milkfish *Chanos chanos* Forsskal fingerlings to potassium permanganate. *Fish Pathol.* 2:151-159.

Ferraris, R.P., F.D. Parado-Estepa, J. Ladja, and E. de Jesus. 1986. Effect of salinity on the osmotic, chloride, total protein and calcium concentrations in the hemolymph of the prawn *Penaeus monodon* (Fabricius). *Comp. Biochem. Physiol.* 83A:701-708.

Ferraris, R.P., M.R. Catacutan, R. Mabelin, and A. Jazul. 1986. Digestibility in milkfish *Chanos chanos* Forsskal: Effect of protein source, fish size and salinity. *Aquaculture* 59:93-105.

Hara, S., H. Kohno and Y. Taki. 1986. Spawning behavior and early life history of the rabbitfish, *Siganus guttatus,* in the laboratory. *Aquaculture* 59:273-285.

Hara, S., M.N. Duray, M. Parazo, and Y. Taki. 1986. Yearround spawning and seed production of the rabbitfish, *Siganus guttatus. Aquaculture* 59:259-272.

Kohno, H., S. Hara, and Y. Taki. 1986. Early larval development of the sea bass *Lates calcarifer* with emphasis on the transition of energy source. *Bull. Jap. Soc. Sci. Fish.* 52:1719-1725.

Lee, C.S., C.S. Tamaru, J.E. Banno, C.D. Kelley, A. Bocek, and J.A. Wyban. 1986. Induced maturation and spawning of milkfish, *Chanos chanos* Forsskal, by hormone implantation. *Aquaculture* 52:199-205.

Lio-Po, G. and M.E.G. Sanvictores. 1986. Tolerance of *Penaeus monodon* eggs and larvae to fungicides against *Lagenidium* spp. and *Halipthoros philippinensis*. *Aquaculture* 51:161-168.

Lio-Po, G. and H. Wakabayashi. 1986. Immuno-response in tilapia, *Sarotherodon niloticus* vaccinated with *Edwardsiella tarda* by the hyperosmotic infiltration method. *J. Vet. Immunol. Immunopathol.* 12:351-357.

Lio-Po, G., C. Pitogo, and C.L. Marte. 1986. Bacteria associated with infection at hormone-implantation sites among milkfish *Chanos chanos* (Forsskal) adults. *J. Fish. Dis.* 9:337-343.

Marte, C.L. and F. Lacanilao. 1986. Spontaneous maturation and spawning of milkfish in floating net cages. *Aquaculture* 53:115-132.

Nagahama, Y., F.W. Goetz, and J.D. Tan. 1986. Shift in steroidogenesis in the ovarian follicles of the goldfish (*Carassius auratus*) during gonadotropin-induced oocyte maturation. *Develop. Growth Differ.* 28:555-561.

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

Pantastico, J.B., S.F. Baldia, and D.M. Reyes, Jr. 1986. Tilapia (*T. nilotica*) and Azolla (*A. pinnata*) cage farming in Laguna Lake. *Fish. Res. J. Philipp.* 11:21-28.

Piedad-Pascual, F. and A. Kanazawa. 1986. Specific amino acid-free semipurified diets for *P. monodon* juveniles. *Mem. Kagoshima Univ. Res. Cent. S. Pac.* 7:65-72.

Santiago, C.B., O.S. Reyes, M.B. Aldaba, and M.A. Laron. 1986. An evaluation of formulated diets for Nile tilapia fingerlings. *Fish. Res. J. Philipp.* 11:5-12.

Segner, H. and J.V. Juario. 1986. Histological observations on milkfish fry reared to metamorphosis using different diets. *J. Appl. Ichthyol.* 2:162-173.

Tabbu, M.Y., M. Lijauco, R. Eguia, and C. Espegadera. 1986. Polyculture of bighead carp, common carp and Nile tilapia in cages in Laguna Lake. *Fish. Res. J. Philipp.* 11:13-20.

Tabbu, N.S., R. Lacierda, and R. Eguia. 1986. Harvesting techniques for Nile tilapia fingerlings. *Fish. Res. J. Philipp.* 11:39-42.

