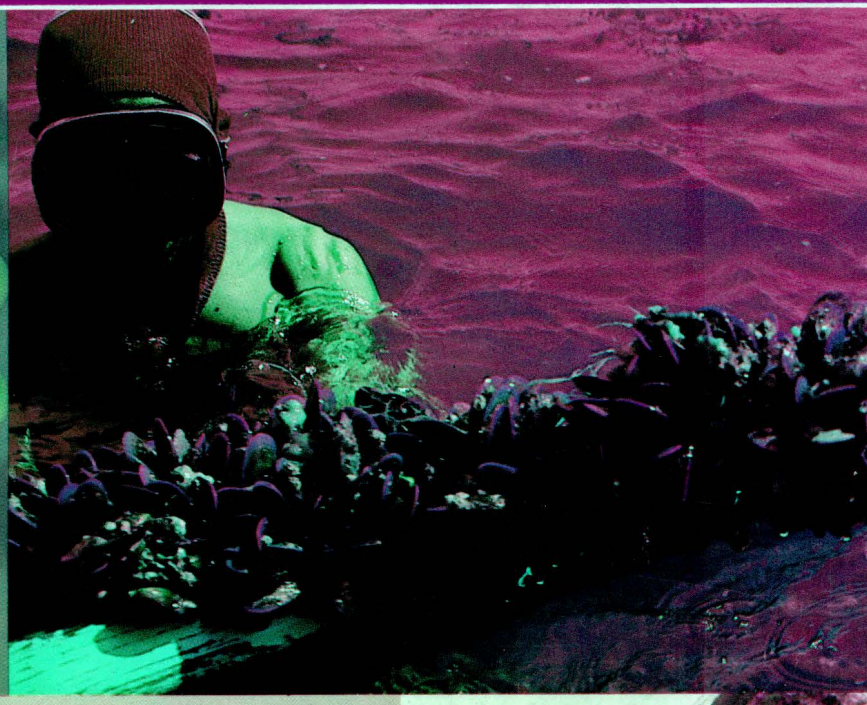
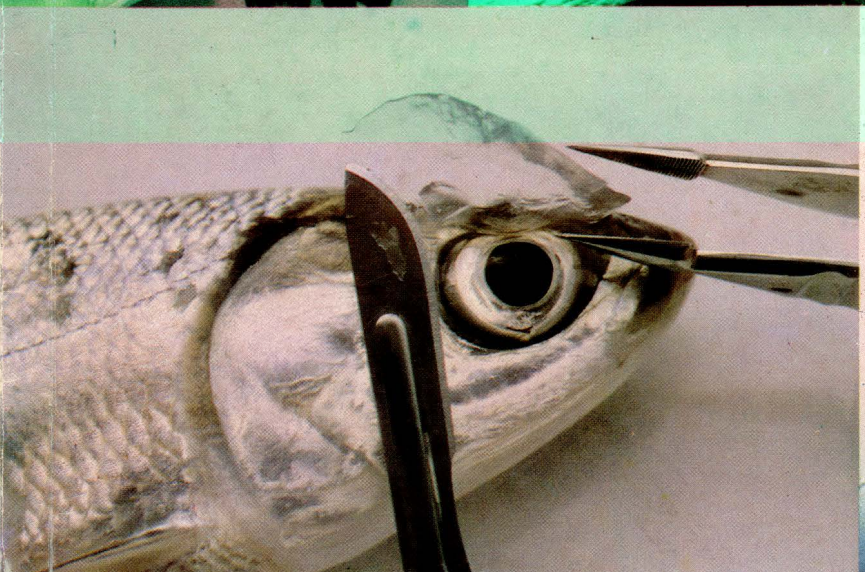
Annual Report 1983

SEAFDEC Aquaculture Department





Contents

Foreword

1983 ended the first decade of operations of the Aquaculture Department. More significantly, it marked the entry of the Department into another decade. The year therefore was a time for evaluation of accomplishments and, fittingly, a time for new institutional adjustments, program reorientation and developmental planning in order to keep up with the dynamic changes in the social and economic situations of the countries in this region and to remain continuously relevant to the needs of their aquaculture industries.

The institutional adjustments and the new programs as well as results of research and development projects that were made in 1983 are reported in this issue of the SEAFDEC Aquaculture Department Annual Report. What we initiated and accomplished in 1983 have but one purpose: to increase further the technological headstart that the Department has generated and sustained for the region's aquaculture industry in the past ten years.

ALFREDO C. SANTIAGO, JR.
Chief
SEAFDEC Aquaculture Department

May 1984

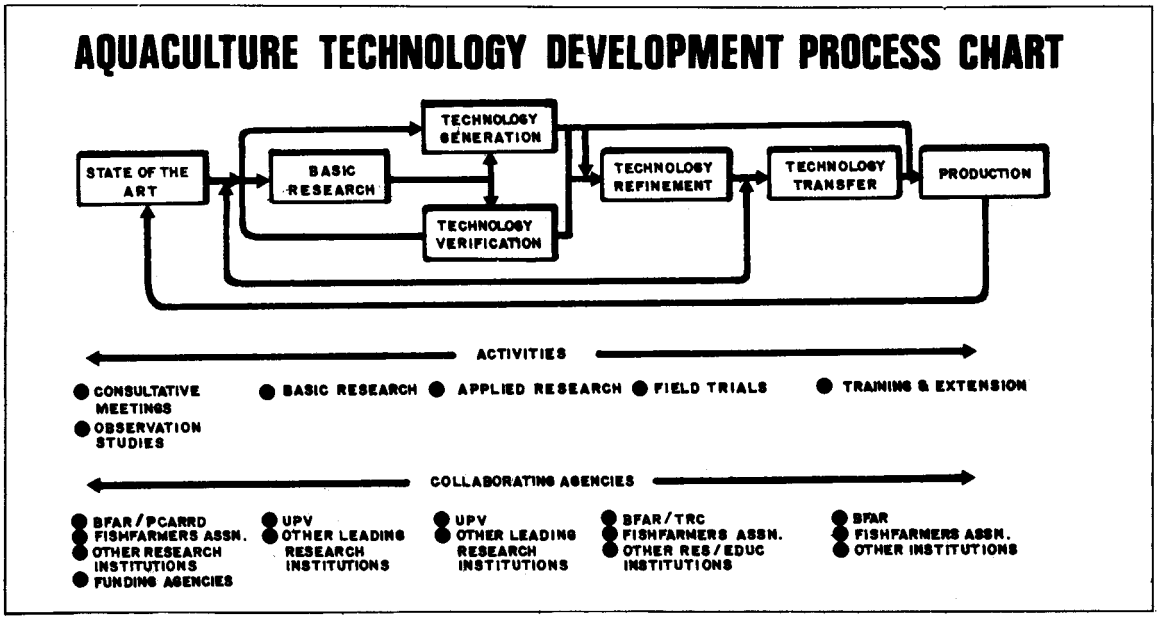
Overview of 1983 Activities

The Department continued efforts towards orienting its activities to the development of the aquaculture industry through a multi-disciplinary team approach in solving production and related problems. A team studies specific problems and evolves out of the results, recommendations designed to do away with bottlenecks in production. Gaps in the production technology are identified through periodic assessment by each program in consultation with representatives of the government and private sector and scientific institutions.

Research programs focus on problem areas specific to economically important aquatic species, which have been grouped into crustaceans, finfishes and molluscs. Training and extension efforts were intensified and technology verification programs were implemented. Projects to strengthen the Department's institutional capability to do and support research have been initiated.

The Naujan substation was re-opened and the Igang substation was improved. The main stations at Leganes, Tigbauan, Binangonan and Batan underwent facility improvement.

The Department also hosted three meetings and conferences: The Symposium on Aquaculture Research and Development held in July; the Sixth Program Committee Meeting of the SEAFDEC in August; and the Second International Milkfish Aquaculture Conference held in collaboration with the International Development Research Centre of Canada in October.



The Technology Development Process Chart now being followed by the Department in planning and implementing its R & D programs.

Research

The Department continued to strengthen its research and production-oriented programs to make these responsive to the needs of the aquaculture industry. The programs are focused on economically important groups of aquatic species, such as finfishes, crustaceans, and molluscs and seaweeds.

Thirteen (13) research projects, comprising 140 studies were implemented in three stations (Tigbauan, Leganes and Binangonan) and in the substations (Batan, Igang and Naujan). The Naujan Substation (Mindoro Oriental) was reactivated to serve as an outreach station for research on milkfish spawning and maturation. Negotiations were made to acquire freshwater pond systems in Bay, Laguna for the Department.

Finfish Program

The program was organized with the aim of solving some of the constraints to the intensification of the finfish industry. The general objectives of the program are: (1) to develop broodstock of good quality for milkfish, tilapia, grey mullet, sea perch (sea bass), rabbitfish, silver carp, bighead carp, and common carp; (2) to refine and/or standardize techniques for the mass production of fish seeds; (3) to develop techniques to catch, transport and store fish seeds with minimum mortality; (4) to improve existing culture techniques so that production can be maximized with minimum inputs; (5) to develop practical diets for different stages of the above-mentioned species, particularly for broodstock, larvae to fry, and fry to fingerlings; and (6) to identify parasites and diagnose diseases afflicting the above-mentioned species and develop methods for their elimination, control and prevention.

To help attain these objectives, four major projects were approved for the program in 1983: Broodstock, Seed Production, Culture, and Special Projects. Activities in the program were implemented at Tigbauan, Leganes, Binangonan, Igang and Naujan stations.

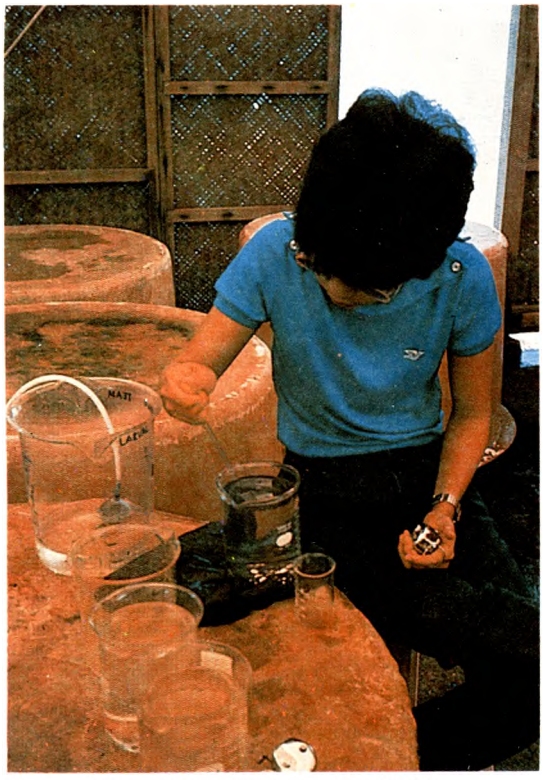
BROODSTOCK DEVELOPMENT

Maturation studies at the Igang Substation focused on the effects of different nutritional and physiological parameters on the reproductive potential of milkfish. In Naujan, the acclimation of adult milkfish or "sabalo" from Naujan Lake to conditions in offshore pens was investigated. Broodstock studies were also undertaken on other commercially important fishes such as carp and tilapia in Binangonan, and seabass and mullet in Tigbauan and Leganes.

- Milkfish (*Chanos chanos*)

The sexual maturation and spawning of hatchery-bred five-year old milkfish reared in floating cages at Igang Substation marked the completion of the milkfish life cycle in captivity. A total of 14 spawnings of hatchery-bred five-year old fish were recorded, producing 770 to 114,000 eggs with survival rates ranging from 8% to 74%. Serum samples from fish of different ages and gonadal stages were analyzed for levels of steroid hormones. In females, both Estradiol-17B (E_2) and Testosterone (T) increased during sexual maturation while in males, gonad development is associated with increased T levels.

Marketable size milkfish were reared in 3-m and 5-m diameter floating cages at stocking densities of 1.0, 2.0 and 4.0 kg/m^3, and were fed crustacean pellets twice daily at 2.0% body weight per day. After 12 weeks, juvenile milkfish grew faster in the 5-m diameter cage than in



Determining the hatching rate of milkfish.

the 3-m diameter cage for all stocking densities tested.

To establish genetic markers for sex in milkfish, serum protein pattern of male and female fish at different stages of maturity were examined using polyacrylamide disc gel electrophoresis. Seven main protein fractions were observed, three of which showed changes in relation to maturation: fraction I, which migrates ahead of the rest; II, which is negatively correlated with the gonadosomatic index (GSI); and VI, which is positive to lipoprotein staining. Fraction VI can be separated into three bands; band no. 2 is prominent only in immature samples. Fractions I and VI show increasing density towards maturation and decreasing density in spent samples for both male and female fish. Although serum protein patterns of male and female milkfish are not significantly different, these can be useful indicators of gonadal maturity.

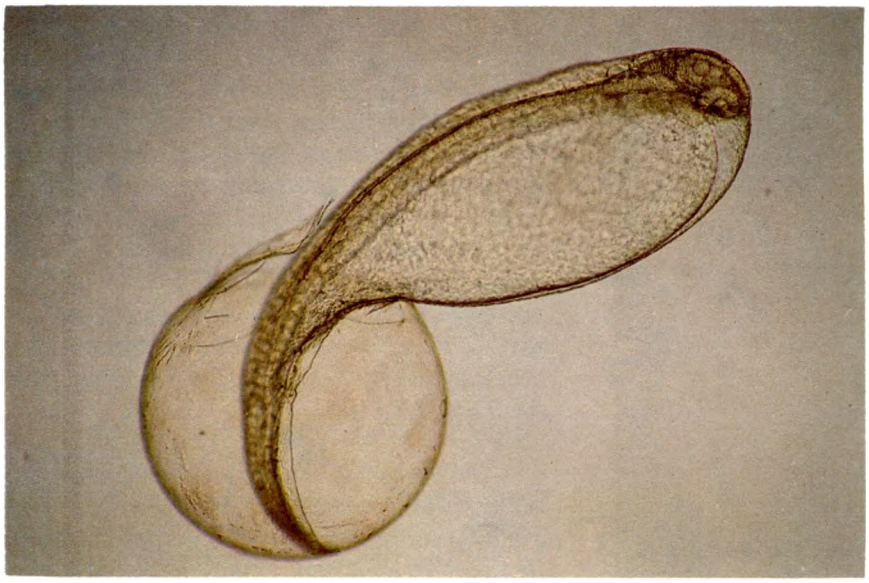
Milkfish fry (21 days after hatching) stocked in the tanks and in pond were sampled at regular intervals until the onset of gonadal differentiation. Milkfish reared in these two holding structures did not differentiate at the same time. Sex differentiation started 4 months after stocking for fish reared in the pond, with body weight ranging from 105.7-173.2 g. Fish reared in the tanks showed signs of sex differentiation about 6 months after stocking, with body weights ranging from 34.2 g to 43.9 g.

A preliminary study investigated the effects of various steroids on pituitary gonadotropin activity and gonad histology in juvenile milkfish. Long acting preparations of Estradiol-17 B, Testosterone, and Progesterone were implanted intraperitonially on two-year old milkfish. After two months, no differences were observed in GSI and gonad histology of treated and control fish. Serum and pituitary samples are yet to be analyzed for steroid and gonadotropin levels.

Milkfish broodstock development under selected pond conditions and diets was also pursued. Eight-month old milkfish juveniles were stocked in three 6,000 m^2 ponds and fed daily with commercial feed (20% and 40% protein) at 2% of the body weight per day. After one year culture period, the fish fed with commercial diets gained a mean weight of 872 g for the diet containing 40% protein and 788 g for the diet with 20% protein. Mean weight gain of 550 g was attained by fish subsisting on natural food (lablab).

- Sea bass (*Lates calcarifer*)

Sea bass juveniles (250-500 g) were stocked in floating cages in Igang and fed trash fish at 10% weight per day. Weight gain was approximately 77% after one year culture period but gonad samples examined were still at the immature stage.



Hatching of milkfish (24 hours after fertilization).

- Tilapia (*Oreochromis niloticus, O. mossambicus,* red tilapia)

Hematocrit values, hemoglobin concentration, erythrocyte count, and erythrocyte sedimentation rate of *Oreochromis niloticus, O. mossambicus* and red tilapia were determined. Higher hematocrit values and hemoglobin concentrations were obtained in male *O. niloticus* and *O. mossambicus* than females. On the other hand, red tilapia females had higher hematocrit values than the males. Attempts are being made to correlate blood properties with length, weight of fish, and degree of sexual maturity.

In another study, breeders were fed with 20% crude protein diets containing varying amounts of ipil-ipil leaf meal (0-80% of the diet). As the dietary level of ipil-ipil leaf meal increased up to 40%, the females recorded a decreasing body weight, while males gained weight invariably. Fry production was highest for those fed with the control diet (0% ipil-ipil) and diet with 20% ipil-ipil leaf meal. Fry production of those fed with 40% ipil-ipil diet decreased by 15%, and those fed with 80% ipil-ipil diet by 57% compared to the control.

Another study determined the optimum sex ratio and appropriate stocking density of *O. niloticus* spawners to increase fry and fingerling production. Tilapia were stocked in land-based (concrete tank) and lake-based (hapa net) hatcheries, in ratios of 1:4, 1:7, and 1:10 male to female at stocking rates of 4, 7 and 10 spawners/m^2. The sex ratio of 1:4 male to female stocked in either concrete tanks or hapa nets at 4 spawners/m^2 produced the highest number of egg and fry.

SEED PRODUCTION

A total of 16 studies were conducted, aimed to solve problems of fry shortage of commercially important fishes such as milkfish, tilapia, carp, sea bass, etc.

- Milkfish

Induced Spawning

One mature female sabalo from Igang, coming from the 1978 artificially-bred batch, was induced to spawn. Initial egg diameter was 0.77 mm and increased to 0.99 mm after injections of luteinizing hormone-releasing hormone (LH-RH) and

two injections of human chorionic gonadotropin (HCG). The fish did not spawn but is still alive.

Sperm preservation

Since mature male and female milkfish are usually not available at the same time, the feasibility of preserving milkfish sperm using two methods was investigated. Under liquid preservation (0-4°C), sperm motility was better in extender solutions containing 150 mM NaCl and 0.8-1.6 g/100 ml of albumin than in solutions containing different concentrations of either NaCl or KCl and lower concentrations of albumin. Under cryogenic preservation (-196°C), however, albumin did not significantly alter sperm motility.

Physiological studies

The salinity tolerance limits and salinity resistance of milkfish larvae were studied. Based on 48-hour median tolerance limits (TLm), Day 21 larvae showed the widest tolerance zone (0 to 70 ppt) followed by the Day 0 (8 to 37 ppt), Day 14 (6 to 28 ppt), and Day 7 (27 to 29 ppt) larvae. Wild caught milkfish larvae (fry) exhibited an upper salinity tolerance limit of 70 ppt, a value similar to that of the 21-day old hatchery-bred larvae. Salinity resistance test on 26-day old hatchery-bred milkfish larvae showed that larvae acclimated in higher salinities had longer resistance time.

Experimental evidence indicated that milkfish fry are equipped with functional chloride cells that respond to abrupt salinity changes. Maximal chloride cell activity was shown in fry transferred from freshwater (0 ppt) or seawater (32 ppt) to 45 ppt; minimal chloride cell activity was shown in fry transferred from seawater or freshwater to 16 ppt. Abrupt transfer of fry from freshwater to 45 ppt resulted in a reduced population of chloride cells which absorb salt followed by a proliferation of a population of cells which excrete salt. Abrupt transfer of fry from seawater to freshwater resulted in a reduced population of chloride cells which excrete salt followed by a proliferation of a population of cells which absorb salt. A gradual acclimation for at least 24 hours should be done when transferring fry from freshwater to 45 ppt, and a gradual acclimation for at least 15 hours when transferring from seawater to freshwater.

The osmoregulatory capability of milkfish juveniles in three size ranges (X = 40 g, 120 g, and 260 g) was studied. The fish were acclimated to 32 ppt and abruptly transferred to 0, 16, 32 and 48 ppt. Blood samples were taken at 0, 1, 2, 3, 5, 7 and 14 days after transfer while intestinal fluid samples were collected at day 0 and 14. Plasma osmolalities in fish exposed to salinities other than 32 ppt deviated from the initial and control values immediately after transfer but were subsequently regulated to near-normal levels after several days. Plasma chloride values followed the same pattern of changes as the plasma osmolality. Values of blood parameters began to stabilize on the third day for the 260 g fish, on the fifth day for 120 g, and on the seventh day for the 40 g juveniles. Results also showed that smaller fishes have larger changes in blood parameter values after transfer to salinities other than the control while bigger ones have smaller but still significant changes. This suggests that bigger fishes are more efficient in handling ionic and osmotic induced stress. Intestinal fluid osmolality showed consistently higher values in the anterior than in the posterior regions in all treatments. On the other hand, chloride concentration was consistently higher in the posterior region. In fish kept at 32 and 48 ppt, chloride concentration in the anterior intestine was significantly less than the surrounding medium indicating that absorption of chloride have occurred in regions more anterior to the intestine.

Feeding Biology and Food Preference

Feeding patterns of laboratory-reared milkfish larvae 9 days (6.09 mm in mean total length, TL), 15 days (8.49 mm TL) and 21 days (12.65 mm TL) after hatching were examined under natural light conditions during a 24-hour period. Active feeding (where more than 50% of larvae have food in the gut), commenced at 0630 hour (1560 lux) for Day 9 larvae, 0540 hour (131 lux) for Day 15 larvae and 0500 hour (0.08 lux) for Day 21 larvae. There appears to be a diurnal pattern in the feeding of milkfish larvae. Larvae of the same age consumed equal numbers of rotifers throughout the daylight hours. Food satiation occurred between 0700-0900 hours at varying amounts for larvae of different ages. The average number of rotifers present in the gut of larvae sampled at one hour interval (as the plateau of food intake was approached) was 10 for Day 9, 25 for Day 15 and 100 for Day 21 larvae.

