# The Philippine Inland Fisheries Project and Aquaculture Production Project—Completion Report

PROJECT: Philippines AID/ea-180
DATES: March 1971-March 1979

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## ACRONYMS USED IN REPORT

| *Acronym* | *Complete title* |
|---|---|
| APP | Aquaculture Production Project |
| BAC | Brackishwater Aquaculture Center |
| BFAR | Bureau of Fisheries and Aquatic Resources |
| CIF | College of Inland Fisheries (Central Luzon State University) |
| CLSU | Central Luzon State University |
| FAA | Fisheries and Allied Aquacultures (Auburn University) |
| FAC | Freshwater Aquaculture Center |
| GRP | Government of the Republic of the Philippines |
| IFP | Inland Fisheries Project |
| NEDA | National Economic Development Authority |
| NFAC | National Food and Agriculture Council |
| NSDB | National Science Development Board |
| PCARR | Philippines Council for Agriculture and Resources Research |
| PL-480 | Public Law (U.S.) Number 480 |
| RELCOM | Research-Extension Linkage Committee |
| SEAFDEC | Southeast Asian Fisheries Development Center |
| UP | University of the Philippines |
| UPCF | University of the Philippines College of Fisheries |
| USAID | United States Agency for International Development |
| USDA | United States Department of Agriculture |

## SUMMARY

The Auburn University International Center for Aquaculture, a unit of the Agricultural Experiment Station's Department of Fisheries and Allied Aquacultures, was involved from 1971 to 1979 in two successive aquacultural development projects, the Inland Fisheries Project and the Aquaculture Production Project, as a contractor of the U.S. Agency for International Development to the Republic of the Philippines.

The goal of both projects was to improve the nutrition of the Filipino people by helping the host country government to develop the substantial potential that existed in the country for increasing production of fish through aquaculture. The strategy for the projects was to develop three institutional capabilities postulated to be prerequisite to the progress of aquaculture in the Philippines: research, manpower training, and extension.

To accomplish these objectives, the Inland Fisheries Project (1971 to 1974) concentrated on the establishment of two research-training centers, the Freshwater Aquaculture Center on the principal island, Luzon, and the Brackishwater Aquaculture Center located centrally in the archipelago on Panay Island. During the project, key staff members from each center were sent to universities abroad for graduate training. Meanwhile, limited research activities were begun in facilities borrowed from the government fisheries agency and private individuals, even before the centers were completed.

The Aquaculture Production Project (1974 to 1979) focused on continued physical development of the centers; intensification and expansion of research efforts; and establishment of two training programs, one leading to an academic degree, the other practical. The project also sought to institute an effective extension program within the national Bureau of Fisheries and Aquatic Resources, and to link this element with the research centers.

When the projects ended in March 1979, they could be credited with several accomplishments:

(1) Two aquacultural research centers, the first in the Philippines, had been established.

(2) Staff members of the centers had developed into competent, highly trained researchers through graduate study plus the several years of practical experience gained during the projects. Six had earned Ph.D. degrees and 10 had earned M.S. degrees at Auburn University under project sponsorship; an additional Ph.D. degree was earned at the University of Washington.

(3) Research programs had been established and were evolving into effective instruments for the development of new technology. In fact, the Freshwater Aquaculture Center was already gaining prominence for its efforts to re-introduce the nearly abandoned practice of rice-cum-fish culture.

(4) Both centers had instituted academic programs leading to degrees in aquaculture; the Brackishwater Aquaculture Center was conducting the first, and only, graduate program in fisheries in the Philippines. The centers had begun also to offer short courses to extension agents and fish farmers.

(5) For the first time, an Extension Division, having formal responsibility for design and implementation of an extension program, had been established within the Bureau of Fisheries and Aquatic Resources. This new division, with assistance of technical advisors from Auburn University, directed an intensive program in two pilot regions to improve the effectiveness of extension activities to aquaculture. These pilot projects are now serving as models for similar efforts throughout the country.

Although many problems remain to be resolved, the projects were instrumental in assisting the Philippine government to establish the institutional components fundamental to the development of the country's aquacultural potential. It remains the responsibility of the host country to carry forward from this sound base. Recommendations relating to future aquacultural development in the Philippines also are included in this report.

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COVER. Aerial views of Brackishwater Aquaculture Center (top) and Freshwater Aquaculture Center (bottom) showing research pond complex and principal buildings.

# The Philippine Inland Fisheries Project and Aquaculture Production Project-Completion Report[1]

JOHNIE H. CRANCE and DANIEL F. LEARY[2]

## INTRODUCTION

THIS REPORT COVERS the rationale, concept, and major accomplishments of two aquacultural development projects of the Government of the Republic of the Philippines (GRP). The projects, entitled "Inland Fisheries Project" (IFP) and "Aquaculture Production Project" (APP), ran consecutively (IFP, 1971-1974; APP, 1974-1979) and had similar objectives. They were separated into two projects primarily for administrative purposes.