Taki, Y., H. Kohno, and S. Hara. 1986. Early development of fin-supports and fin-rays in the milkfish *Chanos chanos*. *Jap. J. Ichthyol.* 32:413-420.

Tan, J.D., S. Adachi, and Y. Nagahama. 1986. The *in vitro* effect of cyclic nucleo-

tides, cyanoketone and cycloheximide on the production of estradiol 17 by vitellogenic ovarian follicles of goldfish. *Gen. Comp. Endocrinol.* 63:110-116.

Ver, L.M. 1986. Early development of *C. iredalei* (Faustino 1932) (Bivalvia: Ostreidae). *Veliger* 29:78-85.

Villegas, C.T. and R. W. Doyle. 1986. Duration of feeding and indirect selection for growth of tilapia. *Aquaculture* 57:89-92.

Vogt, G., E.T. Quinitio, and F.P. Pascual. 1986. *Leucena leucocephala* leaves in formulated feeds for *Penaeus monodon*. A concrete example for the application of histology in nutritional research. *Aquaculture 59:-209-234.*

Papers published by AQD staff in *The First Asian Fisheries Forum: Proceedings* (Manila, Philippines, 26-31 May 1986). Edited by J.L. Maclean, L.B. Dizon, and L.V. Hosillos. Manila, Philippines, 1986. 727 p.:

Alava, V. Combination of dietary fat sources in dry diets for *Chanos chanos* (Forsskal) fingerlings.

Bagarinao, T. and T.E. Chua. Egg and larval size among teleosts: Implication to survival conditions.

Gacutan, R.Q. Effects of coconut milk and brown sugar on crude toxins from *Perna viridis* exposed to *Pyrodinium bahamense var compressa.*

Gacutan, R.Q., M. Bulalacao, and H.L. Baranda, Jr. Bacterial depuration of a grossly contaminated batch of oysters, *Crassostrea iredalei.*

Hara, S., H. Kohno, T. Bagarinao, M. Duray, A. Gallego, and Y. Taki. Feeding habits of larval rabbitfish *Siganus guttatus* in the laboratory.

Kohno, H., S. Hara, A. Gallego, M. Duray, and Y. Taki. Morphological development of the swimming and feeding apparatus in larval rabbitfish, *Siganus guttatus.*

Kungvankij, P., A.G. Taleon, K. Corre, B. Pudadera, G. Taleon, E. Borlongan, and I. Potestas. Use of acetes as the prime food for rearing tiger shrimp larvae.

Lio-Po, G. and R.C. Duremdez. The pathogenicity of bacteria associated with transport stressed *Chanos chanos* Forsskal fingerlings.

Lio-Po, G., R.C. Duremdez, and A. Villaluz. Disease investigation of transport stress-related conditions of *Chanos chanos* Forsskal stocked in Laguna Lake.

Llobrera, A.T. Antibiotic uptake by the giant freshwater prawn *Macrobrachium rosenbergii* using the osmotic infiltration technique.

Llobrera, A.T. and M.L. Bulalacao. Effects of storage on the microbial quality of slipper-oysters, *Crassostrea iredalei.*

Marte, C.L., G. Quinitio, J. Toledo, A. Castillo, and R.C. Mesa. Egg collection of naturally spawned milkfish eggs in floating cage.

Marte, C.L., N.M. Sherwood, L.W. Crim, B. Harvey, and J. Toledo. Induced spawning in milkfish (*Chanos chanos* Forsskal) with mammalian and salmon analogues of gonadotropin releasing hormone (GnRH A) administered as osmotic pump implant, cellulose cholesterol pellet implant or injection.

Millamena, O., J. Primavera, and R. Pudadera. The effects of diet and reproductive performance of pond-reared *Penaeus monodon* Fabricius broodstock.

Nacario, J.F. Improved survival of milkfish, *Chanos chanos* Forsskal larvae reared in bigger tanks.

Nacario, J.F. and N. Sherwood. The use of LH-RH analogues in the spawning of the sea bass, *Lates calcarifer* (Bloch): Comparison of pellet, injection, and osmotic pump.

Palisoc, Jr., F. Observations on the effect of *Epipenaeon ingens nobili* (Epicaridea: Crustacea) in *Penaeus semisulcatus* de Haan and *P. japonicus*).