Unialgal cultures of five species of freshwater algae (the blue-green algae *Oscillatoria quadripunctulata* and *Chroococcus dispersus*, the green algae *Euglena elongata* and *Chlorella ellipsoidae*, and the diatom *Navicula notha*) were fed to milkfish fry to determine their algal preference. The blue-green algae seemed to be most acceptable to the fry during all growth stages. The diatom showed limited acceptability based on poor growth, although it favored high survival in later growth stages. The green algae gave variable results. In a second experiment, *Oscillatoria* alone or in combination with *Chroococcus* resulted in high growth rate and survival. High assimilation rates were observed with ^{14}C-labelled *Oscillatoria* and *Chroococcus*, whereas negligible amounts of the ^{14}C-labelled *Navicula*, *Chlorella* and *Euglena* were assimilated.

Experiments were conducted to assess the nutritive value of *Brachionus plicatilis* reared on three selected algal diets (*Chlorella* sp., *Isochrysis galbana*, and *Tetraselmis tetrahele*), as food for milkfish fry. The survival rates of fry fed with *B. plicatilis* reared on the three algal diets ranged from 93.1 to 95.3%. Growth rate was highest in fry fed with *B. plicatilis* reared on *T. tetrahele*, while fry fed with *B. plicatilis* reared on *Chlorella* sp. were stunted. Fatty acid profiles showed more w3 long chain polyunsaturated fatty acids of C20 and C22 in fry fed with *B. plicatilis* reared on *T. tetrahele* and *I. galbana*, respectively. Fry fed *B. plicatilis* grown on *Chlorella* sp. contained the least total lipids (12.7%). The differences in lipid contents of the diets affected the growth rates but not the survival of the fry.

In a related study, the effect of feeding frequency and feeding rates of *Brachionus plicatilis* and *Moina macrocopa* on the growth and survival of milkfish fry was evaluated. *Brachionus* and *Moina* were fed to the fry at the rate of 30 and 60 individuals/ml, for 30 days. Survival rates ranged from 93.5% to 99.0%. Growth rate was higher in fry fed with *Moina* at the rate of 60 individuals/ml irrespective of feeding frequencies. No difference was recorded in growth rate for fry fed with *B. plicatilis* using the two feeding rates and frequencies.

The culture and utilization of *Oscillatoria quadripunctulata* for milkfish fingerling production were undertaken. Varying concentrations of ipil-ipil and duck manure extracts were used to grow *Oscillatoria* under laboratory conditions. Best growth was obtained in media with lower concentrations of ipil-ipil leaf extract. Acclimated fry stocked in glass aquaria were fed *Oscillatoria ad libitum*. The weight gain of the fry increased when more *Oscillatoria* was given.

Larval and Postlarval Rearing

Thirteen batches of spontaneously spawned eggs of milkfish reared to matu-

rity in floating cages were collected from Igang Substation. These were incubated and the larvae reared up to the fry stage. Hatching rates ranged from 8.9 to 72.7% while survival rates ranged from 7.7 to 77.3%. Four batches of eggs produced larvae with bent bodies. The larvae died on day 2 before yolk resorption was completed.

In another study, two-week old milkfish larvae fed solely with rotifers were weaned abruptly to six artificial diets; one-day old *Artemia* nauplii were fed to the control. After 42 days, survival rates of larvae fed with artificial diets ranged from 38% to 63% compared to 42% for the control. Highest survival was observed for larvae fed with artificial plankton (BP), and lowest for larvae fed with moist egg diet. Increase in length and weight were highest in the control and lowest in those fed with moist egg diet (Figure 1).

The effect of varying stocking and feeding rates on growth and survival of milkfish fry was studied. Survival rate was highest (79.7%) at stocking rate of 8 fry/l and lowest (74.3%) at 16 fry/l with the feeding rate of 60%. Feeding rate of 30% gave the lowest survival rates (39.0, 42.0, 45.8%) for all stocking rates.

Digestive Physiology and Nutritional Studies

The developmental morphology of the esophagus, stomach and intestine of the milkfish was studied from hatching until 4 years old. The digestive tract of the newly-hatched larvae was a simple, undifferentiated tube throughout its length. Three days after hatching, the digestive tract was differentiated into the esophagus, stomach and the intestine. Results are summarized in Table 1. The epithelial cells in the cardiac stomach contain neutral mucopolysaccharides, the only region among those examined where mucus secretion is not acidic. Histochemical tests showed that alkaline phosphate, aminopeptidase, and esterase are already present in the cardiac stomach and/or intestine of the 21-day old larvae.

The digestive enzymes of milkfish fry fed different diets (*Artemia salina* nauplii, larval feed and a combination of both) were studied. The total protease, tryptic, chymotryptic, amylase and lipase activities were all found to fluctuate during the six-week rearing period. These fluctuations can be attributed to the adaptation of the fish to the different diets as well as to the stages of fish development. However, the influence of environmental stress brought about by low oxygen levels can not be ruled out.

A practical larval feed (LPD 831) with a protein base consisting of an enzyme-modified fish protein was evaluated using wild caught fry. This formulated diet was found to be stable, acceptable to the fry, and superior to the traditional feeds consisting of egg yolk and flour. However, severe oxygen depletions causing about 50% mortality within 4 hours was observed in one experimental run using this diet. This suggests that it is not feasible to evaluate practical larval feeds experimentally without provision for and maintenance of adequate levels of oxygen in the rearing tank.

Practical diets containing increasing amounts of ipil-ipil leaf meal were also developed for milkfish fry. Growth in weight and length decreased as the level of ipil-ipil leaf meal increased, and survival rates were low for all treatments.

The apparent digestibility of several ingredients used as protein sources in milkfish diet formulation was tested with 2, 60 and 175 g milkfish in freshwater and seawater. In seawater, gelatin was the most digestible; casein, defatted soybean meal and fishmeal have comparable digestibility; and ipil-ipil meal the least digestible

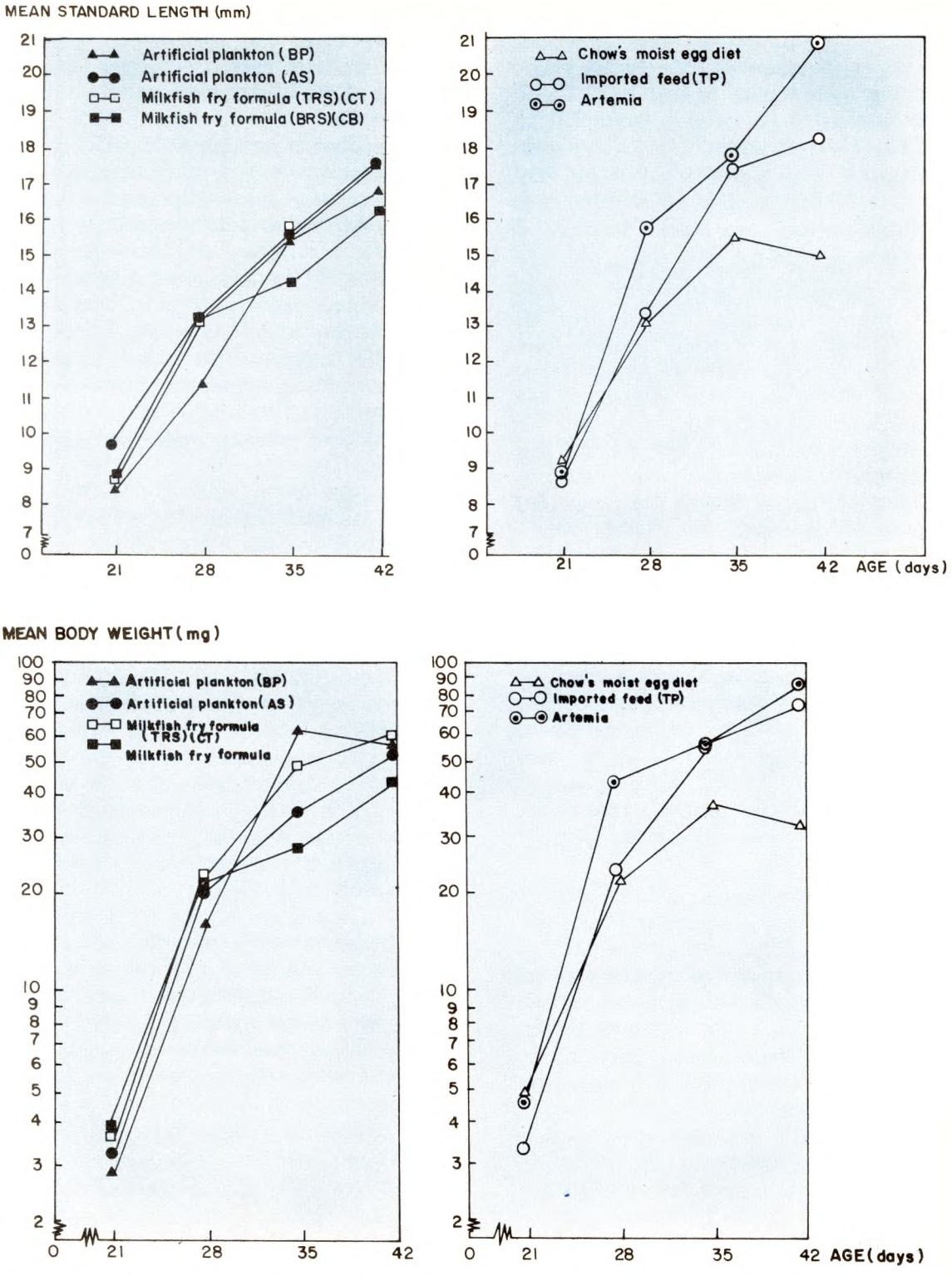


Fig. 1. Growth of milkfish during four weeks of rearing on artificial diets (A) Initial SL 7.5 mm, (B) Initial BW 2.33 mm.

Table 1. Summary of the developmental morphology of the esophagus, stomach and intestine in the milkfish.

Age/Stage	REGION			
	Esophagus	Cardiac Stomach	Pyloric Stomach	Intestine
Newly-hatched	Digestive tract a simple, undifferentiated tube throughout its length			
2-3 days/yolk	differentiated by presence of epithelial cells with secretory products	simple tube composed of low columnar cells without secretory products or cytoplasmic projections, not yet differentiated into cardiac and pyloric regions		differentiated by presence of cytoplasmic projections from the epithelial cells
21 days/fry	appearance of striated circular muscle layer		differentiated from cardiac region by presence of thick circular muscle layer	
45 days/ metamorphosis	mucosal epithelium has copious mucus secretion; development of inner longitudinal muscle layer	development of glands and striated circular muscle	presence of tall columnar cells organized into folds; presence of acellular matrix	appearance of goblet cells and smooth circular muscle larger
60 days/ fingerling	mucosa shows branching			
7 months/ marketable		proliferation of glands		mucosa shows branching; development of outer longitudinal muscle layer
2 years	epithelial cells are organized into lobules			

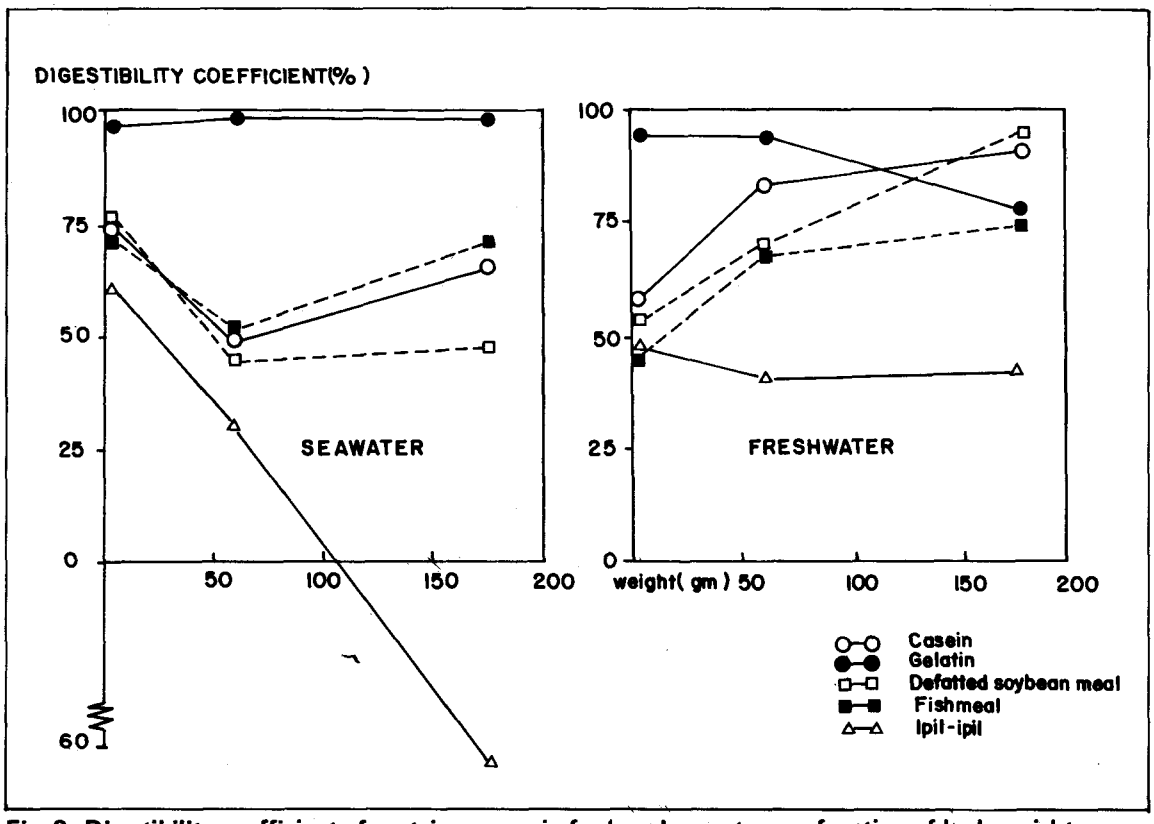


Fig. 2. Digestibility coefficient of protein sources in fresh and seawater as a function of body weight.

apparently due to its high fiber content (8.8%) (Figure 2). In freshwater, digestibility coefficients for defatted soybean meal, casein, fishmeal and ipil-ipil meal increased by at least 15% compared to seawater, while that for casein decreased by 20%.

The qualitative and quantitative nutritional requirements of milkfish fingerling for linoleic and linolenic acids were determined. Fatty acid analyses of fish fed different diets showed that lipid-free and lauric acid diets increased the levels of monoenes in the fish. Linoleic acid suppressed the level of monoenes and increased the polyunsaturated fatty acid (PUFA) content indicating that milkfish can synthesize fatty acids with 20 and 22 carbon atoms from 18 carbon fatty acid sources. The high amount of PUFA in the linoleic and linolenic acid-fed fish contributed to good survival.

Milkfish fingerlings were fed isocaloric, isonitrogenous semi-purified diets containing various sources of fats. Fingerlings fed with diets containing 7 to 10% cod liver oil showed the best growth rate. Combinations using 1:1 ratio of cod liver oil/copra oil and beef tallow/copra oil also showed good growth and survival.

Given the same diet, no apparent differences were observed in the weight, length and percent lipid content of milkfish fry and fingerlings reared in seawater or acclimated to freshwater. Among the tissues studied, the highest total lipid was found in the gills for pond-reared milkfish and in the depot fat for fish under controlled conditions (in tanks). Under both pond and controlled conditions, the intestine contained the least amounts of lipid.

Preliminary inspection of the dose response data for six semi-purified diets

showed a dietary requirement level of 40 g protein per 100 g diet. Milkfish juveniles fed lower than 10% level of protein had low weight gains, low specific growth rates and inferior feed conversion ratios. However, increasing the protein level to 44% did not improve the performance of the amino acid test diet. Survival was 92% over 12 weeks on the diet containing 40% protein; lowest survival was 83% on those fed with the diet containing 32% protein.

Preliminary studies indicate that the levels of ascorbate and ascorbic acid-2-sulfate sulfohydolase (or C_2-sulfatase) activity in the liver and the spleen may be used as indices of the Vitamin C nutritional status of milkfish. However, further purification and characterization of the C_2-sulfatase enzyme is recommended to understand its role in vitamin C nutrition and metabolism.

Diseases, Treatment and Prevention

The tolerance level of milkfish fry and fingerlings to some chemotherapeutic agents was determined. Histopathological responses of gills, liver and kidney to these chemotherapeutics were also analyzed. Results showed that milkfish fingerlings can tolerate up to 1000 ppm of oxytetracycline hydrochloride after 96-hour exposure but the following lesions were observed: lamellar hyperplasia, lamellar detachment, clubbing of the lamellar tips, lamellar fusion, disruption of the filamental systems, bending/twisting of the lamella into abnormal positions, vacuolation of the hepatocytes and disruption of the liver structure. Formalin at 400 ppm was lethal to the fish within 48-hours exposure and histopathological changes in the gills and liver tissues were also observed. Milkfish fingerlings tolerate chloramphenicol up to 1000 ppm after 96 hours.

Mortalities were observed in milkfish larvae reared in tanks/aquaria showing red spots on the surface. The total bacterial load of rearing water from the aquaria with these red spots was almost twice that of aquaria without red spots. Bacterial isolations made from the water, sediments and larvae indicated the predominance of *Vibrio* spp. The ammonia level of the rearing water with the red spot phenomenon was approximately six times than where red spots were not observed.

Gas bubble disease caused mortalities in milkfish fry reared in fiberglass and concrete tanks. Associated signs in live fish include predominantly bilateral exophthalmia, swollen abdomen, hemorrhagic fin bases and hyperemic peritoneal activity. A large percentage of dead fish had perforations in the ventral abdominal cavity.

Some milkfish juveniles polycultured with the Indian prawn in earthen ponds manifested eye abnormalities, e.g. unilateral to bilateral opaque eye membrane/eyeball, exopthalmia and hemorrhagic eyes. Fish with opaque eyes showed higher bacterial counts; bacterial isolates from these fish closely resembled *Vibrio parahemolyticus.*

• Sea Bass

Induced Spawning

The first successful induced spawning of sea bass (*Lates calcarifer* Bloch) in the Philippines was achieved at the Leganes Research Station in August and September, 1983. All of the three females (oocyte diameter ranged from 0.75 to 1.1 mm) and nine males selected for the induced breeding study (3-5 kg body weight, about 3-year old) responsed to Puberogen and HCG given at 100-1,000 I.U./kg fish. Both male and female fish were injected twice at 24 hours interval. The females spawned spontaneously in the tank 9-12 hours after the final injection. Incubation period was 15-20 hours at 26-28°C and 29-32 ppt. With two spawnings, estimated

number of eggs was 11,000 to 180,000; fertilization rates 22 to 70%, hatching rates at 75-85%, and survival rates after 40 days of rearing, 12 to 64%.

Larval rearing

Newly hatched larvae were maintained at 100 individuals/liter but reduced to 40 ind/l and transferred to a bigger tank when they started feeding on *Artemia* nauplii to avoid cannibalism and to maintain water quality. Within the first three days after hatching, the larvae were not fed but single-celled algae were added on the first day to maintain good water quality. Upon yolk resorption, 5 individuals of *Brachionus plicatilis*/ml of water were fed twice daily for 1 week. *Artemia* nauplii, adult *Artemia* and minced fresh fish were given at 10, 20 and 30 days after hatching respectively.

Fourteen-day old sea bass, *Lates calcarifer* larvae were exposed to 1.0 ppm of Thyroxine (T_4) for 4 weeks in 20-l fiberglass tank at 30 larvae/tank. Only one level of T_4 was tested due to limitations of larvae and containers. But statistical analysis showed no significant difference between T_4-treated and untreated larvae.

• **Siganid**

Sperm Preservation

The optimum sperm/egg ratio during dry (undiluted) and isotonic (diluted; 1 part sperm to 24 parts diluent) fertilization of *Siganus guttatus* was determined by using cryopreserved and fresh sperm for fertilizing eggs of varying amounts: 0.5 g, 1.0 g, 2.0 g, 4.0 g, and 8.0 g. Fertilization rates ranged from 82 to 89% when undiluted cryopreserved, undiluted fresh and diluted fresh sperm were added to 1.0 g eggs, while fertilization rate was only 50% when diluted cryopreserved sperm was used. For dry fertilization, the recommended ratio is 0.4 ml cryopreserved sperm for 1.0 g of eggs.

Results of another experiment showed that freezing rate of 20 to 120°C/min gave high sperm motility than slower freezing rate.

Larval Rearing

Siganid larvae are more difficult to rear than milkfish larvae. The mouth opens 34 hours after hatching with the size of about 125 um. These larvae can not readily take rotifers, although fertilized oyster eggs can be used but these were not economical. *Isochrysis galbana* was also tried as food with inconsistent results.

Physiological Studies

Artificially fertilized eggs of *Siganus guttatus* were transferred to seawater of salinities ranging from 8-40 ppt either at the blastomere or at the gastrula stage. Eggs transferred at gastrula stage were more tolerant to salinity change than those transferred at blastomere stage. Percentage of viable larvae was highest at 24 ppt (89.61%) and lowest (29.91%) at 8 ppt. Relatively longer larvae hatched from low incubation salinities compared to those at ambient and higher salinity.

• **Tilapia**

Genetics

The purebred *Tilapia nilotica* grew slightly heavier than the cross *Tilapia nilotica* (M) x *Tilapia mosambica* (F) and *Tilapia nilotica* (M) x *Tilapia aurea* (F) in a 3-month culture period without supplemental feeding in Laguna de Bay. Incompatibility is suspected between *Tilapia aurea* (M) x *Tilapia mossambica* (F).