The purpose of the IFP and APP was to improve the nutrition of Filipinos through the establishment of institutions with aquacultural research, teaching, and extension capabilities to increase aquacultural fisheries production.

## RATIONALE AND BACKGROUND

An important staple in the diet of Filipinos, fish plays a vital role in the nutrition of the people. It is the principal animal protein in the Filipino diet and ranks second only to rice as a source of protein in general.

As important as fish is in the diet of Filipinos, however, production (derived primarily from hunting and capturing wild stocks) is not sufficient to meet the needs of the nation's 43 million people. Protein consumption in the Philippines is estimated to be 7 percent below United Nations Required Daily Allowance. Total fish production during 1975 (latest annual statistics available) was about 1.3 million metric tons, insufficient to meet national needs, table 1. The country's demand for fish in the year 2000 is projected to be 4 million metric tons, or about three times current production.

The GRP recognizes the essential need to increase fisheries production by all feasible means, but this will be a difficult undertaking. Many fisheries scientists feel that the catch from marine stocks is already approaching maximum sustainable yield. Furthermore, the costs of increasing the units of effort required to catch more fish from the sea are becoming prohibitive due to rising costs of energy, fishing vessels, and gear. Nor is increased importation of fisheries products an answer because the Philippines economy cannot afford the high cost in foreign exchange.

Aquaculture has been practiced in the Philippines for centuries. Nevertheless, production from this fisheries subsector has lagged far behind its potential. Only about 106,000 metric tons per year, or about 8 percent of the nation's total fish production, was derived from aquaculture in 1975, table 1. Over 90 percent of the fish produced by aquaculture in the Philippines is milkfish (*Chanos chanos*) grown in over 176,000 hectares of brackishwater ponds in the country. It is estimated that an additional 400,000 hectares of coastal swamplands could be developed into brackishwater fishponds. Average production of milkfish per hectare in existing brackishwater ponds is low (about 600 kilograms per hectare), but technology is available that could double this yield if it were applied effectively.

Essentially, there is no freshwater fisheries industry in the Philippines. However, the potential for development of this subsector is great. Over 1.4 million hectares of irrigated rice paddies have potential for culture, and there are more than 126,000 hectares of swampland that could be developed into freshwater fishponds.

In 1970 the GRP implemented a broad program to augment national efforts aimed at achieving the goal of improved nutrition for Filipinos. Increased production of fish was selected to receive special emphasis as a principal source of protein. As part of the national effort, proposals were developed for projects designed to increase production from all fisheries subsectors. A significant part of the development program was aimed at aquaculture. The high potential for increased aquacultural production, the need for more animal protein to supplement the diet of Filipinos, and the high priority assigned to fisheries development by the GRP provided the basis for USAID assisting the GRP with the IFP-APP.

The IFP officially started in March 1971 when all agreements pertaining to funding, personnel, administration,

TABLE 1. ACTUAL (1973-76) AND PROJECTED (1978 AND 1982) PRODUCTION TARGETS AND DEMAND ESTIMATES FOR FISHERIES PRODUCTS IN THE PHILIPPINES, METRIC TONS

| Year | Production, actual and projected | | | | Estimated demand[4] |
|---|---|---|---|---|---|
| | Inland[1] | Municipal[2] | Commercial[3] | Total | |
| 1973[5] .... | 99,600 | 639,795 | 465,442 | 1,204,837 | — |
| 1974[5] .... | 113,195 | 684,498 | 470,675 | 1,268,368 | — |
| 1975[5] .... | 106,465 | 731,725 | 498,617 | 1,336,803 | 1,442,000 |
| 1976[5] .... | 113,000 | (data not available) | | — | — |
| 1978[4] .... | 173,800 | 814,800 | 582,700 | 1,571,300 | 1,581,100 |
| 1982[4] .... | 252,800 | 973,100 | 720,700 | 1,946,600 | 1,910,900 |

[1] Fish harvested from ponds, lakes, rivers, and streams. About 90 percent of total harvest is milkfish from brackishwater ponds.

[2] Catch from vessels under 3 gross tons and other catch from water controlled by municipalities. Catch is primarily from near-shore, coastal waters.

[3] Catch from marine waters by vessels over 3 gross tons.

[4] Projected estimates for these years are from Fisheries Industry Development Council. They are based on median population growth rate projections and consumer demand growth rate of 4.1 percent estimated by the National Economic Development Study.