Pascual, F. Effect of lecithin and lipid sources on the growth of *P. monodon* juveniles.

Posadas, R. The effect of salinity on the maturation and spawning of ablated *Penaeus monodon* Fab.

Potestas, I.O., P. Kungvankij, L.B. Tiro, and B.J. Pudadera. Comparative study on the growth performance of hatchery-bred and wild caught fry for sea bass *Lates calcarifer* (Bloch).

Primavera, J.H., R.A. Posadas, and N. Aquino. Effect of maturation salinity and spawning salinity on fecundity and hatch rates of ablated and unablated *Penaeus indicus*.

Pudadera, Jr., B., K. Corre, E. Coniza, and G. Taleon, Integrated farming of chicken broiler-fish-shrimp in brackishwater ponds.

Tiro, L., P. Kungvankij, B.V. Pudadera, and I.O. Potestas. Manipulation of extensive culture techniques for economic production of tiger shrimps (*Penaeus monodon*) in brackishwater ponds.

Villegas, C.T., A. Trino, and R. Travina. Correlation between spawner size and the biological components of the reproduction process of *Penaeus monodon* Fab.

Collaborative Projects

The Department continued to collaborate with the following international and national agencies:

International Development Research Centre (IDRC) of Canada

The Department continued to implement Aquaculture Training, BRAIS Project, and research projects in collaboration with IDRC. The first involves manpower training while BRAIS aims to provide quality and effective information services on tropical aquaculture, particularly on brackishwater aquaculture.

In May, a two-year research grant was awarded by IDRC to AQD to undertake the research project entitled "Fish Genetics Network" in cooperation with Dalhousie University in Canada and three Asian research institutions. The project aims to develop a selection and produce a salinity-tolerant strain of commercially superior tilapia (*Oreochromis niloticus*).

In June, another two-year grant was awarded to AQD by IDRC to undertake research on the efficacy of a range of synthetic luteinizing hormone-releasing hormone analogues (LH-RH-A) administered by various means on the spawning response of milkfish and sea bass. The "Fish Gametes" project is implemented by AQD in collaboration with the University of Victoria and Memorial University of Newfoundland, Canada.

US-AID/Oceanic Institute

The research project on some aspects of the artificial propagation of milkfish had been implemented at AQD's Naujan Substation in collaboration with US-AID through the Oceanic Institute.

The research project was terminated on 30 June 1986. Representatives from Oceanic Institute (OI) US-AID, SEAFDEC, and IDRC will meet in Singapore in April 1987 to discuss extension of the project and identify areas of collaboration.

IFREMER/COP

In March, the Institute Francais de Recherche pour L'exploitation de la Mer (IFREMER) Center Oceanologique du Pacifique (COP) awarded a two-year research grant to AQD for the implementation of the project entitled "Induction of spawning in *Lates calcarifer* by hormonal and environmental manipulation and weaning of larvae and rearing them to metamorphosis by using artificial diets."

UNDP/FAO-NACA

The Department continued to implement the UNDP/FAO-NACA Training Course for Senior Aquaculturists in Asia and the Pacific Region. AQD serves as the Regional Lead Center in the Philippines for the Network of Aquaculture Centres in Asia (NACA).

Also being implemented is NACA's project on the second-

ment of junior scientists. During the year, two Indonesian junior scientists underwent training at AQD. On the other hand, one AQD staffer also underwent training at NACA's Regional Lead Center in Thailand.

Artemia Reference Center (ARC)

A memorandum of agreement for the continuation of the collaborative research project on *Artemia* with ARC of the State University of Ghent, Belgium was signed in December. The project shall include mass production of *Artemia* in indoor systems; processing, utilization and storage of *Artemia;* and mass production of *Artemia* cysts and biomass in ponds.

ICMRD-University of Rhode Island

AQD negotiated with the International Center for Marine Resources Development (ICMRD) through the University of Rhode Island for the implementation of a collaborative research, development, and education program in various disciplines relevant to marine resources.

American Soybean Association (ASA)

ASA continued to award research grants to specific studies particularly in nutrition and feed development.