Nutritional Studies

Four feeding trials were conducted to determine the quantitative essential amino acid requirements of *T. nilotica* fry for lysine, histidine, arginine and phenylalanine. After seven weeks, results showed good survival and growth rates with diets containing 0.5% histidine.

Another study revealed that *Tilapia* fry showed excellent growth and survival when fed with the combination of *Moina*-rice bran and *Moina-Chlorella*-rice bran.

• Carps

The optimum water hardness conditions for hatching carp eggs were investigated. High hatching rates (57-98%), survival rates (42-69%) and viability (58-77%) were attained at 400 and 500 ppm $CaCO_3$. Water absorption was highest in the lower concentrations of $CaCO_3$, but lowest in higher concentrations as a result of the osmotic pressure of the media on the eggs. Incubation period was 18 hours at 26.5°C.

Selected phytoplankton and zooplankton species, namely: *Moina, Oscillatoria, Chroococcus,* and *Chlorella* were fed singly or in combination to the fry of silver, bighead and common carp. Results showed that among the live food organisms tested, growth rate was highest in fry fed with the zooplankton *Moina macrocopa* (Figure 3). Algal species such as *Oscillatoria* and *Chroococcus* were also acceptable, to a limited extent for silver and bighead carp hatchlings, but not for the common carp fry. Survival rate attained was also high on fry fed with *Moina* (Figure 4).

• Grey Mullet

Twenty-day old larvae of grey mullet, *Mugil cephalus* were stocked in 5-liter glass beakers at 10 larvae/l and exposed for 4 weeks at 0.5 ppm and 1.0 ppm of Throxine (T_4). T_4-treated *M. cephalus* larvae appear to have better growth in terms of mean length and weight compared to the controls, although statistic analysis of the data showed no significant difference between T_4-treated and untreated larvae.

CULTURE

Verification and refinement of culture techniques for various finfishes were carried out at the Leganes and Binangonan Research Stations.

• Milkfish

The culture studies for milkfish included rearing in nursery and grow-out brackishwater ponds at Leganes and in freshwater cages in Laguna de Bay.

Nursery

Milkfish fingerlings were stocked in holding/transition ponds following the lablab method of culture, at stocking densities of 15, 20, 25 and 30 fingerlings/m^2. Nylon screen substrates were installed across the pond bottom to increase area for attachment of fish food organisms. Supplemental feeds composed of fine rice bran mixed with fresh trash fish were given every other day at 2% of the biomass after 30 days from stocking. The highest average weight gain of 4.6 g after 3 months was attained by fish stocked at 20 ind/m^2; those stocked at 15 ind/m^2 gained 4.1 g while those stocked at 25 and 30 ind/m^2 gained 3.8 g. Results of the study will be evaluated at the end of a six-month culture period.

A pilot scale study on milkfish fingerling production was undertaken using nylon screen substrates and supplemental feeding. Milkfish fry were grown to fingerling size in earthen nursery ponds for

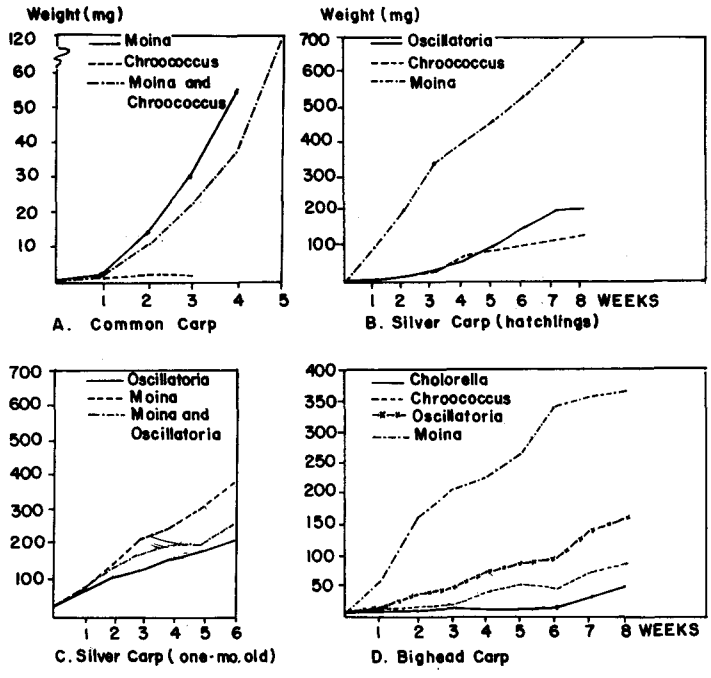


Fig. 3. Growth rate of carp fry fed with different algal species and *Moina* given singly or in combination.

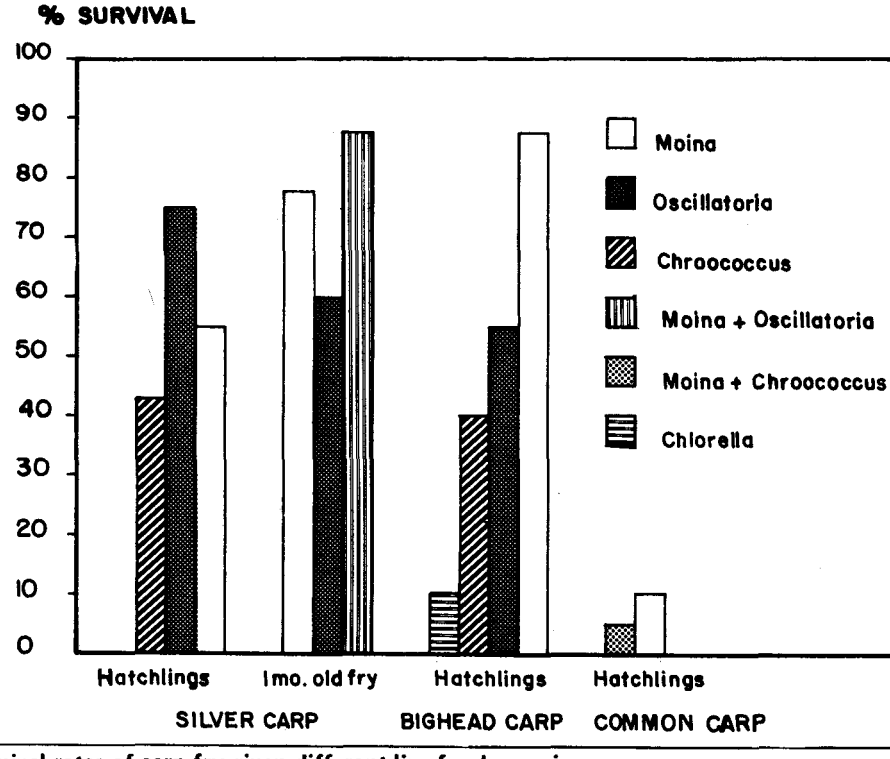


Fig. 4. Survival rates of carp fry given different live food organisms.

60 days at stocking density levels of 75 and 100 fry/m^2, using the lablab method of culture. Minced fish was given daily at 2% body weight. No significant difference in terms of growth and survival rates was observed for the two stocking densities (Table 2). This technique improves the existing practice which uses no nylon screen substrates nor supplemental feeds and results in only 50 to 60% survival.

In Laguna Lake, milkfish fry were reared to fingerlings in nursery cages at different stocking rates with or without supplemental feeding. The best growth and survival rates were obtained for stocking rates at 100 to 125 fry/m^2. Supplemental feeding did not improve growth or survival. Fingerling size (5 to 10 cm length) was attained in four to six weeks, similar to results reported for brackishwater nursery ponds.

Grow-out

The effects of stocking density and feeding regime on the growth and survival of milkfish in grow-out ponds using the deep water method were assessed. Milkfish fingerlings with mean total length of 5.8 cm and body weight of 1.4 g were stocked in six 1,900 m^2 ponds at densities of 4,000, 6,000 and 8,000 ind/ha. Each pond was fertilized with (N:P:K) fertilizers consisting of urea and 16-20-0. After a 120-day culture period, highest average survival of 96.3% was attained at stocking level of 8,000 ind/ha. The highest mean length (0.24 cm) and weight (6.6 g) were attained at stocking level of 4,000 ind/ha (Table 3).

Two size groups of fingerlings were stocked at staggered time intervals in brackishwater ponds. Four treatments were evaluated, all at a stocking density of 6,000 fish/ha, with the stocking schedule shown in Table 4. Five-gram fingerlings averaging 90 mm in length were used at each stocking, except for treatment I which was stocked simultaneously with 5-gram and 4-gram fingerlings each at 3,000 fish/ha for a total of 6,000 individuals/ha. Treatment IV attained the highest average weight gain of 216.6 gram/fish while treatment I showed the lowest (165.7 g/fish) for a 90-day culture period. Survival rates for each treatment were comparable.

A modular pond system (Figure 5) for milkfish culture was evaluated. Four sets of newly constructed ponds were used, each set having three ponds built progressively in a ratio of 1:2:4 (corresponding areas of 550, 1100 and 2200 m^2). Milkfish fingerlings averaging 12 g per fish were stocked using 2 schemes: (a) stocking rate of 3,000/ha based on the area of the last module, and (b) stocking rate of 3000/ha based on the total area of all modules. At harvest, mean weight and survival were 251.0 g and 87.0% for scheme (a), and 242.8 g and 89.0% for scheme (b). The net production of 613.5 kg/ha/crop for scheme (b) was significantly higher than in (a) (357.4 kg/ha/crop). This difference in production was influenced by the increase in stocking rate in scheme (b). Based on seven croppings per year and using scheme (b), a total net production of about 4 tons per year is attainable.

Another pilot-scale study was undertaken to refine stock manipulation techniques in the modular pond system. One set of modular ponds with respective areas of 1, 2 and 4 hectares was used. Two production runs each lasting for 90 days, at a stocking density of 3,000 fish/ha based on the area of the last module, yielded a gross production of 2.2 tons and 2.4 tons (average weight of 200.8 g/fish and 93.3% survival for the first run and 198.4 g and 99.4% survival rate for the second run).

- **Tilapia**

Azolla pinnata grown in hapa cages

Table 2. Growth and survival of milkfish fry grown to fingerling size in nursery ponds with substrates and supplemental feeding.

Stocking Density	Weight (g)		Length (mm)		%
	Initial	Final	Initial	Final	Survival
75 fry/m^2 (112,000 fry/1,500 m^2)	0.005	2.5	13.13	71	81%
100 fry/m^2 (150,000 fry/1,500 m^2)	0.005	3.0	13.13	65	79%

Table 3. Stock and harvest data of milkfish reared for 120 days in 1,900 m^2 earthen ponds using the deep-water method.

(Stocking Density)	Pond No.	Stocking		Harvest		Production (kg/ha)	Survival (%)
		No. of individuals	Average weight (g)	No. of individuals	Average weight/fish (g)		
(0.4/m^2) Average	1	760	1.4	419	217.8	480.2	55.1
	6	760	1.4	644	182.2	617.0	84.7
		760	1.4	531.5	200.0	548.6	69.9
(0.6/m^2) Average	2	1,140	1.4	1,134	119.9	715.4	99.5
	4	1,140	1.4	908	120.0	573.3	79.7
		1,140	1.4	1,021	120.0	644.4	89.6
(0.8/m^2) Average	3	1,520	1.4	1,454	101.1	773.2	95.7
	5	1,520	1.4	1,473	84.2	652.2	96.5
		1,520	1.4	1,463.5	92.6	712.7	96.3

Table 4. Stocking schemes for milkfish fingerlings stocked at staggered time intervals.

Stocking Schemes	Treatments			
	I	II	III	IV
0-day interval	6,000	3,000	3,000	3,000
15-day interval	–	3,000	–	–
30-day interval	–	–	3,000	–
45-day interval	–	–	–	3,000
Total fish per hectare	6,000	6,000	6,000	6,000

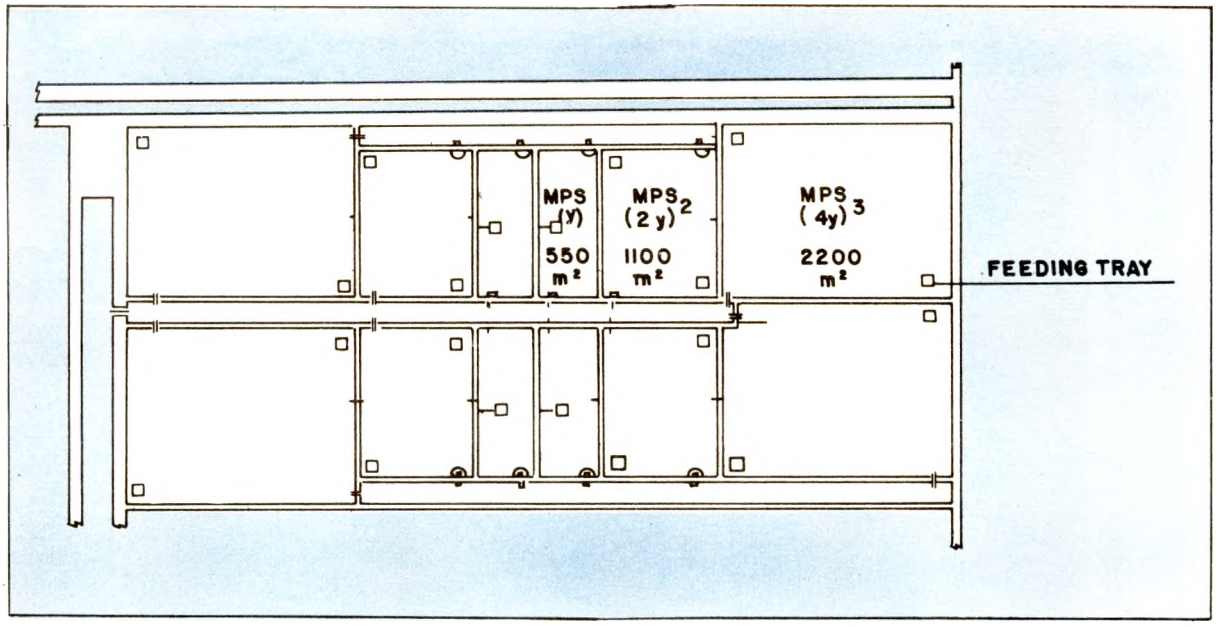


Fig. 5. The experimental modular pond system at Leganes Research Station.

in Laguna Lake were fed directly to tilapia. In one experiment, postfingerlings of *T. nilotica* with initial mean weight of 134. g and length of 9.2 cm, stocked in B-net cages (1 x 1 x 1 m) at 25 fish/cage, were given *Azolla* at 30% of the body weight. By the third month, the tilapia gained 45% weight compared to the control which received no supplemental feeding. In a second experiment, tilapia with initial mean weight of 12.8 and length of 41.1 mm were given *Azolla* at 70% and 35% of the body weight. Preliminary results are shown in Figure 6.

- Carps

Bighead carp post-fingerlings with average weight of 21.4 g were stocked in 5 x 5 x 3 m *B*-net pens at a density of 8 ind/m^2. After 10 months, the highest average weight attained was 435.0 g.

SPECIAL PROJECTS

Ten special projects were carried out under the Finfish Program for 1983. Among these were collaborative studies with other agencies such as the Ministry of Natural Resources (MNR), Bureau of Fisheries and Aquatic Resources (BFAR), and the University of the Philippine Marine Science Center (UP-MSC), as well as studies aimed at increasing fry supply through more efficient catching methods and improved techniques for increasing their survival.

- National Bangus Breeding Program (NBBP)

The National Bangus Breeding Program was launched in collaboration with the MNR and the BFAR to accelerate the development of simplified technology for propagating milkfish.

Its objectives are:

1. to develop technology for propagating milkfish and test its economic viability for commercial application;

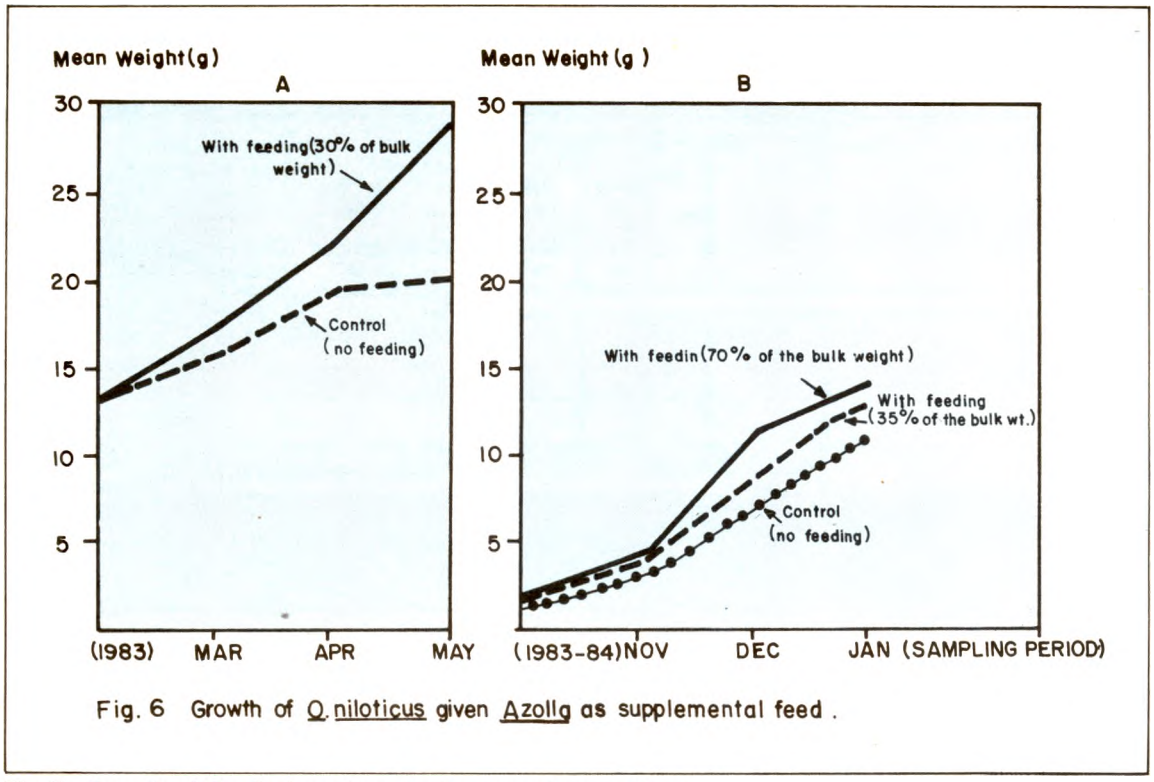


Fig. 6. Growth of *O. niloticus* given *Azolla* as supplemental feed.

2. to increase fry supply in selected natural fry grounds, particularly those close to productive fishponds;

3. to establish hatcheries in fishpond areas far from natural sources of fry;

4. to eliminate or minimize transport mortality of fry; and

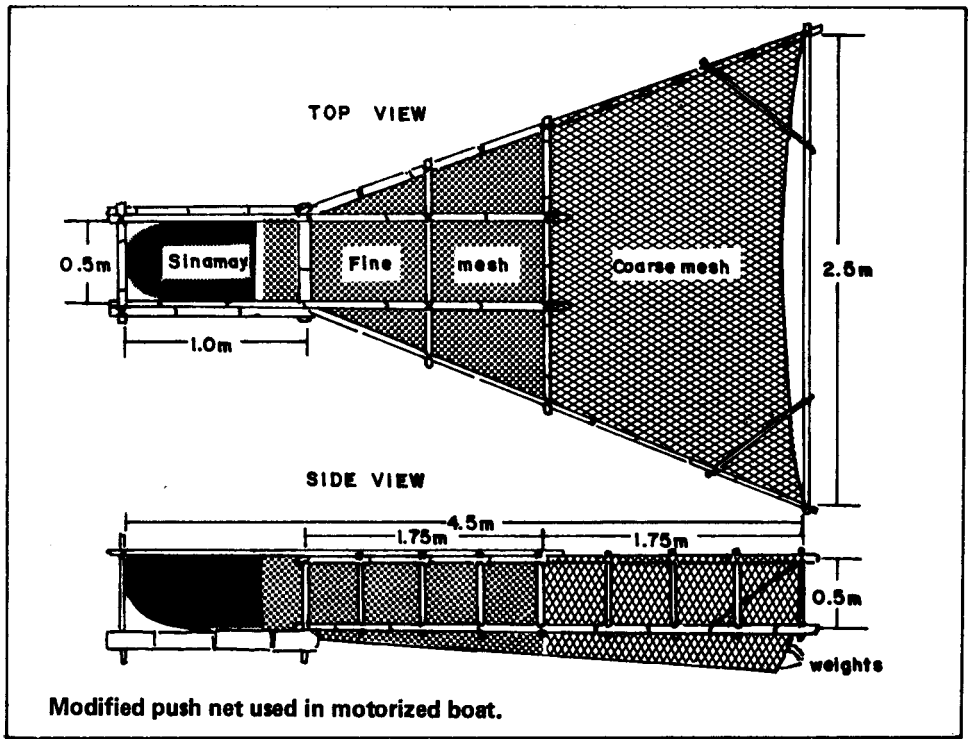
5. to produce excess fry for export.

The NBBP established twelve (12) farm sites in the country. As of November 1983, the total stocks in the NBBP maturation sites was estimated at 5,333 milkfish juveniles, with ages ranging from 6 to 42 months.