[5] Fisheries statistics of the Philippine Bureau of Fisheries and Aquatic Resources.

[1] Both projects were financed by the Government of the Republic of the Philippines and the United States Agency for International Development (USAID). Auburn University provided technical advisory services to the project through contract AID/ea 180.

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TABLE 2. IFP-APP COSTS BY COMPONENT, 1971-79

| Component | Costs (000's $U.S.) | | |
|---|---|---|---|
| | U.S. | GRP[1] | Total |
| **Freshwater Aquaculture Center** | | | |
| A. Capital improvements | 469[2] | 80 | 549 |
| B. Commodities | 136 | 2 | 138 |
| C. Technical advisory services[3] | 290 | — | 290 |
| D. Participant training[4] | 100 | — | 100 |
| E. Operation & maintenance, salaries | — | 370 | 370 |
| SUBTOTAL | 995 | 452 | 1,447 |
| **Brackishwater Aquaculture Center** | | | |
| A. Capital improvements | 620[2] | 161 | 781 |
| B. Commodities | 165 | 2 | 167 |
| C. Technical advisory services[3] | 290 | — | 290 |
| D. Participant training[4] | 152 | — | 152 |
| E. Operation & maintenance, salaries | — | 789 | 789 |
| SUBTOTAL | 1,227 | 952 | 2,179 |
| **Extension (BFAR)** | | | |
| A. Capital improvements | — | — | — |
| B. Commodities | 60 | — | 60 |
| C. Technical advisory services[3] | 199 | — | 199 |
| D. Participant training[4] | 50 | — | 50 |
| E. Operation & maintenance, salaries | — | 700 | 700 |
| SUBTOTAL | 309 | 700 | 1,009 |
| TOTAL | 2,531 | 2,104 | 4,635 |

[1] GRP costs are approximate. Exchange rate 1U.S.$ = ₱7.2 (pesos).
[2] Peso funds generated under PL-480 Title I (total of ₱7,746 for FAC and BAC).
[3] Costs for housing and in-country travel by U.S. technical advisors and USAID project management/administrative costs are not included.
[4] Costs for international travel by participants are not included.

and operations were signed. Funding for the IFP-APP was provided by several GRP agencies, including the National Science Development Board (NSDB), the National Economic Development Authority (NEDA), the National Food and Agriculture Council (NFAC), the University of Philippines College of Fisheries (UPCF), Central Luzon State University (CLSU), the Bureau of Fisheries and Aquatic Resources (BFAR), and the Philippines Council for Agriculture and Resources Research (PCARR).

The UPCF served as the primary proponent and lead agency for the IFP and CLSU served as the co-proponent. In the case of the APP, the UPCF, CLSU, and BFAR served as co-proponents and shared responsibilities for supporting the three primary components of the project: the Brackishwater Aquaculture Center (BAC), the Freshwater Aquaculture Center (FAC), and development of improved extension services, respectively. The International Center for Aquaculture of Auburn University's Department of Fisheries and Allied Aquacultures (FAA) provided about 18 years of technical advisory services to the two projects. Costs of the projects are listed in table 2.

## PROJECT CONCEPT

The basic concept of the two aquacultural development projects was to develop a coordinated aquacultural production program in the Philippines. It was recognized that the GRP needed to provide four institutional services to the fish farming industry to enable it to develop more rapidly: (1) research to improve and generate aquacultural technology, (2) manpower training (teaching) to provide trained, qualified personnel to both the private and public sectors, (3) extension services to transfer technology and assist fish farmers in putting research results into practice, and (4) administrative organization and support to coordinate and implement aquacultural programs effectively. Figure 1 depicts the conceptual interrelationships of these services to each other and to the clientele they collectively support. They were no different