International Center for Living Aquatic Resources Management (ICLARM)

The Department collaborated with ICLARM in the implementation of research projects under the Asian Fisheries Social Science Research Network (AFSSRN). AQD joined AFSSRN in May 1985, and as of December 1986, two research studies on the production economics of prawn (*P. monodon*) hatchery, nursery, and grow-out production systems were completed. The study on the cost and returns of newly developed aquaculture systems is still ongoing.

University of the Philippines in the Visayas (UPV)

In addition to the implementation of the Training Course for Senior Aquaculturists in Asia and the Pacific with UNDP/FAO-NACA and UPV, AQD is also working with UPV on the development of communication materials under the Rainfed Resources Development Project in collaboration with PCARRD.

University of the Philippines, Marine Science Institute (UPMSI)

The Department continued to work with the UPMSI on the determination of genetic variation of milkfish within Philippine waters. The study shall be valuable in the formulation of milkfish stock management strategies in the country.

Bureau of Fisheries and Aquatic Resources (BFAR)

The Department continued to work with BFAR for in-situ seminars with assistance from local fishfarmers associations. Technology verification of extensive and semi-intensive prawn culture conducted in early 1986 involved the four Demonstration and Training Centers (DTC) of BFAR fishponds.

The Department continued to provide technical assistance to the National Bangus Breeding Program (NBBP). Monitoring activities conducted in March revealed that 5 year-old sabalo stock in Alaminos, Pangasinan spawned as evidenced by eggs found in egg collectors installed in the cage. Spawning also occurred in April and May at Masinloc, Zambales and Sta. Cruz, Davao and also in September at Calape, Bohol.

On the other hand, AQD through BFS, in cooperation with BFAR, launched its 1986 Cooperators' Program. Carp fingerlings were distributed to members of the Samahan Ng Maliliit na Fishpen Operators from Pila-Pila, Binangonan; Nagsulu, Cardona; and Pililia, Rizal. A Memorandum of Agreement was signed to formalize the extent of AQD assistance to local fishermen.

Philippine Council for Agriculture Research and Resources Development (PCARRD)

With PCARRD as the coordinating agency, the Department collaborated with UPV and MAF-BFAR in developing communication materials under the Fisheries Sub-project of the Rainfed Resources Development Project (RRDP). The project aims to improve fish production and increase income of fish farmers through effective information delivery systems or communication strategies, and development of low-cost communication materials. The Fisheries Subgroup developed and produced a variety of mutually reinforcing prototype communication materials based on benchmark information previously documented.

Other National Agencies

A research and development project was implemented by AQD in collaboration with UPV, the Ministry of Agriculture and Food (MAF), and the Iloilo Fish Producers Association (IFPA). The project aims to field-test SEAFDEC formulated feeds for prawn developed at AQD. SEAFDEC is also a member of the Regional Food and Agriculture Council (RFAC).

An initial experimental run on semi-intensive prawn production under different pond conditions was made in August-December. Results were encouraging. Two more experimental runs using similar prawn diets and feeding technique will be conducted next year.

FAO World Food Day

The SEAFDEC Binangonan Freshwater Station (BFS) was the site of the 6th FAO World Food Day Celebration last October 16. The Station was chosen by the WFD National Executive Committee composed of 20 government agencies in line with this year's theme on the "Fishermen and Fishing Communities."

The focus of this year's celebration was on small-scale fisheries, their vital contribution to food supplies and to the improvement of the socio-economic conditions of fish-farming communities, one of the five programs of action proposed during the 1984 FAO World Conference on Fisheries Management and Development.

The WFD Celebration was attended by participants and distinguished guests from the Ministry of Agriculture and Food, the National Food Authority,

SEAFDEC Member Countries are committed to promoting world food sufficiency. Above, their flags including that of SEAFDEC unfurl at the Aquaculture Department main station in Tigbauan, Iloilo, Philippines.

the Municipality of Binangonan, Bureau of Fisheries and Aquatic Resources, Embassy of the People's Republic of China, and NACA. The offices of FAO and UNDP were also represented.

The celebration was highlighted by a symposium (Pulong-pulong sa Binangonan) on "Optimizing Local Fishery Resources" with more than 100 small fishermen participants from Rizal, Laguna, and Cavite. Two position papers on optimizing local inland and capture fisheries were delivered by Dr. Arsenio S. Camacho, BFS Head, and BFAR Assistant Director Inocencio Ronquillo.