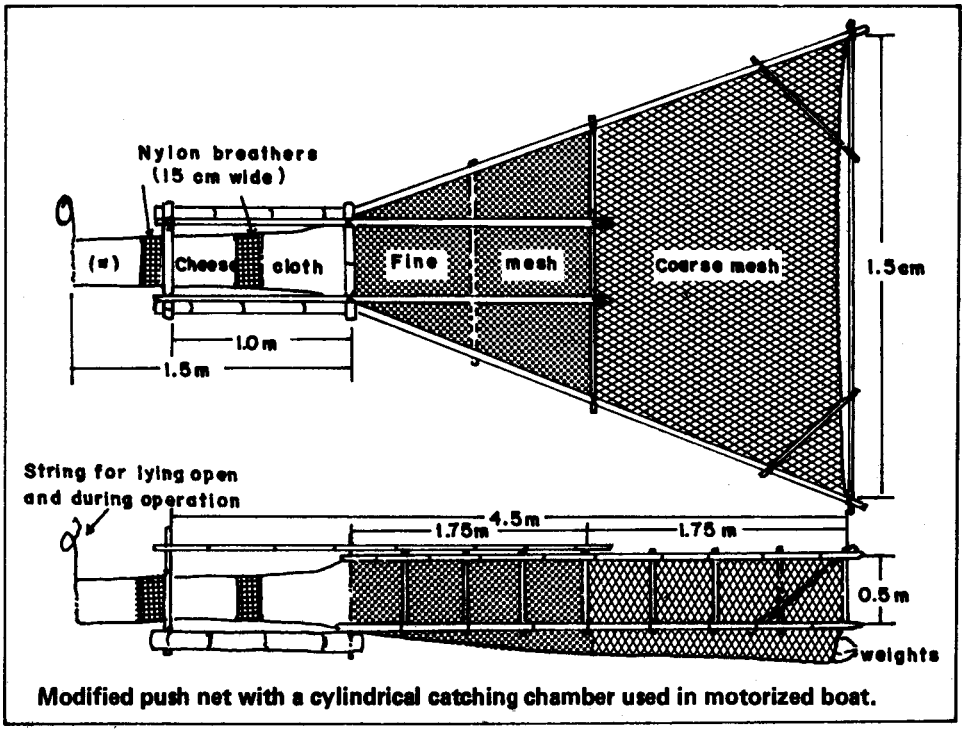
- **Evaluation of Fry Catching Gear**

In a study aimed at developing more efficient methods of catching milkfish fry, two types of motorized fry sweepers, one with open catching chamber, the other with a cylindrical catching chamber (Figure 7), were assessed. An efficient motorized push net should be able to catch at least 2,000 per eight-hour operation. The sweeper with cylindrical catching chamber was more efficient (and with lower mortality), than that with the open catching chamber (Table 5). The former model could also be operated even when sea condition exceeds number 2 on the Beaufort scale.

The milkfish fry catch efficiency of two moving gears, one with and one without a fish lamp at night, was evaluated at Barangay Tubog, Hamtik, Antique (Figure 8), one of the best milkfish fry grounds in the Philippines. Fry collection was carried out continuously for 121 hours along the shore, with both gears on opposite directions 100 meters apart. The



Modified push net used in motorized boat.



Modified push net with a cylindrical catching chamber used in motorized boat.

Fig. 7. Two types of milkfish fry catching gears.

Table 5. Milkfish fry catch using motorized push net with open and cylindrical catching chamber at different distances from the shore.

Distance (mm)	Number of Catch		Total
	Open catching chamber	Cylindrical catching chamber	
0 – 50	98	188	286
60 – 100	10	16	26
150 – 200	8	10	18
250 – 300	1	0	1
400 – 500	0	0	0

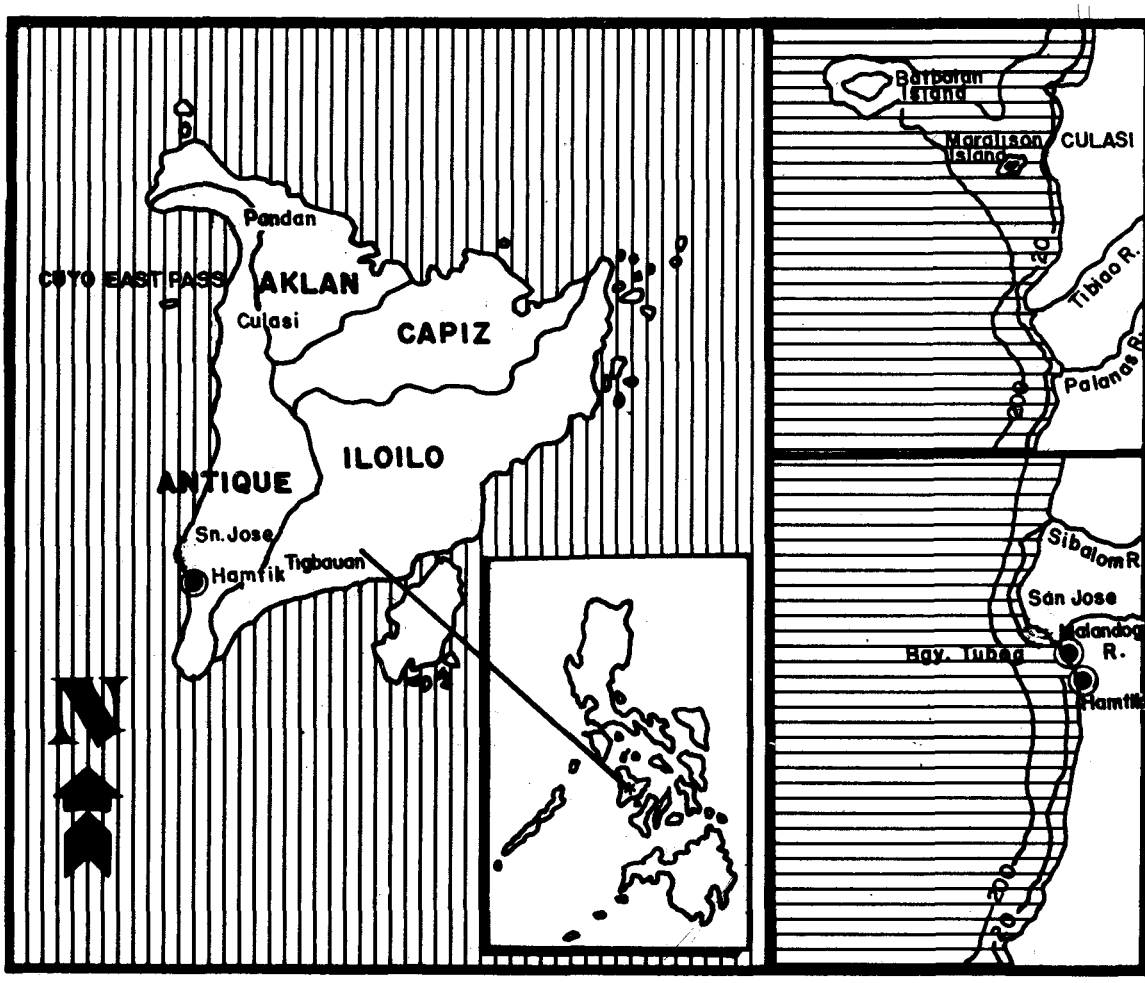


Fig. 8. Map showing the Philippines (inset) and the study area.

mean catch at daytime for gear A (without light) and gear B (with light at nighttime) was 1,390 and 1,419 milkfish fry per day respectively. The mean catch at nighttime for gear A was 1,245 fry, and for gear B 1,232 fry, on a daily basis. No significant difference in the catch of both gears at day time and at nighttime is observed.

- Methods for Increasing Fry Survival

The effect of different salinity-stocking density combinations on survival of fish fry for a six-week culture period was investigated using glass aquaria. Three salinity levels (0, 20, 32 ppt) and stocking density levels (10, 25, 50 fry/liter) were used. Up to the third week of rearing, no differences could be observed among the treatments. Survival was lower at the high salinity-stocking density levels on the fourth week of rearing compared to the other combinations. These suggest that milkfish fry can be stored with minimal mortality for three weeks at high stocking density regardless of the salinity. However, lower salinity and stocking density are recommended for long term storage to increase survival.

In a related study, milkfish fingerling reared in brackishwater ponds were acclimated to lower salinities then transported for stocking at Laguna Lake. Marine plywood tanks (1.2 x 5 x 0.6) were used for acclimation, and plastic bags and live boat or "Petuya" (Figure 9) were used for transport. The fingerlings were stocked immediately in net cages (2 x 6 x 2 m) upon reaching the site in the lake. Fish that were not acclimated died within one hour after packing in plastic bags, while no mortality occurred for acclimated fingerlings during the six-hour transport. Total mortality was observed within the first day of stocking for fingerlings conditioned in 28 ppt salinity and transported at the same salinity. Newly caught fingerlings transferred directly to plastic bags containing fresh water and fingerlings acclimated in 5 ppt salinity for 5 days showed better survival than those transported by the Petuya method. Brackishwater pond-reared milkfish fingerlings survive better if acclimated to 5 ppt salinity for 5 days prior to transport and stocking in freshwater.

- Genetic Studies

In a collaborative study with the UP-MSC, the level of genetic variation of one wild population of milkfish sampled twice from the western coast of Panay was determined using standard techniques for single gene analysis. Thirty-one gene loci were investigated, 22 of which were fixed and 9 were polymorphic for at least two and at most six alleles. Results indicated that the wild milkfish population was characterized by a set of four quantitative population indicators: allelic frequency, genotypic frequency, heterozygosity and degree of polymorphism. On the basis of single gene analysis, the wild milkfish population conforms to the Hardy-Weinberg definition of a randomly-mating population.

- Hydraulic Evaluation of Tanks

The hydraulic characteristics of a 4-meter diameter canvas tank for milkfish broodstock, a 600-liter circular raceway for milkfish fry, and a 4-meter diameter ferrocement tank for prawn broodstock were investigated. The 4-meter diameter canvas tank as it is presently used has a dead space ranging from 10.8% to 17.4% of its total volume. Aerating the suspected dead spaces resulted in minimal and insignificant change in the dead volume. Installing an improved drain pipe design indicated a possible reduction of the dead volume to as low as 7.9% of the tank volume. The 600-liter circular raceway exhibited dead space ranging from 11 to 29.5% of the total volume. Relatively less dead space is attained when the water

Fig. 9. Petuya (live boat) used in transporting milkfish fingerlings.

inlet is diametrically opposite the drain than when it is located three quadrants away from the drain. No definite trend could be established from the effects of aeration. The 4-meter diameter ferrocement tank equipped with airlift pumps showed a dead space of 5.0% of the total volume. Without the airlift pumps, however, substantial by-passing of water from the inlets direct to the drain at the bottom of the tank resulted in a dead space of 62.8% of the total volume. The use of several dyes to pinpoint the exact location of dead spaces in the tank was ineffective.

- *Arius* sp.

Arius sp. fingerlings were reared in 1 m^3-cages in Laguna Lake at a stocking density of 4 ind/m^3. In one month of cage culture, fish fed with artificial feed (40% CP) gained 10.8 grams while those fed with trash fish gained 12.3 grams. In another experiment, "eyed" eggs of *Arius* sp. were collected from the lake and incubated in a bell jar. Hatching was staggered and lasted for 7 days, with the yolk totally consumed in 20 days. Unhatched eggs ranged in diameter from 12 to 14 mm, while hatchlings measured from 23 to 27 mm. Upon consumption of the yolk, the fingerlings measured 35 to 40 mm in length, with an average weight of 2 grams.

- Nutrient Studies

The factors involved in the conversion of organic substances (100% chicken manure and ipil-ipil leaf extracts) to inorganic nutrients (NH_3-N, NO_2-N, NO_3-N) and PO_4-P) were investigated. Conversion took two to three days under anaerobic conditions and three to four days under aerated conditions. Temperature and oxygen appeared to influence the nitrification/denitrification process. A 1:1 volume by volume combination of chicken manure and ipil-ipil leaf extracts showed the best results.

- Limnological Studies in Laguna Lake

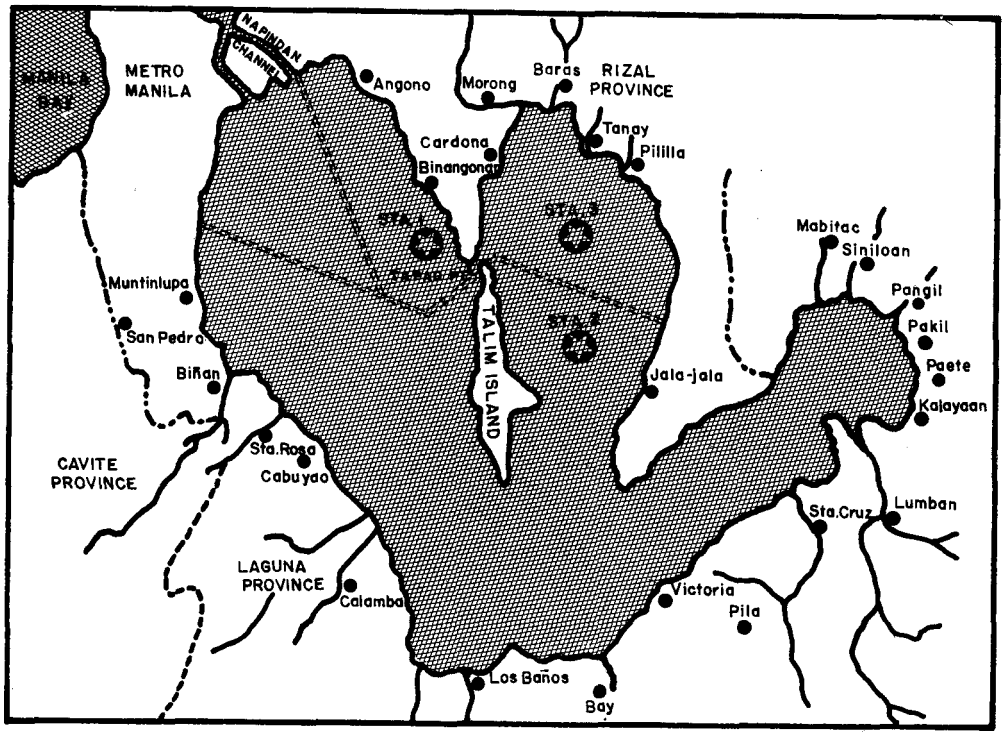


Fig. 10. Map of Laguna de Bay indicating the sampling station from August to December 1983.

The phyto-and zooplankton populations in Laguna Lake were studied. The zooplankton community was composed mainly of 3 orders: Copepoda, Cladocera, and Rotifera. Copepoda composed 70% and 74% of the total zooplankton standing crop in Central Bay and in the Tapao Pt. vicinity, respectively, during August to November 1983. Cladocera comprised 27% and 23% of the total zooplankton while Rotifera 4% and 3% in the same respective study areas. In Tapao Pt., a peak in zooplankton standing crop occurred in September 1983 shortly following blue-green algal blooms. High levels of phosphate characterized the lake waters previous to and during the blue-green blooms. Zooplankton standing crop particularly in Central Bay was considerably lower than the standing crops during these months in 1980, 1981 and 1982.

The algal population was also monitored in West Bay and Central Bay from August to November 1983. The two areas showed marked differences in algal population. Algae occurred in greater numbers in Central Bay than in West Bay. Moreover, the predominant group of algae in Central Bay was the Cyanophyta while in West Bay, diatoms predominated.

Temperature and dissolved oxygen profiles showed that Laguna Lake underwent various-short and irregular periods of stratification in between circulations. On this basis, Laguna Lake is classified as a warm, shallow and polymictic Lake.

- Naujan Special Project

The project aims to maintain adult milkfish "sabalo" or broodstock coming from Naujan Lake for extensive integrated breeding studies. "Sabalo" migrating to the sea from Naujan Lake are trapped by fish traps at Bancuro along the Butas River. The fish are transferred to tanks for acclimation to 14-15 ppt salinity for a period of 2 to 3 weeks, then stocked in marine fishpens. As of December, a total of 56 sabalo were stocked on offshore pens near Buloc-buloc.

Crustacean Program

The program is composed of the following projects: Broodstock Development, Seed Production, Pond/Cage Culture, and Special Project. Species involved are *Penaeus monodon, P. indicus, P. merguiensis* and *Scylla serrata* with emphasis on *P. monodon.* Studies are oriented towards the (1) refinement, verification, standardization and packaging of prawn (*P. monodon*) broodstock, hatchery, nursery and pond technology for dissemination to farmers; (2) development of broodstock, hatchery, nursery and pond technologies for *Scylla serrata;* (3) verification of the commercial production of *Artemia* cysts for use in local hatcheries; (4) development of practical diets for different stages of the above-mentioned species; and (5) identification of parasites and diagnosis of diseases afflicting these species and methods for their control and prevention.

BROODSTOCK DEVELOPMENT

Refinements of maturation techniques in commercially important penaeids were carried out in Tigbauan land-based tanks and in Leganes ponds.

The spawning of wild *P. monodon* broodstock in flow-through and non-flow-through land-based tanks was studied. No significant difference in spawning as well as in egg and nauplii production was observed for the two systems.

In a separate study, different salinity levels were used for broodstock maturation. The highest number of spawnings was in 30-35 ppt followed by 25 ppt and 15 ppt.

The total lipid content and fatty acid composition in tissues of wild-caught

P. monodon at various stages of maturity were determined. Findings suggested that the lipids are stored in the hepatopancreas and subsequently transferred to the ovaries. As maturation proceeds, ovarian lipid progressively increase levels until full maturity and subsequently drop to initial levels after spawning (Fig. 11). The fatty acid profile of maturing ovaries consistently showed the presence of arachidonic (20:4 ω 6), eicosapentaenoic (20:5 ω 3), and docosahexaenoic (22:6 ω 3) acids. These are also the major polyunsaturated fatty acids (PUFA) reflected in the spawned egg and in male testes. The results indicate the importance of highly unsaturated fatty acids in the diet for captive broodstock.

Practical diets containing cod liver oil or soybean oil in combination with fresh squid, mussel and annelids were fed to *P. monodon* broodstock. These diets were formulated based on the fatty acid profile of mature *P. monodon.* Diets containing cod liver oil resulted in good spawning as well as nauplii production.

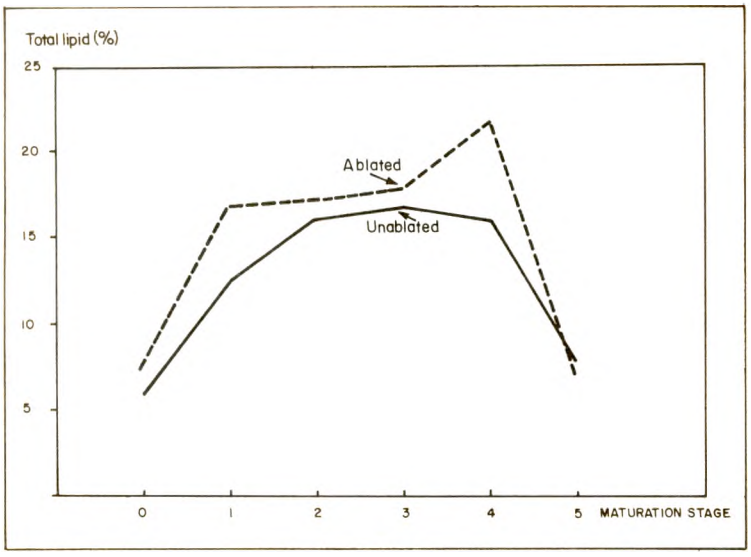


Fig. 11. Variation in ovarian lipids of ablated and unablated *P. monodon* broodstock (Tigbauan/Guimbal source).

In Leganes, post juveniles were reared in ponds up to the broodstock stage using two types of crustacean pellets and natural food through fertilization. The study indicated the need for supplemental feed for growing prawns even at low stocking density since natural food is not sufficient.

Marketable size *P. monodon*, stocked in ponds to broodstock size were given trash fish and commercial pellet. After one month, green mussel *Perna viridis* were stocked in the same ponds to check plankton bloom. Survival rates in ponds with mussel were higher than in those without the bivalve after 165 days of culture. The high survival rates of mussel (85-95%) indicated the feasibility of growing this in ponds.

• Diseases. *P. monodon* spawners reared in concrete tanks and earthen ponds manifested black spot lesions on the carapace, abdominal segments and appendages. The incidence rate was as high as 36% in concrete tanks and 20% in ponds. Bacterial isolations yielded predominantly the group of *Vibrio* spp. Preliminary investigations indicate that two *Vibrio* species can cause mortalities in prawn juveniles with injuries. The test bacteria can tolerate salt concentrations from 0.5 to 8% and temperatures from 12 to 40°C. Potential effective chemotherapeutants include Chloramphenicol, Furazolidone, Nitrofurantoin, Oxytetracycline and Sulfamethozazole trimethoprim.

SEED PRODUCTION

Seed production of commercially important penaeids was carried out in Tigbauan, Leganes and Batan stations. The project focused on the refinement of

mass production of algae and on larval and postlarval rearing techniques particularly on non-live feeds, nutritional requirement and development of nursery holding techniques.

- Algal Culture

The effects of varying N:P ratios on selected algal species were determined. *Isochrysis galbana* was cultured with and without silicate fertilizer at 26-32°C and 28-32 ppt salinity. Growth was faster at 2:1 NP ratio plus silicate, with mean population density of 3.1×10^5 cells/ml in six days. The same result was observed in the culture of *Nannochloris* sp. with continuous illumination under the same temperature and salinity but with a mean population density of 3.9×10^6 cells/ml in five days. For both species, increasing N:P ratio beyond 2:1 did not significantly increase the population density.

Three algal species commonly used in prawn hatcheries (*Chaetoceros calcitrans, Tetraselmis* sp. (Batan strain) and *Skeletonema costatum*) were subjected to different culture conditions to determine ways of reducing costs of culturing them. Although stock cultures can be maintained under ambient conditions, higher densities were produced by cultures provided with continuous lighting. Fast growth of *C. calcitrans* and *S. costatum* were also related to the high silicate content of the media used.

- Larval Feeding

Marine yeast isolates from Batan, Aklan were assessed as possible food source of prawn larvae. Feeds consisting of yeast, *Saccharomyces cerevisiae* and *Rhodotorula aurantica* were given singly or in combination with *C. calcitrans* and *Tetraselmis* sp. The larvae fed with yeast and algae at 1:1 proportion gave high survival rates. *Rhodotorula aurantica* was a better feed component than *Saccharomyces cerevisiae.* The results suggested that yeast could be used as a supplemental diet. Yeast can also be grown in high densities with minimum inputs.

In Batan, it was observed that *C. calcitrans/S. costatum* when added to *Tetraselmis* sp. improved survival rates of prawn larvae. The resulting postlarvae were stocked offshore in floating nursery cages measuring 10 m^3 in Batan Bay at 30,000/cage. The postlarvae were fed with *Artemia* nauplii, trash fish and mussel meat. Survival in cages was as high as 90% during summer months.

Optimum feeding levels of various non-live feeds such as trashfish, brown mussel, whole egg, egg yolk and soybean cake in combination with *Tetraselmis* sp. were determined. There was no significant difference on the survival rates at different feeding levels of mussel, trashfish and soybean cake. At lower feeding levels of whole egg and egg yolk, the survival rates were significantly higher. The growth of the larvae did not differ when fed with various feeding levels of non-live feeds.

- Nutritional Requirements

The levels of lipid and fatty acid composition during larval development of *P. monodon* were examined. Lipid content in *P. monodon* was observed to decrease with developmental stage (egg to postlarva) indicating the utilization of stored lipid as energy source during larval development. As the larvae developed, levels of 16:1 and 18:1 fatty acids were observed to decrease coupled with a corresponding increase in PUFA (Fig. 12) particularly 20:5 ω 3 and 22:6 ω 3, indicating their importance as diet components. Algae and egg yolk are commonly used as feed for the larvae. The algae were found to contain 20:5 ω 3 while egg yolk was high in

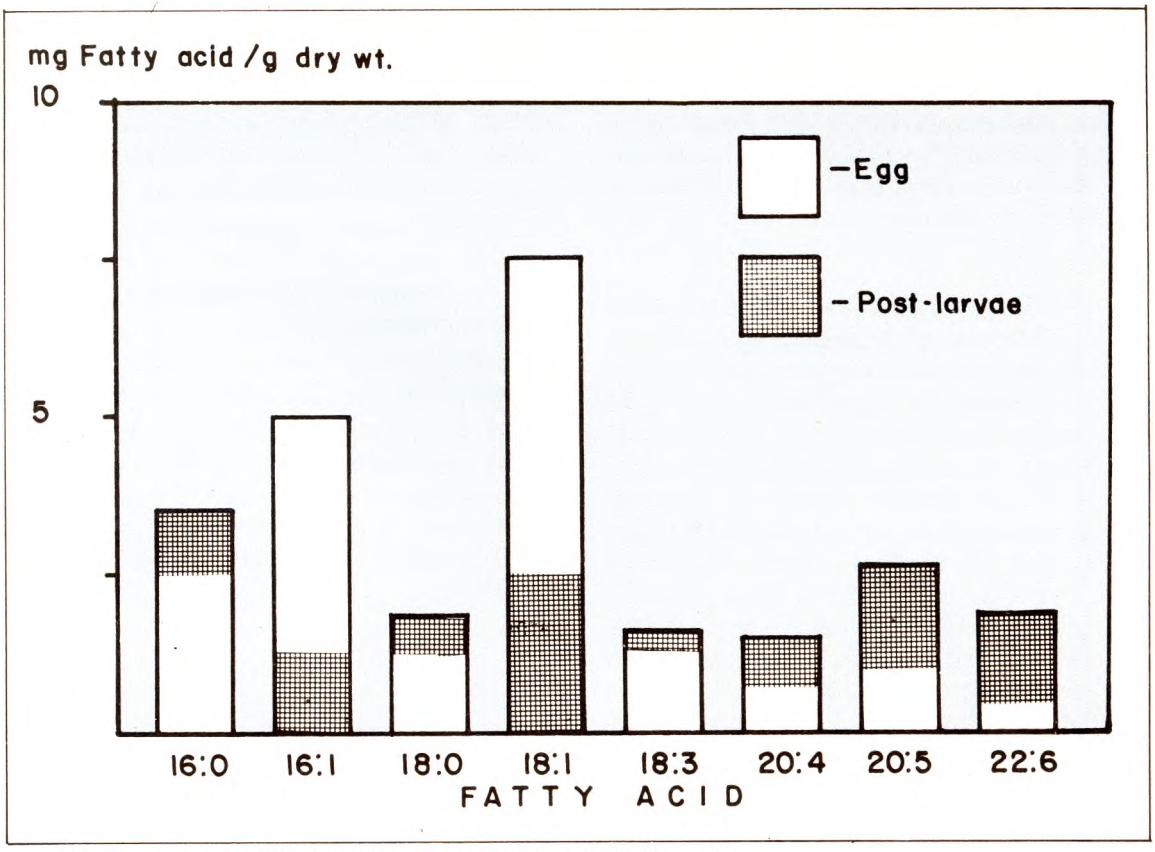


Fig. 12. Fatty acid content during larval development of *P. monodon*.

total lipids but low in polyunsaturates. Crustaceans generally have limited capacity for long chain PUFA synthesis and has to be provided in their diets. These essential fatty acids must be made available in appropriate amounts to insure successful larval development and survival.

P. monodon juveniles fed with various lipid sources (beef tallow, cod liver oil and soybean oil) and their combinations were observed to respond to semi-purified diet containing 12% cod liver oil. Prawn juveniles fed non-lipid diet had the lowest survival rate and weight gain. Combination of cod liver oil and soybean oil in equal amounts improved the survival and growth rates compared to soybean oil alone. The addition of 1% soybean lecithin to cod liver oil markedly increased the survival rate but weight gain was low.

The effects of soybean lecithin in growth and survival were evaluated. Five practical diets containing Peruvian fish meal, shrimp head meal, defatted soybean meal, rice bran, vitamin and mineral mixes and various amounts of lipid or lecithin were fed to *P. monodon* juveniles for eight weeks. Prawn fed diet with 2% lecithin and 4% cod liver oil attained the highest weight increase (387.2%), followed by those given diets containing 4% soybean oil and 2% lecithin (273.2%). Survival rates ranged from 33-42% in all the treatments.

Carbohydrate requirement of *P. monodon* juveniles was assessed using three levels (10, 20, 30%) of three sources (trehalose, sucrose, and glucose). Highest weight gain during an eight-week feeding trial was observed in juveniles fed 20% trehalose. Likewise, percent weight gain was

better in animals fed trehalose, followed by sucrose and glucose. Survival rate was best when 10 and 20% of trehalose or 20% sucrose was present in the diet. Since trehalose is not locally available, sucrose would be an appropriate carbohydrate to use in semi-purified diets.

Feeding trials using purified diets were conducted to determine the optimum protein, fat and carbohydrate levels in the diet of *P. monodon* juveniles. Dietary lipid (1:1 ratio of cod liver oil and soybean oil) at 8% level in combination with 40% casein and 20% sucrose gave better growth rate compared with 5% lipid level. Weight gain decreased from 358% to 192% when lipid level was increased to 11%. Increasing the amount of casein from 40% to 45% or 50% at 20% CHO and 8% lipid levels did not further increase the growth rate. The optimum protein level for prawn juveniles with diet containing 20% CHO and 8% lipid was estimated to be 40% with a metabolizable energy of 3120 Kcal/kg.

- **Water Management and Stocking Density**

Preliminary investigations on the effects of different water management schemes on growth and survival of *P. monodon* postlarvae (PL_5-PL_{35}) suggested better response with simple aeration followed by biological filtration and airlift aeration.

Optimum stocking density of postlarvae (PL_5) grown to juveniles in fiberglass nursery tanks was 5,000 and 10,000 shrimp/ton with a survival rate of 47% and 43%, respectively. At 15,000 shrimp/ton, a survival rate of 27% was obtained. Weight gain was higher at low stocking densities.

- **Holding/Stunting**

The development of economically viable technique for holding/stunting of *P. monodon* juveniles through stocking density was conducted in nursery tanks. After 4 weeks, high survival and growth rates were attained at lower stocking densities (3,000 and 5,000/ton), compared to higher stocking densities (8,000 and 10,000 ton). Cannibalism was significant as the density went beyond 5,000 ton due to overcrowding.

In a related study, *P. monodon* juveniles starved for 15 days showed no gross irreversible effects after re-feeding with a complete diet and a semi-purified diet containing protein only. This suggests that juveniles can be held in tanks for a few weeks at a maximum stocking of 5,000/ton.

- **Disease**

Microscopic and microbial examinations were conducted on *P. monodon* larvae and postlarvae reared in Tigbauan hatchery and nursery tanks.

Four species of *Vibrio* were identified and associated with larval mortalities of zoea and mysis stage. Biochemical tests showed strains of *Vibrio* close to *V. parahaemolyticus*. *V. alginolyticus* were the most prevalent bacteria commonly isolated from weak and dying prawn larvae with *V. anguillarium* and *V. costicola* probably occurring as opportunistic bacteria. On the postlarval stages, filamentous bacteria were observed heavily concentrated on pleopods and pereiopods and distributed throughout the body.

- **Other Penaeids**

In the larval rearing studies of *P. indicus*, results indicated that larvae can best survive at 20 ppt for zoeal stages and 25-34 ppt for the mysis stages. Successful hatch-

ery operations were also undertaken to produce postlarvae of *P. indicus* and *P. merguiensis*. For a period of one year, a total of 700,000 postlarvae (PL_{25}) were produced from ablated wild-caught prawns.

POND/CAGE CULTURE

The refinement of various culture techniques for rearing commercially important penaeids were carried out in Leganes. The culture of *P. monodon* in freshwater was tried in Laguna Lake.

• Extensive

Agricultural and industrial wastes were used as fertilizer in brackishwater ponds. The ponds were fertilized with rice hull, mud press, boiler ash, bagasse and chicken manure and stocked with *P. monodon* juveniles at 3,000 ha. Supplementary feeding was given at the end of the second month until harvest. Survival rate ranged from 80-100% and mean body weight increased from 1.5 g to 26-29 g.

• Semi-Intensive

Based on the assumption that natural food in a fertilized pond can support higher stocking density within the first 2 months than the traditional stocking rate, the extensive culture technique was modified for economic production. *P. monodon* postlarvae stocked at 1, 2 and 4 /m^2 in fertilized pond were fed after the second month of culture. After 120 days, increased stocking density resulted in higher yield, while growth and survival rates decreased.

The stocking density of 3-4 shrimps/m^2 in an 8,000 m^2 ponds was evaluated. Commercial feed pellets were given at 10% of the biomass on the second month, 8% on the third and 4-5% thereafter. Gross production was high with an average of 523 kg/ha for a stocking density of 4 /m^2 and 397.9 kg for 3 /m^2.

The study on the different stocking density of *P. indicus* was also conducted. Commercial pellets were given daily in feeding trays. Yields were almost similar in ponds stocked at 10 and 15 /m^2 followed by 5 /m^2.

In another experiment, P. *monodon* postlarvae in brackishwater ponds at 4 /m^2 were fed with different artificial diets. After 143 days of culture, highest mean weight gain and production were attained by prawns fed with three commercial diets containing 45% crude protein, followed by experimental diet with 35% crude protein. Highest average survival was in ponds fed with experimental diet. Feed conversion ratios (FRC) were 3.4, 4.2, and 4.6 for the commercial diets, and 6.1 for the experimental diet. This indicated that supplementary feeding of prawns stocked at 4/m^2 was necessary especially towards the end of the culture period.

• Intensive

The use of aquamill or paddle wheel aeration in the intensive culture was evaluated. Aquamills were operated in 4 ponds

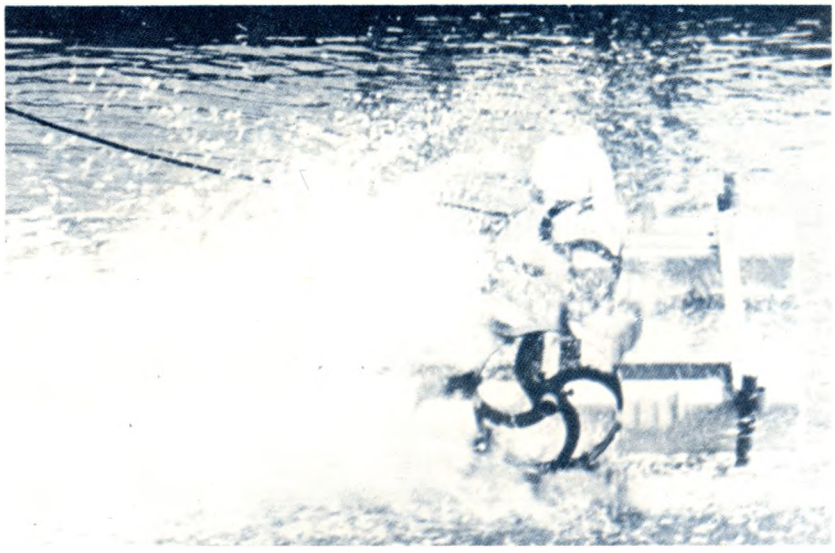
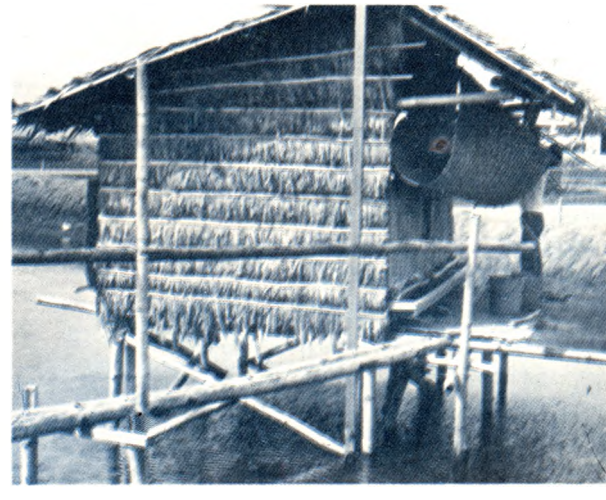


Fig. 13. Aquamill operated in prawn pond at 3.5 hours per day.

at 3.5 hours/day. *P. monodon* (PL_{25}), fed with crustacean pellet were cultured for about 5 months. Highest production of 1,257.5 kg/ha was obtained from ponds with aquamills compared to 847.0 kg/ha from ponds without aquamills. Two units of the ponds with aquamills employed staggered harvesting which gave an average weight of 13.5 g during final harvest. Findings showed that staggered harvesting in intensive culture systems allow slow growing prawns to grow bigger. FCR was best (3.01) in ponds which employed staggered harvesting and aquamills.

The integration of aquaculture with animal husbandry has been practiced with promising results. The culture of *P. indicus* and *C. chanos* was integrated with poultry raising. High production and mean body weight were observed for *P. indicus* reared in ponds with chicken droppings. The survival rates were 66-86% and 81-100% for *P. indicus* and *Chanos chanos*, respectively, in a 125-day culture period. Financial analysis showed net earnings of ₱290 and ₱445 for ponds with 50 and 75 layers, respectively.



- **Soft-shelling**

The role of pesticides in soft shelling of *P. monodon* juveniles was investigated. Aquatin, Gusathion A and Brestan were tested using concentrations not higher than the recommended level in ponds. Soft-shelling or papery exoskeleton was observed in shrimp previously exposed to Aquatin at concentrations 10 to 100 times lower than the normal level used in ponds.

Data from a survey of prawn farms in Panay also suggested the possible relations of feeds and feeding to softshelling.

- **Cage Culture**

The effects of three types of feeds on the growth of *P. monodon* in Laguna Lake were assessed. *P. monodon* postlarvae (PL_{50}) were acclimated to freshwater and stocked in cages at 20 /m^3. Three types of supplemental feeds, namely: algal cake alone, algal cake and trash fish/shrimp at 1:1 ratio, and trash fish/shrimp, were fed to prawns at 15% of the body weight daily. The highest growth of prawns was attained in feeds consisting of algal cake and trash fish/shrimp at 1:1 ratio, followed by algal cake alone.

SPECIAL PROJECTS

Under this project, the aquaculture techniques already tested and packaged are utilized for income generation and demonstration. Project activities include mass production of larvae, juveniles and marketable sizes of prawns and crabs, and verification of the potential production of these species as well as *Artemia*. These verification projects are being conducted in collaboration with some government agencies in various regions of the country.

- **Crab Culture**

Scylla sp. (mudcrab) were grown singly or in combination with milkfish in 0.5 and 1.0 ha bamboo-fenced ponds. In the polyculture system, mudcrabs were stocked at 5,000 juveniles/ha and milkfish at 2,500 fingerlings/ha, while for the monoculture system, stocking density was 10,000 juveniles/ha. Aggregate production after three months were 698 kg/ha and 338 kg/ha/crop respectively, and 579.1 kg/ha/crop from one pond with milkfish.

- **Earthworm and Marine Annelids as Protein Source**

In collaboration with the Philippine Government's Kilusan ng Kabuhayan at Kaunlaran (KKK) or livelihood program, a study on the use of earthworm and marine annelids as protein sources in prawn feeds was conducted. Dried earthworm and annelids incorporated in the diets gave better growth and survival of *P. monodon* juveniles than worms incorporated in the "wet form". Survival rates were higher for prawns given diets containing earthworm compared with those containing marine annelids. Earthworm as protein

Mud crab, *Scylla serrata*.

source is comparable to squid in terms of growth and survival of the prawns. However, earthworm has become more expensive than squid.

- *Artemia* Culture

Artemia production trials in an integrated salt-milkfish-prawn pond, and *Artemia* culture experiments were conducted from February to July 1983 at Leganes and some selected saltfarms in Bohol, Cebu and Negros Oriental. Highest production of *Artemia* cysts (over 20 kg/ha/mo) was recorded in July due to improved fertilization and feeding scheme in ponds. Salt harvest exceeded 100 tons/ha/mo. Maintenance of high salinity through the use of an overflow pipe system enabled production of *Artemia* even during the rainy season.

- Culture of *P. indicus* and *P. merguiensis*

The effect of water depth on the culture of *P. indicus* and *P. merguiensis* was examined. Brackish ponds were maintained at two depths, 70-100 cm and 40-70 cm. Prawns were stocked at 50,000 cm and cultured for 90 days with supplementary feeding. Commercial prawn pellets were given at 8% of the biomass on the second month and 6% on the third month. The mean survival rate in deeper ponds was significantly higher (70%) than in shallow ponds (38%). However, there was no significant difference in the mean body weight at the end of the culture period. Results suggested that production of white shrimps gave more favorable results in deeper ponds than in shallow ponds.

Left, samples of different commercial penaeid species, below, *Artemia salina*.

Molluscs and Seaweeds Program

Green mussel, ***Perna viridis.***

Studies under the Molluscs and Seaweeds Program were aimed at developing appropriate technology for mollusc and seaweed cultivation. Specific objectives are (1) to determine the feasibility of a low-cost hatchery for producing oyster and mussel seed to augment supply of wild seed; (2) to test improved methods for cultivation of mussels, oysters and seaweeds; (3) to develop post-harvest measures for shellfish to maintain quality and sanitation standards acceptable to regional and international markets; and (4) to gather benchmark information on other species of mollusc and seaweeds with good mariculture potential.

Five projects under the program were implemented in Tigbauan, Batan, Leganes and Igang Stations: Hatchery/Seed Production, Mollusc Culture, Seaweed Cultivation, Postharvest Handling and Special Projects.

HATCHERY/SEED PRODUCTION

Appropriate routines for hatchery-production of seed of the green mussel *Perna viridis* and the slipper oyster *Crassostrea iredalei* were developed.

Various concentrations of *Isochrysis* sp. (T-ISO, Tahiti strain) cells ranging from 10,000 to 75,000 cells/ml were tested to determine the optimum feeding rate for mussel larvae. At a stocking rate of 3 larvae per ml, growth up to day 10 was best at 30,000 cells/ml. Mean survival rate was lowest at 75,000 food cells per ml due to excessive production of pseudofeces. For the oyster, preliminary results indicated that the following routine is workable for rearing larvae:

(1) Stock larvae at 3-5/ml.

(2) Feed *Isochrysis* + *Chaetoceros* at 25,000 cells/ml or *Isochry-*

sis only at 30,000-50,000 cells/ml;

(3) Renew water totally every two days.

A quick method for inducing mussels and oysters to spawn using both rheostimulation and bio-stimulation was developed. Thermostimulation was coupled with these two stimuli when ambient temperatures were low.

Occurrence and abundance of both pathogenic and non-pathogenic marine bacteria were the greatest obstacle in rearing mussel and oyster larvae. The problem was twofold. Presence of pathogenic bacteria such as *Vibrio* even in small numbers, caused total mortality in 12-24 hours. On the other hand, presence of non-pathogenic bacteria in larval cultures was just as fatal when their numbers exceeded 1 million/ml. The problem was compounded by the carry-over bacteria cells despite total water renewals, leading to a cumulative bloom of such residual bacterial populations. Initial trials with the use of "Sulfadiazine" as possible inexpensive anti-bacterial agent did not yield positive results.