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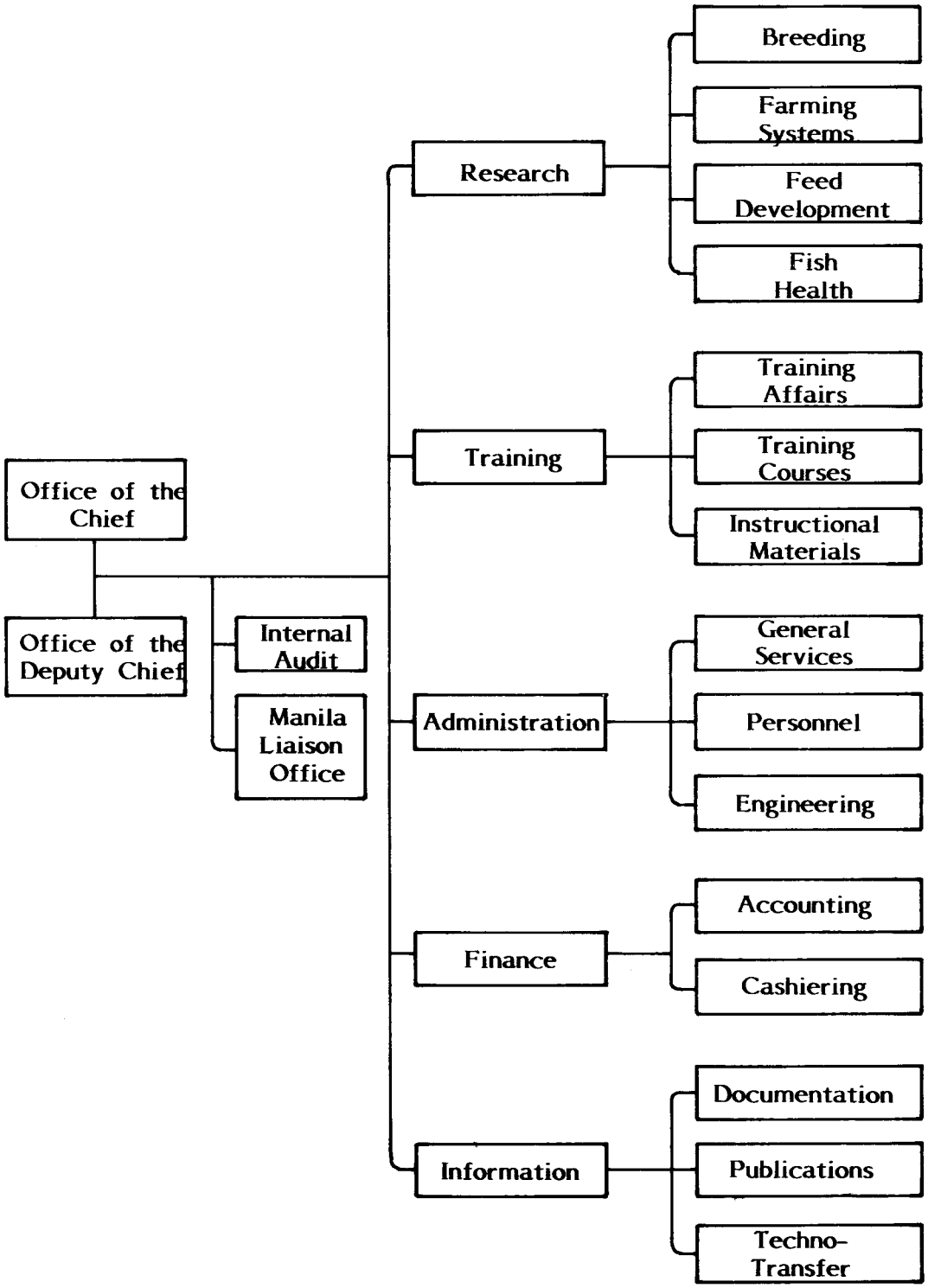
ORGANIZATIONAL CHART OF THE AQUACULTURE DEPARTMENT*



*Approved during the Nineteenth Meeting of the SEAFDEC Council, Tokyo, Japan, 18-21 November 1986

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