Ready-to-settle oyster larvae harvested from feeding-rate experiments were successfully induced to settle on finely-ground *Placuna* shells. Ground shell particles were spread on the screened bottom of a floating (1 meter x 1 meter) frame constructed from 2-inch diameter PVC pipes. Circulation inside the frame was effected by air-lifting water into the frame; water draining through the screened bottom. Larval attachment occurred within 24 hours, yielding some 5,000-6,000 free oyster seed. (Figure 14). These seeds were transferred to an upwelling-type nursery tank where they were fed *Isochrysis* and other diatom *ad libitum.*

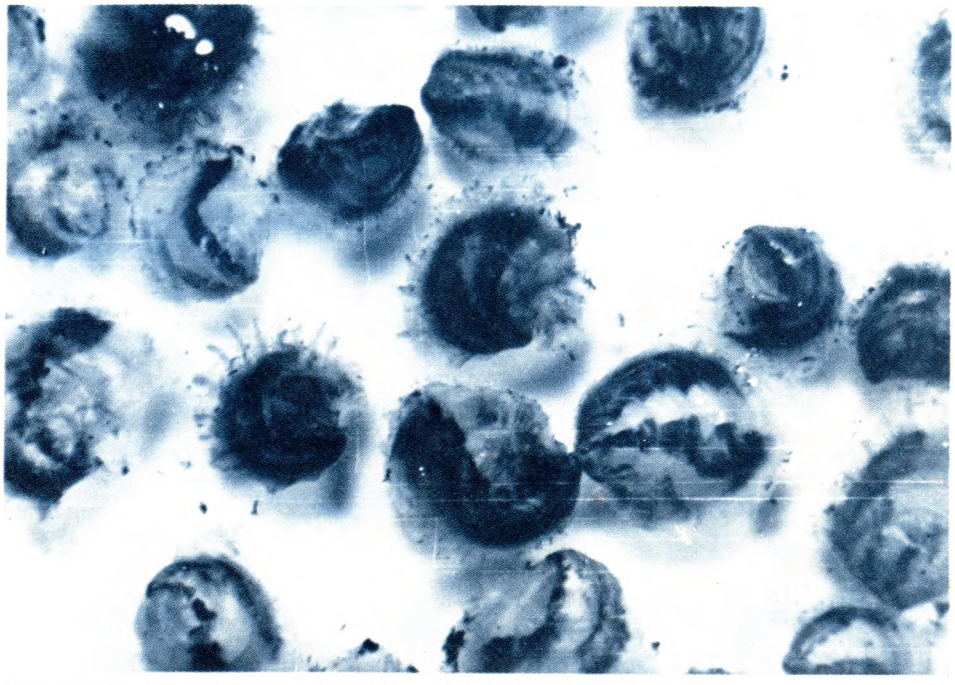


Fig. 14. Hatchery produced cultchless seed of the oyster, *C. iredalei.*

MOLLUSCS CULTURE SYSTEMS

Farming trials were conducted using three different culture systems: rafts, modified longlines, and intertidal trays.

Both the raft and longline system of farming mussels and oysters were tested at Batan, Aklan. To determine the feasibility of collecting natural seed for raft and longline farming in the chosen sites at Batan and Banga Bays, Aklan spatfall of mussel and oyster seed were monitored at 9 sampling stations from July to September, 1983. Peaks in occurrence of ready-to-settle larvae of both species occurred in the second half of September (Figures 15a, 15b and 15c) and actual occurrence of spatfall was confirmed by the good catch of mussel and oyster seed on test collectors.

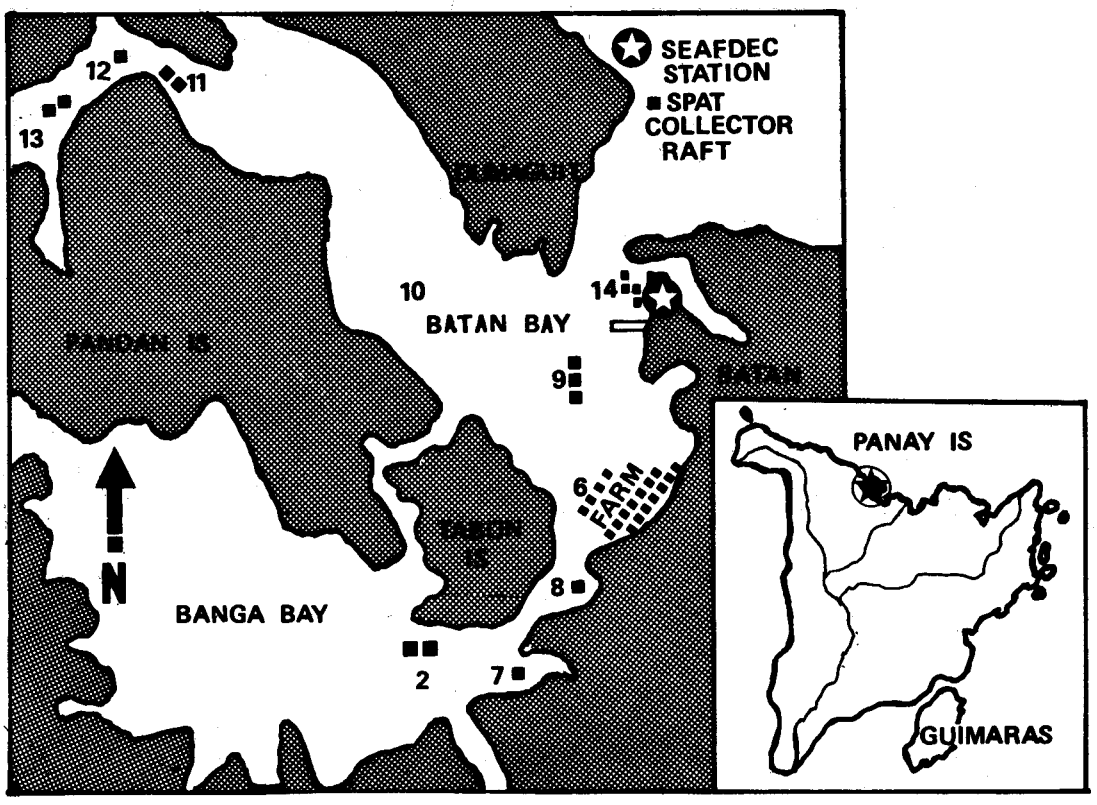


Fig. 15-A. Batan and Banga Bays showing spat collection stations (numbers) and installed rafts (as of October 1983).

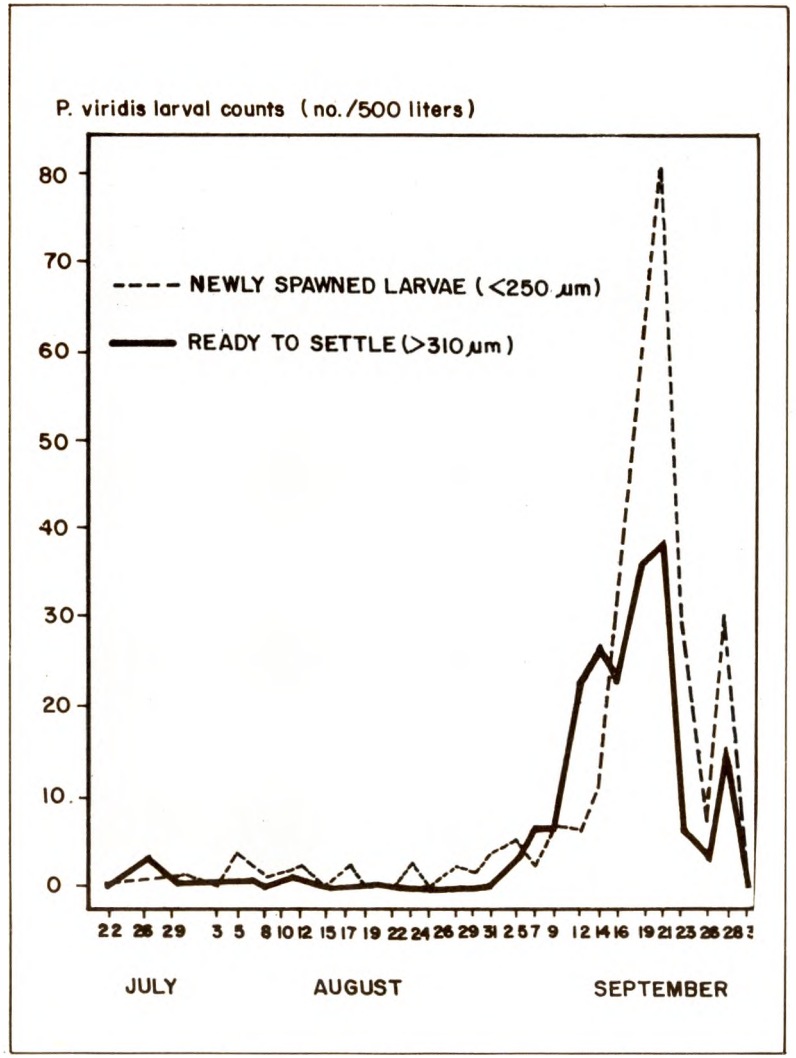


Fig. 15-B. Abundance of mussel larvae in the plankton (Batan Bay, Aklan, 1983).

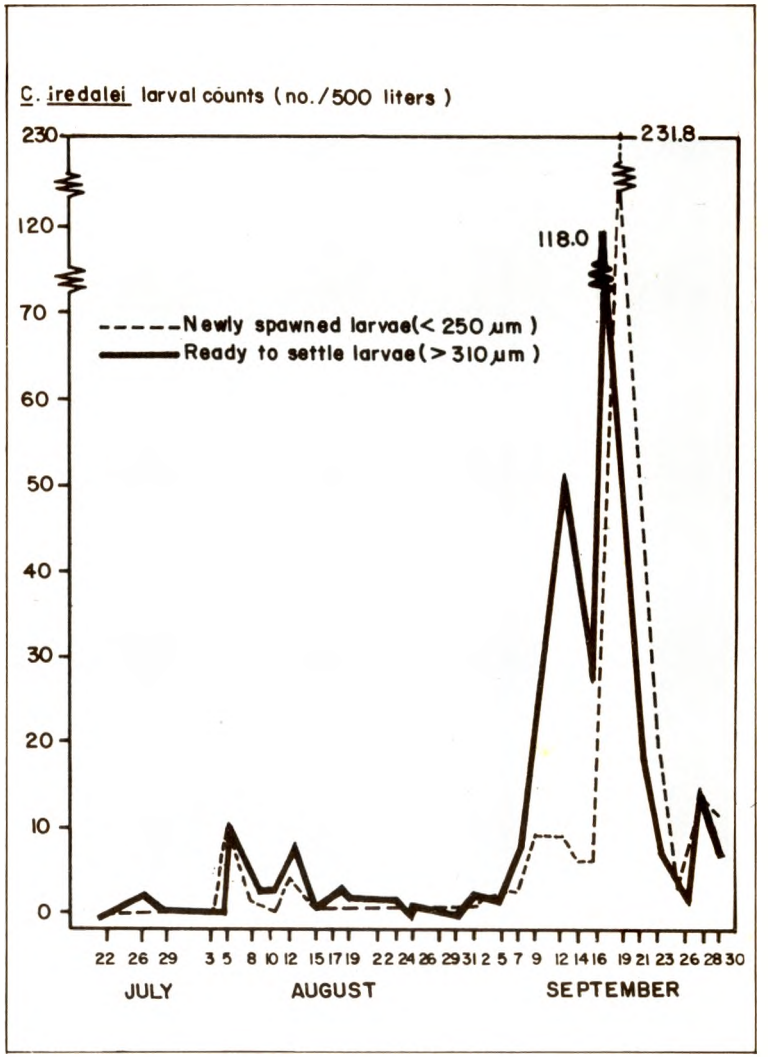


Fig. 15-C. Abundance of oyster larvae in the plankton (Batan Bay, Aklan, 1983).

To evaluate the technical feasibility of the raft method of cultivation at Batan, 4 meter x 4 meter raft (Figure 16) prototypes were constructed using bamboo and styrofoam buoys. Six rafts were stocked with transplanted mussels while eight were stocked with oysters. Preliminary data on growth indicated a faster growth rate in mussels from 0.5-1.5 meter depths. Condition index of the mussels, however, was not significantly better than those grown below 1.5 meter.

An experimental longline was constructed by hanging one growing rope to one plastic-gallon buoys, the buoys 1 meter apart and inter-connected with monofilament nylon twine to form a 5 buoy x 20 buoy module kept in shape by bamboo poles (Fig. 17). One module was stocked with transplanted oysters, and another with mussels. Over-all performance of the longline module over a five-month period was poor, suggesting, that the longline method needs further improvement and modifications. One plastic-gallon buoy could only support 13 kg weight of growing mussels and oysters. The excessive bobbing of the light buoys caused considerable loss of crop due to slippage, and the vertical growing ropes entangle whenever opposing currents and eddies occurred.

In Gui-gui creek near the Department's Leganes Research Station, oysters were cultivated to ascertain their growth and survival rates in intertidal trays (Figure 18). Various sizes were initially stocked at 500/tray, then gradually thinned to 300/tray. Average growth rate was best with oyster which were above 30 mm at stocking. Average growth in height of these oysters was 2.13 mm per month over a 9-month growing period; average increase in weight was 5.3 g per month. The most active growth of oysters occurred from March-August, followed by very poor growth from September to December. This study suggests that 30 mm oyster seeds are the preferred size for transplanting to intertidal trays. Regular exposure to sun and air for 0.5-6 hours did not seem to seriously affect growth and survival. Mortality was 5-10%, mostly from mechanical stress of culling and handling. Although oyster seed settled densely on the bamboo structures, monitoring of oyster larvae at the farm site failed to detect the occurrence of spatfall. Considering the limited area at Gui-gui creek, expansion of oyster farming operations would not be possible.

Fig. 16. Experimental raft for cultivation of oysters and mussels.

Fig. 17. Experimental longline at Batan Bay.

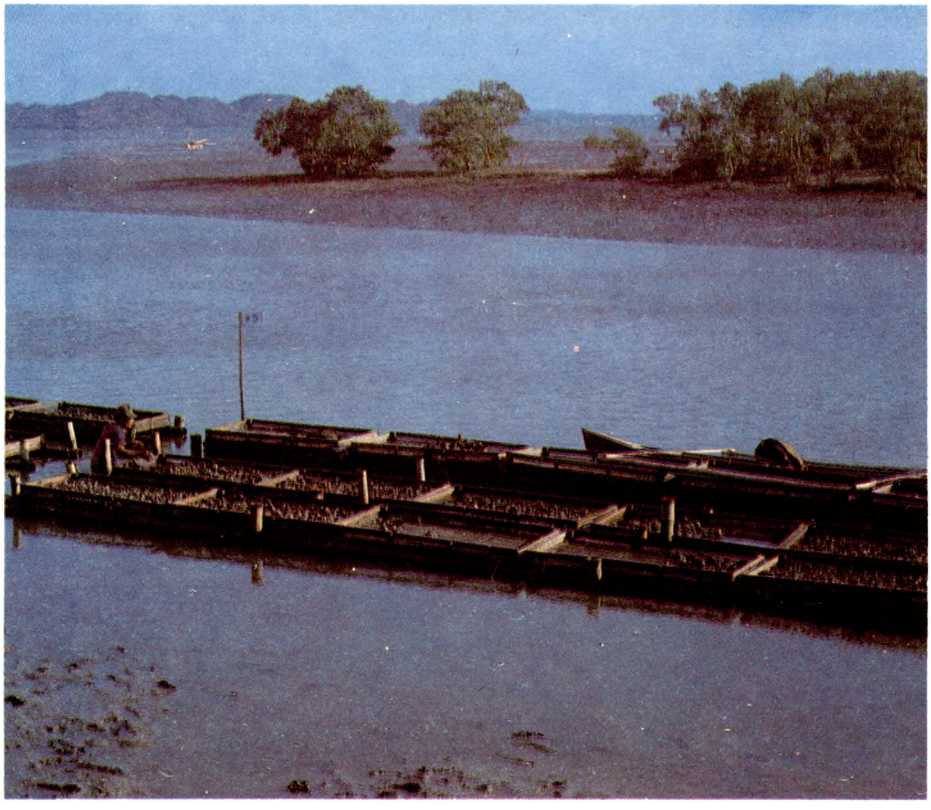


Fig. 18. Tray method of oyster culture.

SEAWEED CULTIVATION

Eucheuma and *Caulerpa* were introduced in Batan Bay and in Igang to assess the feasibility of cultivation of these two species in these areas.

Cuttings of these species were attached to horizontal monofilament twine kept afloat with bamboo poles. Growth of test plants in Batan Bay was poor, however, due to heavy run-off of freshwater during rainy days resulting in reduced salinities that killed many of the plants. The chosen site at Igang proved promising for culture of seaweeds, especially of *Eucheuma.* Test plants grew well and siltation was minimal. There were signs, however of grazing by herbivores.

POST-HARVEST HANDLING OF BIVALVE SHELLFISH

Depuration studies were conducted on oysters and mussels to maintain quality standards acceptable to local and international markets.

The influence of water flow rates on the rate of bacteria elimination by the oyster *Crassostrea iredalei* was assessed. Contaminated oysters with high coliform counts (MNP 2400 +) were depurated using pre-filtered non-UV treated seawater at flow rates of 3, 5 and 7 liters per minute (Figure 19). Satisfactory depuration of coliforms to acceptable levels in oysters can be achieved in 24 hours with a flow rate of at least 3 liters per minute. Depuration for 24 to 48 hours reduced the bacterial content in oysters to acceptable levels, but extending the period to 72-96 hours did not prove advantageous. Maximum reduction of bacterial content to acceptable levels in oysters was attained within the ranges of the following parameters: Temperature 29-29.5°C; 29.4-33 ppt salinity; Dissolved oxygen 3.0-5.5 ppm; and pH 6.2-7.4. The above mentioned flow rate was sufficient to maintain the oxygen level in the water.

Fig. 19. Experimental depuration tanks.

The bacterial flora of the green mussel *Perna viridis* was examined to check the spoilage of oysters and mussels by cold storage. Total plate counts of samples varied from 2.1 x 10^5 to 4.8 x 10^5 cells per gram of meat. The counts were high and indicative of the unsanitary conditions in which mussel were maintained. A total of 48 bacterial strains were identified, 54% of which were gram-negative, the rest gram-positive (Table 6).

Table 6. Incidence of bacterial genera in a market sample of *Perna viridis*.

	No. isolates	Proportion
Gram-negative genera		
Vibrio	10	20.8
Enterobacteriaceae	8	16.7
Aeromonas	4	8.2
Pseudomonas	1	2.1
Flavobacterium	3	6.3
Gram-positive genera		
Staphylococcus	1	2.1
Bacillus	16	33.3
Corynebacterium	2	4.2
Micrococcus	2	4.2
Acinotobacter	1	2.1

Mussels, unblanched, blanched in seawater, and blanched in seawater and vinegar, were also studied bacteriologically after 0, 1, 5, 12, 19 and 26 days under cold-storage. One hundred forty-nine bacterial strains were isolated from the treated mussels. *Bacillus* was the most numerous genus in the total bacterial flora. The appearance of *Pseudomonas* correlated well with spoilage. As early as the second day, *Pseudomonas* was detected in unblanced and seawater-blanched samples.

SPECIAL PROJECTS

Two special projects were implemented to gather benchmark information on resources with mariculture potentials.

• Placuna Resource Survey

An assessment of the abundance of the windowpane shell *Placuna placenta* (kapis) was undertaken from April to early June 1983. Two species were encountered: *P. placenta* and *P. sella*. The resource survey covered both the northern and southern coast of Panay Island, as well as the Western coast of Negros Island. Only 4 out of the 24 areas surveyed were found to still have sizable stocks of *Placuna*. These were: off the Tigbauan-Guimbal boundary; off Buncayao Point of Pilar Bay, Capiz; off Madrid, Pontevedra, Negros Occidental; and off Canmoros, Binalbagan, Negros Occidental. The *Placuna* popula-

Table 7. Kapis beds in Western Visayas

Reported kapis beds of Western Visayas (BFAR)	Existing beds (AQD) at time of survey
Aklan:	
Batan Bay and Vicinities	none
Capiz:	
Tinagong Dagat	none
Sapian Bay	none
Capiz Bay	none
Culasi Bay	none
Pilar Bay	Pilar Bay
Iloilo:	
La Paz, Iloilo	none
Leganes	none
Zarraga	none
Dumangas	none
Guimaras Vicinity	none
Carles	none
Oton	none
Tigbauan	none
Guimbal	Guimbal
Miag-ao	none
Negros Occidental:	
Aguisan	none
Himamaylan	none
Hinigaran	none
Binalbagan	Binalbagan
Pontevedra	Pontevedra
San Enrique	none
Pulupandan	none
Cadiz	none

tion off the Tigbauan-Guimbal boundary was a young population wherein 97% were below the harvestable size (75 mm or more). The kapis bed in Pilar Bay was composed mostly (99.6%) of mature and harvestable-size shells. In Negros Occidental, 25% of the shells found off Pontevedra were of harvestable sizes, while in Binalbagan 83% of the shells were of harvestable size. *Placuna* resources from these four existing natural beds will definitely be harvested to the very last shell in

a few months' time. It is very clear from the survey of formerly rich kapis beds that unregulated intense exploitation of these *Placuna* resources in the past has depleted the resource in both Panay and Negros Island. Unless remedial measures are adopted to save the remaining meager population of *Placuna*, the over-exploited resource might not recover.

- **Productivity of Batan Bay, Aklan**

Nutrient levels of the mollusc farm site in Batan Bay were studied. Mean values for the standing stock of phytoplankton in terms of Chlorophyll a, actual organisms count, suspended particulates, and primary productivity were recorded. Chlorophyll a showed an almost uniform mean value up to the depth of 5% incident light and a general decrease at depths below 0% incident light. The suspended particulates showed almost uniform values from the surface up to the depth of -70% incident light. Actual count of phytoplankton showed a minimum at 40% incident light depth and maximum at -70% incident light depth. The most common phytoplankton genera were *Chaetoceros*, *Coscinodiscus*, *Nitzchia*, *Prorocentrum*, *Ceratium*, and *Dinophysis*. Mean primary production values showed a maximum at 60% incident light depth (18.2 $mgCM^{-3}hr^{-1}$). Average primary production rate is 5.4 $mg-CM^{-3}hr^{-1}$.

RESEARCH SEMINARS

Research seminars on various subject matters were conducted by the staff and visiting experts at the three stations.

Date	*Title*	*Speaker*
March 17	Response of *P. monodon* to different types of supplemental feeds	Nilda Tabbu
March 24	Prawn culture, Japan experience	Eduard Rodriguez
April 14	Polyculture of *P. monodon* and *T. nilotica*	Kaylin Corre
April 28	Aquaculture training NACA experience	Florentino Apud
May 10	Echo seminar on Northern Panay Trip	Senior Research Staff
May 12	Training on amino acid uptake and metabolism, Scotland experience	Relicardo Coloso
May 17	Economics of various aquaculture enterprises	Danny Evangelista
May 18	Chemical oceanography	Arthur Sanchez
May 25	Application of amino acid analyzers in aquaculture research	Veronica Penaflorida
May 26	Breeding and culture of sea bass, *L. calcarifer*	Pinij Kungvankij
May 31	Nutrient transport in fishes	Ronaldo Ferraris

June 1	The visual feeding threshold and action spectrum of Northern anchovy larvae	Teodora Bagarinao
June 15	Tryptophan requirement and metabolism in rainbow trout	Relicardo Coloso
June 23	Breeding and culture of *Tilapia*	Rafael Guerrero III
June 28	Electrophoresis of *T. nilotica*	Zubaida Basiao
June 29	Effects of feeding different zooplankton species on growth and survival of *P. monodon* larvae and postlarvae	Dioscoro dela Peña
July 13	Nutritional value of five phytoplankton species to the larvae of *P. monodon*	Eve Aujero
July 19	Porphyra culture in Japan	Fernando Suñaz
July 20	Preliminary studies on the isolation and culture of marine yeast	Elsie Tech
July 26	Fish processing	Florian Orejana*
July 27	Research experiments in University of Rhode Island	Oseni Millamena
August 4	Prawn diseases	Gilda Po
August 25	Early development, larval biology, and substrate settlement preference of *Modiolus metcalfei* with notes on the hinge structure	Ihra Potestas
August 30	Cage culture in other countries	Malcolm Beveridge*
September 7	Growth, survival and fatty acids composition of *Chanos chanos* fry fed *Brachionus plicatilis* reared in three selected algal diets	Oseni Millamena
September 14	Effect of cryoprotectant on the cryogenic preservation of the sperm of milkfish *Chanos chanos*	Shiro Hara
September 14	Preliminary studies on ion and osmoregulation in milkfish	J.M.E. Almendras
September 16	Quantitative dietary fat requirement of *Chanos chanos* fingerling in a controlled environment	Veronica Alava
September 16	Aquaculture practices of selected Pacific Countries and training activities at Scripps Institution of Oceanography	Jessie Banno
September 16	Apparent digestibility measurement in feedstuff for milkfish	Mae R. Catacutan

*Department guests

September 19	Food and feeding habits of milkfish fry collected from two different habitats	Jessie Banno
	Weaning of hatchery-bred milkfish larvae from live food to artificial diets	Marietta Duray
September 20	An investigation of gas bubble disease occurrence among *Chanos chanos* fry	Roselyn Duremdez
	The developmental morphology of the digestive tract in milkfish *Chanos chanos* Forsskal	Josefa Tan
September 29	Laboratory propagation of certain crab species	Alice Laviña
October 13	Aspects of marine environment pollution	Arthur Sanchez
October 17	Hormones in milkfish	Clarissa Marte
October 18	Fish nutrition	Felicitas Pascual
October 20	Prawn culture in Leganes Station	Masanori Suemitsu
October 24	Uses and application of liquid scintillation counting	Bechman/Boie Technicians*
October 26	"Red Tide" in Western Samar	Rogelio Gacutan/ Marlo Tabbu
October 27 & November 9	Effects of dissolved oxygen on the survival, growth, and energetics of *Macrobrachium rosenbergii*	Jose Llobrera
October 28	Milkfish and siganid larvae: differences in size, yolk resorption and susceptibility to starvation	Teodora Bagarinao
November 15	Earthworm as a potential feed ingredient for prawn	Felicitas Pascual
November 16	Bacteriological safety assessment of *Clostridium botulinum* in modified atmosphere packaged fish	Alcestis Llobrera
November 23	Amyloodinium-like protozoan parasite in gills of grey mullet	M.C.L. Baticados
November 24	Red tide phenomenon	Rogelio Gacutan & Marlo Tabbu
November 25	Effect of salinity change on the chloride cells in the gills of milkfish fry	Paciencia Young

Training and Extension

Trainees in tilapia culture build net cages at the Binangonan Research Station.

The Department has evolved interrelated training and extension programs to develop the appropriate technical manpower required for the large-scale development of the aquaculture industry in the region, and to hasten the transfer of technology developed in the laboratory and the field to the end-user. The year 1983 saw the intensification of programs in an effort to improve fish production, generate employment opportunities as well as increase rural income particularly in fishpond communities through the effective transfer of aquaculture technology.

To refine the technologies developed in the Department's research stations, field testing and verification studies were also conducted.

About 1,700 people with varied aquaculture interests availed of the training and extension programs in 1983.

TRAINING PROGRAMS

The Department conducted the following training programs during the year:

- *Hatchery and Cage Culture of Tilapia in Freshwater (April 11-May 10),* a one-month technician level course geared towards the development of technical skills in tilapia culture, particularly on cage construction and installation, with 21 participants coming from the Philippines, Britain and Nigeria;

- *Aquabusiness Project Development and Management or APDEM (June 6-25),* a 3-week seminar-workshop designed to provide executives and key staff members in aquabusiness companies and other aquaculture oriented institutions the necessary management tools for efficient aquabusiness project management. Co-sponsored by SEAFDEC AQD and the Southeast Asian Regional Center for Graduate Studies and Research in Agriculture, the sixth session was attended by 17 participants;

- *Small-Scale Prawn Hatchery and Nursery Operations (July 6-September 6),* a 2-month technician level training designed for the acquisition of basic skills for effective management of small scale hatchery, broodstock and nursery systems for *P. monodon,* with 20 participants

from the Philippines, Malaysia and Thailand;

- *Training Course for Senior Aquaculturists in Asia and the Pacific Region*, a Network of Aquaculture Centres in Asia/SEAFDEC/University of the Philippines in the Visayas collaborative program, was on its 3rd session with 21 participants from 11 countries. The 2nd course ended 25 March 1983 with 16 participants from 8 countries.

Special courses were conducted on:

- *Hatchery and Cage Culture of Tilapia in Freshwater (May 30-June 17)* upon the request of the Laguna Lake Development Authority and the Farm Systems Development Corporation with 24 participants.

- *Prawn Development Operations* for 30 BFAR technicians. Phase I (July 6-October 6) covered theoretical and practical sessions held at AQD stations; Phase II was conducted in BFAR demonstration centers where actual grow-out pond operations were carried out.

- *Mussel and Oyster Culture (June 13-July 1)* upon the request of the Bureau of Fisheries and Aquatic Resources. The three-week course designed to train technicians, field biologists and extension workers on practical methods and techniques in shellfish farming had 15 participants.

- *Tilapia Culture (November 1983-February 1984)* for Raul Leon Perez of Cuba at Binangonan Research Station, sponsored by the UNDP.

- *Brackishwater and Freshwater Aquaculture (March-October)* for Yenhartati Musa of Indonesia at Tigbauan and Binangonan stations, sponsored by the German Foundation.

- *Plankton Aquaculture (October 1983-September 1984)* for Aung Kyi of Burma at Binangonan and Tigbauan stations, sponsored by UNESCO.

- Eighty-four graduating students from different fishery schools in the country underwent *Off Campus Training* at the Department's research stations.

TECHNOLOGY VERIFICATION

Technology verification projects were conducted in collaboration with the Bureau of Fisheries and Aquatic Resources and the private sector. The projects aim to test potential aquaculture techniques in different areas, determine the suitability of certain areas for commercial production, and establish culture techniques at the farm level and enhance their adoption by the private sector.

The seven on-going projects are: Extensive Prawn Culture (*P. monodon*); Semi-Intensive Prawn Culture Using SEAFDEC Formulated Feeds; Production of White Shrimp in Brackishwater Pond; Crab-Milkfish Polyculture in Brackishwater Pond; Monosex Tilapia Culture; Production of Brine Shrimp in Salt Pond; and Semi-Intensive Culture of *P. monodon* in Selected Areas in the Philippines.

The extensive culture of *P. monodon* was designed to stock 3,000-5,000 juveniles in a one-hectare brackishwater pond to be reared for four months with natural feeds including *Chaetomorpha* (lumot) and/or *Ruppia* (Kusay-kusay). The project is being tried in Barotac and Carles, Iloilo, and San Enrique, Negros Occidental.

The semi-intensive prawn culture using SEAFDEC formulated feeds intended to culture 20,000 to 30,000 juveniles in a one-hectare brackishwater pond for a period of 3-4 months. SEAFDEC formulated feeds were given to the prawns at 5-10% of total prawn weight per feeding

day. The trial run was conducted in ponds of the Panay State Polytechnic College in Pontevedra, Capiz.

The production of *P. indicus* in brackishwater pond was designed to stock 40,000-50,000 juveniles in a one-hectare pond for a rearing period of 3-4 months, using trash fish as supplementary feed. The project was conducted in Balasan and Barotac Nuevo, Iloilo and Baybay, Roxas City.

The polyculture of 5,000 crab juveniles with 2,000 milkfish fingerlings was conducted in a one-hectare pond in Dumangas, Iloilo for a period of four months using trash fish as feed. Partial selective harvesting was carried out for the crab stock after three months culture with a recovery rate of 30%. Total harvest of milkfish yielded a 100% survival rate.

The monosex culture of *Tilapia nilotica* was designed to stock 10,000 all male fingerlings in a one-hectare brackishwater pond for a period of 3-4 months. Feeds included a variety of natural food organisms supplemented by rice bran, coconut meal and ipil-ipil leaves. The project was conducted in Barangay Tabucan, Mandurriao, Iloilo City. After three months culture, the average weight gained was 33.7 grams.

The production of brine shrimp in salt pond involved inoculation of *Artemia* cysts in small salt ponds and reared from six months to one year. The project was initiated in a slat pond in Manhuyod, Negros Oriental.

The field-testing of the semi-intensive culture of *P. monodon* in selected areas in the Philippines was initiated in two project sites, in Pagbilao, Quezon and at the SPDA farms in Zamboanga del Sur.

EXTENSION PROGRAMS

A total of 1,143 participants attended the *in situ* workshop, conferences and symposia held in various regions.

- Bacolod City, Negros Occidental — Symposium on Brackishwater Pond Culture (March 13-14)
- Aurora, Zamboanga del Sur — Seminar on Brackishwater Pond Culture (April 11-16)
- Belison, Antique — Seminar on Fry Collection, Handling, Storage and Transport (May 28-29)
- Estancia, Iloilo — Seminar on Brackishwater Pond Culture of Crab and Prawn (June 4)
- Aparri, Cagayan — Symposium on Brackishwater Pond Culture and Management (August 5-6)
- Dipolog City, Zamboanga del Norte — Seminar on Brackishwater Pond Culture (August 17-21)
- Roxas City, Capiz — Consultative Meeting on Prawn Hatchery/Nursery (August 20)
- Iloilo City — Symposium on Concepts of Extension Services (September 12-13)
- Cotabato City, South Cotabato — Seminar on Brackishwater Pond Culture (September 12-17)
- Davao City — Seminar on Aquaculture Development and Management (September 22-25)
- Lucena City, Quezon — Symposium on Brackishwater Pond Culture (October 17-18)

- Catarman, Northern Samar — Seminar on Brackishwater Pond Culture (October 26-30)

- Lala, Lanao del Norte — Seminar on Brackishwater Pond Culture (November 21-24)

- Surigao City — Symposium on Brackishwater Pond Culture (November 21-24)

- Surigao City — Symposium on Brackishwater Pond Culture and Management (November 28-December 2)

LIBRARY AND DOCUMENTATION SERVICES

Library collections now stand at 6,719 monographs, 5,300 reprints, 3,500 pamphlets, 2,233 bound journals, 1,250 SEAFDEC publications, 354 microfiches and 37 rolls of microfilms and an additional of 440 monographs titles were received. Gifts/exchanges came to 258 monographs, 1,169 serial issues, 175 reprints, and 5 microfiches.

The Department-wide Library system was implemented, with the organization of the libraries at Leganes and Binangonan. Computerization of library processes was undertaken in collaboration with the NACA — Regional Lead Centre of the Philippines Computer Unit. This is also in preparation for the implementation of the Brackishwater Aquaculture Information System (BRAIS) in 1984, in collaboration with the International Development Research Centre of Canada.

Documentation activities centered on the compilation, organization and publication of abstracts and bibliographies, the servicing of outreach information through Selective Dissemination of Information and the Scientific Literature Service, and the strengthening of the document delivery capacity. The *Aquaculture Abstracts* was entered as an information service material in the *Aquatic Science and Fisheries Abstracts* (ASFA) cf., Vol. 13 No. 3, 1983. The *Milkfish Bibliography* was compiled for the Second International Milkfish Aquaculture Conference in October.

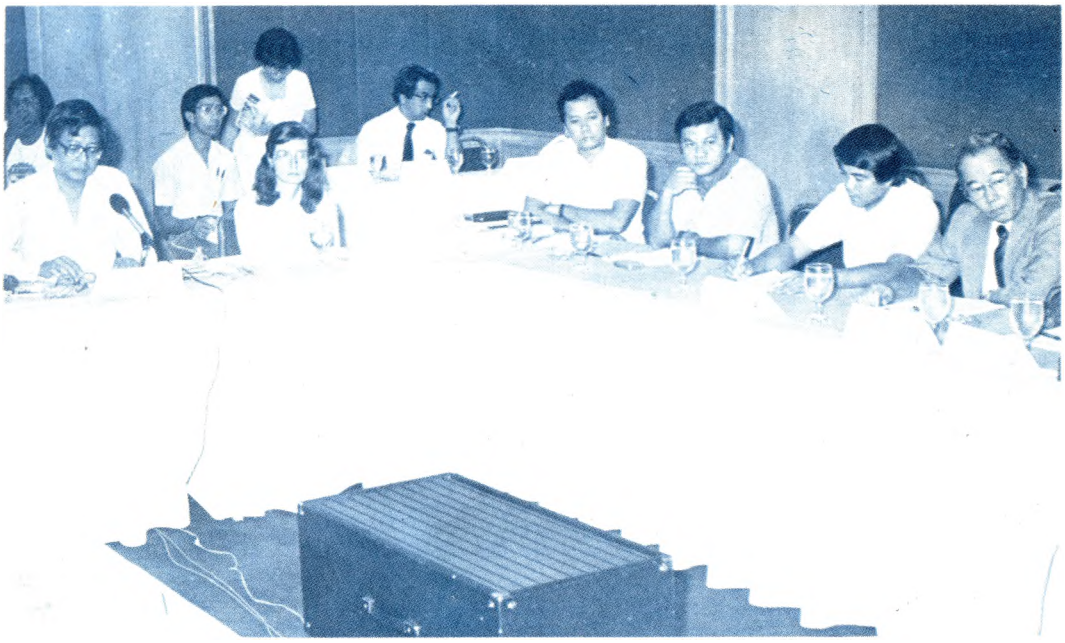
CONFERENCES AND MEETINGS

The Second International Milkfish Aquaculture Conference, sponsored by the Department and the International Development Research Centre of Canada, brought together some 200 scientists and technologists from Canada, U.S.A., Indonesia, Japan, Taiwan, Sri Lanka, Thailand, Singapore, Malaysia, and the Philippines.

Past achievements, current problems and prospects of milkfish culture were discussed during the Conference held in Iloilo City, Philippines on 4-8 October 1983. Eleven country and industry papers were discussed by resource persons from several Asian countries. Five special papers in various disciplines were also presented by scientists who have specialized in milkfish biology and culture. Twenty three oral and 21 poster presentations were made under five topics: artificial propagation, physiology, culture, nutrition and feed development, and pathology/ecology.

The Symposium on Aquaculture Research and Development for the Next Decade was held during the Department's 10th Anniversary Celebration in July 1983. The symposium identified priorities and programs of aquaculture research and development for the next 10 years and fostered closer ties and cooperation among institutions involved in aquaculture research and development.

The Department also hosted the 6th Program Committee Meeting of SEAFDEC which convened in Manila on 23-26 August



Top, AQD Chief Alfredo C. Santiago, Jr. presents the Department's program of activities for 1984-85 during the 6th SEAFDEC Program Committee meeting. At left is Dr. Veravat Hongskul, committee chairman and SEAFDEC secretary-general.

Right, Natural Resources Minister Teodoro Q. Peña addresses participants of the Second International Milkfish Aquaculture Conference. At right is Assemblyman Narciso D. Monfort.

1983. The SEAFDEC Program Committee, composed of chiefs and deputy chiefs from the three technical departments and representatives from member countries, namely, Malaysia, Singapore, Thailand, Japan, and the Philippines, reviews the technical programs of each department before it is approved by the SEAFDEC Council of Directors.

Publications/Documentation

In support of the Department's information and technology dissemination program, extension manuals, technical reports, newsletters, brochures and leaflets were published.

Extension Manual No. 2 — *Nutrition and Feeding of Penaeus monodon;* Third Edition; June 1983.

Extension Manual No. 5 — *Farming of Prawns and Shrimps;* Third Edition; September 1983.

Extension Manual No. 7 — *Broodstock of Sugpo, Penaeus monodon;* Third Edition; June 1983.

Extension Manual No. 8 — *Farming Mussels Using Rafts;* First Printing; July 1983.

Two technical reports were revised and printed with financial support from IDRC. These are: Technical Report No. 9 — *Milkfish Fry and Fingerling Industry of the Philippines: Methods and Practices;* Second Edition; September 1983; and Technical Report No. 10 — *A Guide to Induced Spawning and Larval Rearing of Milkfish, Chanos chanos (Forsskal);* Second Edition; September 1983.

A Compilation of Technical Papers on Milkfish and Other Finfishes, Volumes I and II were published in July 1983. These volume contain technical papers on breeding, larval rearing, ecology, and pathology of milkfish and other finfishes authored by AQD researchers since 1975.

Two extension leaflets on *Site Selection for Brackishwater Ponds and Soil Sampling and Preparation for Laboratory Analysis* were produced as guides for extension workers and fishfarmers.

Three brochures on the activities of AQD entitled *Harnessing Aquaculture for National and Rural Development, Research Programs,* and *Aquaculture Research and Development: The First Decade* were printed in June.

The Department's *Annual Report 1982* was published in April. The Department also revived the *Asian Aquaculture,* a monthly newsletter and *Aqua Farm News,* another monthly publication which

serves as a production guide for fishfarmers and extension workers.

Proceedings of the seminar-workshop on *Aquaculture Research and Development: The Next Decade* was published in August.

Video tape and slide-tape presentations were also produced in collaboration with the Network of Aquaculture Centres in Asia and the Japanese International Cooperation Agency. Among the 25 video tape presentations produced during the year are: *Milkfish — From the Wild to the Farm; Farming the Coastal Waters; Technology Boost to the Prawn Industry of the Philippines; Tilapia Cage Farming — A New Enterprise for Small Fishermen; Aquaculture Research and Development: The First Decade; Binangonan Research Station Omnibus; Naujan Station; Leganes Station* and other training, extension and public relations materials.

Forty-four (44) scientific papers were contributed by department staff to various international and national journals and/or presented at scientific meetings and conferences.

INTERNATIONAL PUBLICATIONS

Basiao, Z. 1983. An investigation on enzyme and other protein polymorphism in Japanese stocks of the Tilapias *Oreochromis niloticus* and *Tilapia zilli.* Aquaculture (in press).

Murai, T.*, A. Sumalangcay, Jr. and F.P. Pascual. 1983. Supplement of various attractants to a practical diet for juvenile *P. monodon* Fabricius. Fish. Res. J. Phil. (in press).

Quinitio, G.F. and Gunzo Kawamura*. 1983. Field experiment on the driving effect of gear for catching milkfish fry. Mem. Kag. Univ. Res. Cen. for the South Pacific (in press). (in press).

Storch, V*., J.V. Juario and F.P. Pascual. 1983. Preliminary observations on the early effects of nutritional stress on the liver of milkfish, *Chanos chanos* (Forsskal) and on the hepatopancreas of the tiger prawn, *Penaeus monodon* Fabricius. Aquaculture (in press).

Storch, V*., W. Stahlin* and J.V. Juario. 1983. The effect of different diets on the ultrastructure of hepatocytes of *Chanos chanos* fry (Chanidae, Teleostei): An electron microscopic and morpholometric analysis. Marine Biology (in press).

Villaluz, A. and A. Unggui. 1983. Effects of temperature on behavior, growth, development and survival in young milkfish, *Chanos chanos* Forsskal. Aquaculture (in press).

*visiting researchers

NATIONAL PUBLICATIONS

Banada, V. 1983. The occurrence of postlarval fishes associated with milkfish fry at Malandag, Hamtik, Antique. Fish. Res. J. Phil (in press).

Marte, C. and L. Crim*. 1983. Gonadotropin profiles in serum of milkfish treated with salmon pituitary homogenate. Kalikasan Philipp. J. Biol. 12(1-2): 1983.

Pascual, F.P. and A. Sumalangcay, Jr. 1983. Gum arabic, carrageenan of various types and sago palm starch as binders in prawn diets. Fish Res. J. Phil. (in press).

Villegas, C.T. and I. Bombeo. 1983. Effects of increased stocking density and supplemental feeding on the production of milkfish fingerlings. Fish. Res. J. Phil. (in press).

Young, A. and R. Travina. 1983. Preliminary studies on predicting the settling season of oysters, *Crassostrea iredalei* in Himamaylan River-estuary, Negros Occidental. Kalikasan Philipp. J. Biol. (in press).

ABSTRACTS AND SCIENTIFIC PAPERS PRESENTED

Aujero, E., O. Millamena, E. Tech and S. Javellana. 1983. Nutritional value of five marine phytoplankton species isolated from Philippine waters as food for larvae of *Penaeus monodon.* Paper presented at the First International Biennial Conference on Warm Water Aquaculture-Crustacea, Brigham Young University, Hawaii Campus, February 9-11, 1983.

Baliao, D.D., E. Rodriguez and D. Gerochi. 1983. Culture of mudcrab *Scylla serrata* (Forsskal) at different stocking densities in brackishwater ponds. Paper presented at the First International Biennial Conference on Warmwater Aquaculture-Crustacea, Brigham Young University-Hawaii Campus, February 9-11, 1983.

Jumalon, N.A., D.G. Estenor, R.F. Bombeo and A.M. Dadole. 1983. Studies on *Artemia* production in earthen ponds in the Philippines. Paper presented at the First International Biennial Conference on Warmwater Aquaculture-Crustacea, Brigham Young Univerysity-Hawaii Campus, February 9-11, 1983.

Jumalon, N.A. and R. Robles, 1983. Sampling and stocking density for *Artemia* production in ponds. Paper presented during the First International Biennial Conference on Warmwater Aquaculture-Crustacea, Brigham Young University-Hawaii Campus, February 9-11, 1983.

Quinitio, E., D. de la Pena, Jr., and F. Pascual. 1983. The use of substitute feeds in larval rearing of *Penaeus monodon.* Paper presented at the First International Biennial Conference on Warm Water Aquaculture-Crustacea, Brigham Young University, Hawaii Campus, February 9-11, 1983.

Quinitio, E. and E. Reyes. 1983. The effect of different feed combination using chicken egg yolk in *Penaeus monodon* larval rearing. Paper presented at the First International Biennial Conference on Warm Water Aquaculture-Crustacea, Brigham University, Hawaii Campus, February 9-11, 1983.

Pantastico, J.B. 1983. Acceptability of five species of freshwater algae of Tilapia (*Oreochromis niloticus*) fry. Paper presented at the Asian Finfish Nutrition Workshop, Singapore, August 23-26, 1983.

Baticados, M.C.L. and G.F. Quinitio. 1983. Occurrence and pathology of an Amyloodinium-like protozoan parasite on gills of grey mullet, *Mugil cephalus.* Paper presented at International Helgoland Symposiums , 1983, Helgoland, Federal Republic of Germany, September 11-16, 1983.

Aujero, E. and E. Tech. 1983. Preliminary studies from the isolates and culture of marine yeast. Paper presented at the Symposium on Research Biology and Biotechnology for Developing Countries, Singapore, November 2-4, 1983.

Abstracts

Papers presented at the Second International Milkfish Aquaculture Conference, Iloilo City, Philippines, October 4-8, 1983.

Villaluz, A. 1983. Capture, handling, transport and acclimatization of milkfish fry and fingerlings.

Baliao, D. 1983. Milkfish nursery pond and pen culture in the Indo-Pacific Region.

Po, Gilda Lio. 1983. A review of diseases of milkfish, *Chanos chanos* (Forsskal).

Hara, S*. and L.B. Tiro, Jr. 1983. The effect of cryoprotectant on the cryogenic preservation of the sperm of milkfish, *Chanos chanos.*

Marte, C.L., F.J. Lacanilao and J.V. Juario. 1983. Completion of the life cycle of milkfish *Chanos chanos* (Forsskal) in captivity.

Duenas, C.E. and P.S. Young. 1983. Salinity tolerance and resistance of milkfish larvae.

Ferraris, R.P., J.M.E. Almendras, A.P. Jasul and J.M. Ladja. 1983. Preliminary studies on ion and osmoregulation in milkfish.

Ferraris, R.P., J.D. Tan and M.C. de la Cruz. 1983. The developmental morphology of the digestive tract in the milkfish *Chanos chanos* Forsskal.

Gorriceta, I.R. and L.V. Benitez. 1983. Lipid digestion in milkfish grown in ponds on two types of natural food bases.

Santiago, C.B., M.C. Aldaba, M.A. Laron and O.S. Reyes. 1983. Factor affecting survival of milkfish fry during acclimation to freshwater.

Apud, F.D. and B.J. Pudadera, Jr. 1983. Integrated farming of *Penaeus indicus*, *Chanos chanos*, and poultry in brackishwater ponds.

Baliao, D.D. 1983. Milkfish production in a modular pond system with supplemental feeding.

Villegas, C.T., O.M. Millamena and F.O. Escritor. 1983. Growth, survival and fatty acid composition of *Chanos chanos* fry fed *Brachionus plicatilis* reared on three selected algal diets.

Alava, V.R. and M.C. de la Cruz. 1983. Quantitative dietary fat requirements of *Chanos chanos* fingerling in a controlled environment.

Coloso, R.M., L.B. Tiro and L.V. Benitez. 1983. A reference amino acid pattern for milkfish, *Chanos chanos* juveniles.

Duray, M.N. and T.U. Bagariano. 1983. Weaning of hatchery-bred milkfish larvae from live food to artificial diets.

Ferraris, R.P., M.R. Catacutan, R.A. Mabelin, A.P. Jasul and F.P. Pascual. 1983. Apparent digestibility measurement in feedstuffs for milkfish.

Pantastico, J.B., J.P. Baldia and D.M. Reyes. 1983. Feed preference of milkfish (*Chanos chanos* Forsskal) fry given different algal species as natural feed.

Banno, J.E. 1983. The food and feeding habits of the milkfish fry *Chanos chanos* (Forsskal) collected from two habitats along the coast of Hamtik, Antique.

Cruz, E.R., C.T. Tamse and C.L. Pitogo. 1983. Tolerance and histo-pathological response of milkfish, *Chanos chanos* Forsskal, fingerlings to potassium permanganate.

Kumagai, S.*, T.U. Bagariano and A.O. Unggui. 1983. Growth of juvenile milkfish in the wild.

Muroga, K.*, G. Lio-Po, C.L. Pitogo and R. Imada*. 1983. *Vibrio* sp. isolated from milkfish (*Chanos chanos*) with opaque eyes.

Po, G.L., R.O. Duremdez and A.R. Castillo, Jr. 1983. An investigation of gas bubble disease occurrence among *Chanos chanos* fry.

Another seventeen (17) papers were contributed for Poster Presentation during the Second International Milkfish Aquaculture Conference, Iloilo City, Philippines, October 4-8, 1983.

Juario, J.V., M.N. Duray, V.M. Duray, J.F. Nacario, J.M.E. Almendras. 1983. Induced breeding and larval rearing experiments with milkfish *Chanos chanos* (Forsskal) in the Philippines.

Requintina, P.D. 1983. Serum protein patterns of milkfish, *Chanos chanos*, in relation to gonadal maturation.

Tan, J.D. 1983. Histological study of the hypophysial-gonadal system during sexual maturation and spawning in the milkfish *Chanos chanos* Forsskal.

Hara, S., E.M. Avila, T.U. Bagarinao and M.M. Parazo. 1983. Diurnal feeding patterns of milkfish (*Chanos chanos*) larvae under laboratory conditions.

Hara, S., M.M. Parazo and E.M. Avila. 1983. The influence of starvation on food intake and growth of milkfish (*Chanos chanos*) fry in captivity.

Apud, F.D. 1983. Integrated polyculture of *P. indicus*, *P. monodon* and *C. chanos* with poultry.

Baliao, D.D. and A.N. Marasigan. 1983. Effects of varying densities and size-group combination of milkfish yield in fertilized ponds.

Jumalon, N.A. 1983. Analysis of "lab-lab" production in a tropical fishpond: A multivariate approach.

Tabbu, M.Y. 1983. Polyculture of milkfish (*Chanos chanos*) with green mussel (*Perna viridis* Linnaeus) in brackishwater ponds.

Acosta, B.O. and J.V. Juario. 1983. Biological evaluation of *Brachionus plicatilis* fed *Chlorella* sp., *Isochrysis galbana* and *Tetraselmis* sp. and their combinations as feed for milkfish (*Chanos chanos*, Forsskal) fry.

Bautista, M.N. and M.C. de la Cruz. 1983. Effects of dietary linoleic and linolenic acids on growth, survival, fatty acid composition and liver histology of milkfish fingerlings.

Juario, J.V. and V. Storch. 1983. Biological evaluation of the phytoplankton, *Chlorella* sp., *Isochrysis galbana* and *Tetraselmis* sp. as food for milkfish fry.

Lim, C. and V.R. Alava. 1983. Artificial diets for *Chanos chanos* (Forsskal) fry.

Pascual, F.P. 1983. Biological evaluation of some practical diets developed for milkfish fingerlings.

Banada, V.C. 1983. The occurrence of postlarval fishes associated with milkfish fry at Malandog, Hamtik, Antique.

Tamse, C.T., F.P. Pascual and M.C. de la Cruz. 1983. Some histological observations on the opaque eyes of milkfish, *Chanos chanos* (Forsskal).

Trino, A.T. and R.D. Fortes. 1983. Relationship of selected fish food organisms with the occurrence of wild milkfish juveniles in the mangrove lagoon at Nabunut Island.

Administration

Reorganized to effectively support the Research, Training and Extension Divisions, the Administrative Division consists of five supportive sections: Auxillary Services, Finance, Personnel Management, Physical Plant, and Property and Supply Management.

PERSONNEL DEVELOPMENT

The Department had a total work force of 742 personnel, as of December 31, 1983, distributed as follows: Research Division — 418; Training and Extension Division — 42; Administrative Division — 223; Office of the Chief — 26; and External Affairs Office — 33. Of the total 418 personnel involved in research, 215 are in Tigbauan Research Station, 93 in Binangonan Research Station, and 110 in Leganes Research Station.

Dr. Alfredo C. Santiago, Jr. assumed office as Department Chief effective January. Prior to his appointment, Dr. Santiago was a Researcher of the Binangonan Research Station where he had served as Station Head.

Dr. Yasuhiko Taki assumed his post as Deputy Chief effective June. Dr. Taki is Associate Professor in the Tokyo University of Fisheries, from which he earned graduate and post-graduate degrees in aquaculture in 1954 and 1955, respectively. He served as Icthyologist/Aquaculturist in Laos in 1966-67 and 1970-71 under a USAID program. In 1974 he assisted the Cantho University in Vietnam as Fisheries Expert under a JICA Cooperation Project.

The research capability of the Department was strengthened with the completion of graduate studies by 8 of its staff in 1983. Three finished their doctoral degree and five completed their masteral programs.

Ph.D. Degree

- Llobrera, Alcestis, Ph.D. in Sea Food Technology, Texas A & M University, "Bacteriological safety as-

sessment of *Clostridium botulinum* in fresh fish and shellfish packaged under modified atmosphere containing CO_2".

- Llobrera, Jose, Ph.D. in Fisheries, Texas A & M University, "Effects of dissolved oxygen on the survival, growth and energetics of juvenile freshwater shrimp, *Macrobrachium rosenbergii*".

- Sanchez, Arthur, Ph.D. in Oceanography, University of Washington, "Chemical speciation and absorption behavior of plutonium in natural water".

Master's Degree

- Corre, Kaylin, M.S. Aquaculture, University of the Philippines in the Visayas "Culture of prawn (*P. monodon*) in combination with Nile Tilapia at varying stocking densities in brackishwater pond".

- Estepa, Fe Dolores, M.S. Aquaculture, University of the Philippines in the Visayas, "The effect of feeding different zooplankton on the growth and survival of *Penaeus monodon* larvae"

- Pena de la, Dioscoro, Jr., M.S. in Aquaculture, University of the Philippines in the Visayas, "Effect of different levels of aeration and mechanical agitation on the development and survival of *Penaeus monodon* Fabricius larvae".

- Sunaz, Fernando, M.S. Fisheries, Tokyo University, "Basic studies of the culture of micro-algae as food for marine animals".

- Bagarinao, Teodora, M.S. Marine Biology, University of California, San Diego, "The visual feeding threshold and action spectrum of the northern anchovy (*Engraulis mordax* G) larvae and some ecological implications.

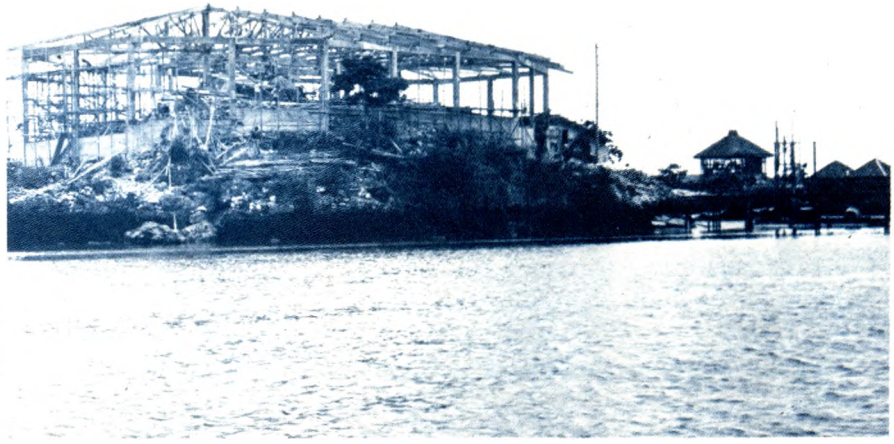
INFRASTRUCTURE DEVELOPMENT

Major infrastructure developments in support of research activities include the following:

At the Leganes Research Station, construction of the Hatchery/Nursery Complex for prawn research, the *Artemia* saltbed production pond facilities, the 1.0 ha crab pond, and the 200-lm x 2m oyster trays were completed. Repair of the main gate drainage, mechanized excavation of 1.5 ha prawn maturation pond at the Jalaud sector, maintenance and rehabilitation of existing ponds and pond facilities, and the construction and extension of drain canals for ponds were undertaken. A push pump to provide the water requirements of the ponds and a 150 KVA generating unit to provide sufficient electricity in the station were installed.

Water pipelines for the development of an alternate water source were installed at the Tigbauan Research Station. A 450 KVA generator was installed to provide the needed electricity supply in case of power shortage or failure. The offices and laboratories in the Nutrition and Reproductive Physiology Building were occupied in April.

Additional fishpens and cages were constructed at the Binangonan Research Station. Renovation of the Hatchery Building; construction of the Training and Extension Building and Dormitory; boat fabrication; repair of staff houses; improvement of facilities at the BRS Liaison Office; completion of the internal



An aqua-laboratory is being developed in Igang for expanded coastal aquaculture, mariculture and maturation studies.

The Naujan Research Substation in Mindoro Oriental. Sabalo abound in the area and the province has great potentials for aquaculture.

road network and the freshwater pumping system; and improvement of power and aeration systems were also undertaken.

An aqua-laboratory is being developed in Igang for expanded coastal aquaculture, mariculture and maturation studies. Construction of a wet laboratory with an area of 697.3 sq m and living quarters is ongoing. The laboratory can accommodate five 50-ton circular tanks, four 10-ton circular tanks and an algae culturing area of approximately 120 m^2. Fishpens, floating cages and a floating utility house were also constructed.

Facilities at the Batan Substation were also improved. A seawall and a bamboo catwalk from the Station to the maturation pens were installed.

The Naujan Substation was reactivated to serve as an outreach station for milkfish spawning and maturation.

INSTITUTIONAL LINKAGES

The Department continued to strengthen its relationships with international and national organizations involved in aquaculture research and development. A number of significant projects were implemented in 1983 with financial and technical assistance from various funding institutions and donor agencies.

International

- **Japan International Cooperation Agency (JICA)**

As part of its annual technical assistance to the Department, JICA made available in 1983, the services of the following experts:

1. Dr. Yasuhiko Taki as Deputy Chief
2. Mr. Mitsuru Yamasaki as JICA Coordinator
3. Mr. Shiro Hara assigned to the Finfish Seed Production Project
4. Mr. Yoshibumi Yashiro assigned to the Crustacean Seed Production Project; and
5. Mr. Masanori Suemitsu assigned to the Crustacean Pond Culture Project

JICA also awarded study/travel grants to the following research staff of the Department:

1. Amado Sumalangcay, Jr. for a six-month training in artificial feed preparation and related studies at Kochi University, beginning February 1983.
2. Ilda Gorriceta for attendance in the Pacific Congress held at the University of Otago, New Zealand on February 1-11, 1983.

Production of video tapes on the activities of the Department was made possible through assistance from JICA.

- **International Development Research Centre (IDRC) of Canada**

In connection with its assistance to the Department's milkfish research project (Phase III), IDRC also awarded study/travel grants to qualified staff members, including:

1. Jesse Banno for participation in the training in plankton for aquaculture at Scripps Institute of Oceanography, University of California from January 3-July 18, 1983.
2. Dr. Julia Pantastico and Dr. Lita Benitez for attendance in the Asian Finfish Nutrition Workshop held in Singapore on August 13-26, 1983.
3. Jose P. Baldia for attendance in the Workshop on Hatchery Technique for Freshwater Fish Culture in Southeast Asia held in Colombo, Sri Lanka on December 4-13, 1983.
4. Luis Ma. Garcia for the completion of an M. Sc. course in Zoology at the University of Alberta, Canada.
5. Clarissa Marte for the completion of a Ph.D. degree in Reproductive Physiology at the University of Singapore.
6. Relicardo Coloso for participation in the training on amino acid uptake and metabolism in Scotland from September 1982 to April 1983.

IDRC also sponsored the Second International Milkfish Aquaculture Conference held in Iloilo City on October 4-8, 1983.

The implementation of the Brackishwater Aquaculture Information System (BRAIS) will commence in 1984 with technical and financial assistance from the IDRC.

- **Network of Aquaculture Centres in Asia (NACA)**

At the Aquaculture Department, which was identified as the Regional Lead Center in the Philippines (RLCP), NACA continued to implement four activities namely: the third Training Course for Senior Aquaculturists in Asia and the Pacific Region; research and refinements of existing shrimp culture techniques and economically important finfishes, such as sea bass; the Aquaculture Information System; and Video Tape productions on the activities of the Department.

A Memorandum of Understanding in connection with the implementation of the Philippine National Aquaculture Center linked with NACA was signed on 21 July 1983, by the Director of the Bureau of Fisheries and Aquatic Resources, the Chief of the Aquaculture Department and Director of RLCP,, and the NACA representative in the Philippines and NACA training coordinator.

- **French Government**

The Government of France assigned Dr. Patrick Soletchnik, to work on the "Constitution of *Siganus* broodstock under improved conditions and rearing of larvae".

Study /travel grants were also awarded to the following staff:

1. Dr. Alfredo C. Santiago, Jr. for an observation/study tour of the various aquaculture centers in France.
2. Rosario Pudadera for a six-month training in France on prawn broodstock development beginning October 1983.

- **International Foundation for Science (IFS) of Sweden**

A research grant was awarded by IFS for the Department's research on "Integration of *Artemia* production with salt production and milkfish/prawn culture in earthen salt ponds".

IFS also sponsored the attendance of Nepheronia Jumalon to the First International Biennial Conference on Warm Water Aquaculture-Crustacea held in Hawaii on February 9-11, 1983.

- **Artemia Reference Center (ARC) of Belgium**

ARC assigned Mr. Luke de Ruyck to assist in the intensive *Artemia* culture projects of the Department.

- **British Council of the U.K.**

The British Council continued to support the one-year study grant of Isidra Tuburan in London. Her study centered on the qualitative and quantitative analyses of algae, their identification and culture.

- **American Soybean Association**

The American Soybean Association awarded two grants for the Department's research on fish nutrition and feed development.

The attendance of Emilia Quinitio to the First International Biennial Conference on Warm Water Aquaculture-Crustacea, was sponsored by the American Soybean Association.

- **Southeast Asian Regional Center for Graduate Studies and Research in Agriculture (SEARCA)**

The conduct of the Aquabusiness Project Development and Management (APDEM) workshop is a collaboration between the Department and SEARCA.

National

- **Ministry of Natural Resources (MNR) and Bureau of Fisheries and Aquatic Resources (BFAR)**

For the continuous implementation of the National Bangus Breeding Program (NBBP) in twelve (12) farm sites in the Philippines.

- **Philippine Federation of Rural Broadcasters**

For information dissemination through the broadcast of aquaculture and other related information.

- **Philippine Business for Social Progress-Center for Rural Technology Development (PBSP-CRTD)**

For carp technology verification projects.

- **Philippine Federation of Aquaculturists**

For prawn culture verification projects.

- **Mariano Marcos State University**

For the implementation of technology verification project in Northern Luzon, involving the establishment of a prawn production complex and a demonstration farm for seaweeds culture.

- **Farm System Development Corporation (FSDC) Laguna Lake Development Authority (LLDA)**

For pen and cage culture technology for milkfish and tilapia in Laguna Lake, and the implementation of Program UNLAD (United Neighborhood for Livelihood and Development) of the Philippine Government.

- **University of the Philippines in the Visayas (UPV)**

For research, training and extension to further aquaculture development in the country and the region.

SOURCE OF FUNDING

For 1983, the Government of the Philippines contributed a total of US $3.58 million, as its commitment to the Aquaculture Department for the advancement of aquaculture in the country and the region.

The Japanese Government's support, through the Japan International Cooperation Agency (JICA), was in terms of equipment, Japanese expertise, training and fellowship grants, and staff development. Substantial support also came from the International Development Research Centre (IDRC) of Canada through a research grant for milkfish research.

Financial and technical assistance also came from the Network of Aquaculture Centres in Asia, the International Foundation for Science, Artemia Reference Center, the Government of France, the British Council, and the American Soybean Association.●

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