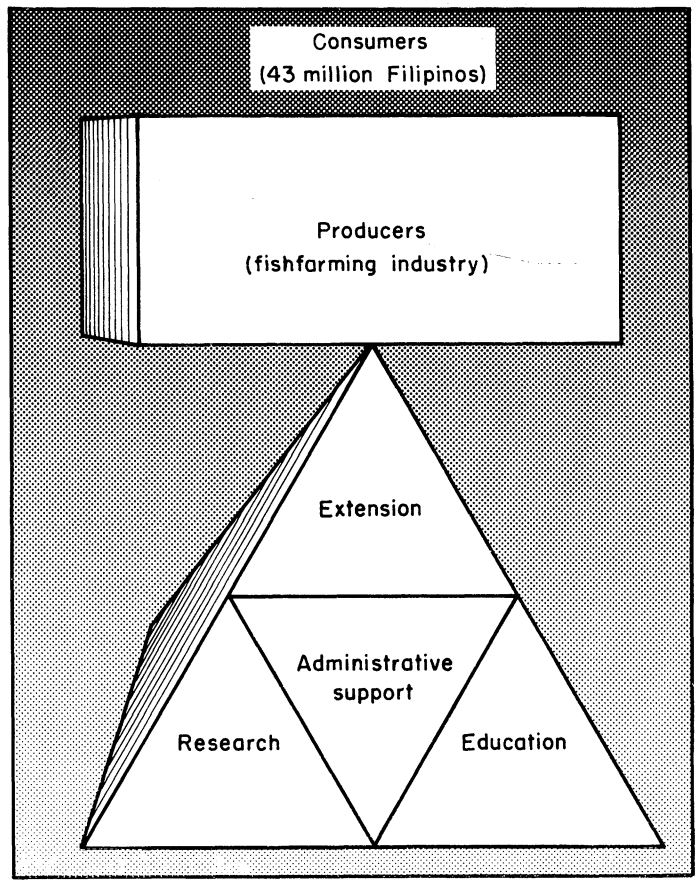



**FIG. 1. Conceptual interrelationships of the institutional services essential for a coordinated aquacultural production program.**

from those required for a coordinated aquacultural development program in the United States or in any other country.

In 1970, when the GRP intensified efforts to increase fish production, there did not exist in the Philippines an aquacultural research center, an institution that granted degrees in aquaculture, or a formally established aquacultural extension agency. The IFP was designed to focus on the development of two aquacultural centers, each with a trained staff actively engaged in conducting aquacultural research, teaching, and extension training programs. What followed was the construction and development of the FAC located on the campus of CLSU at Munoz, Nueva Ecija, and the BAC located at Leganes, Iloilo (see location map, figure 2).

While major facilities at the FAC and BAC were being completed and equipped with essential commodities, a core staff of Filipinos for each of the centers was trained at Auburn University, Appendix 1. Also, during this initial construction phase of the project, Auburn-FAA advisors assisted in conducting practical research field trials in facilities belonging to private fishpond owners, BFAR, CLSU, and the Iloilo Regional School of Fisheries. The FAC was officially inaugurated November 28, 1973, and pond research at the station was initiated in early 1974. Research facilities at the BAC became operational in early 1974 and limited research was begun in some of the ponds.

The APP, which began in July 1974 and ended March 1979, was a follow-on to the IFP. It focused on (1) completing and equipping facilities at FAC and BAC, (2) establishing a formal aquacultural extension program in the BFAR and training of BFAR extension personnel, (3) intensifying research ac-

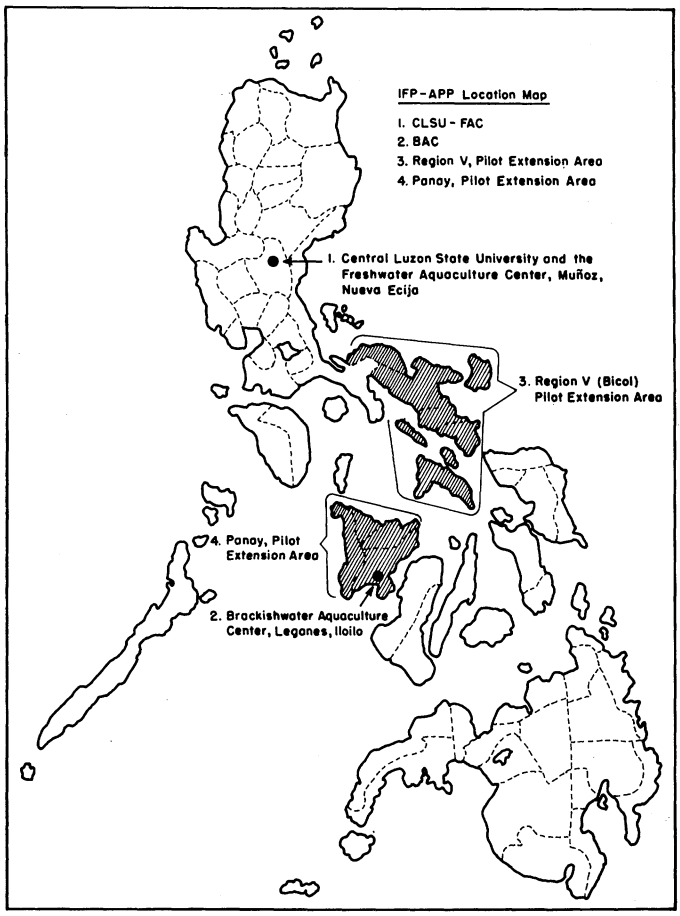



**FIG. 2. IFP-APP location map.**

tivities at the two centers and linking research programs with the extension program in BFAR, and (4) continuing the training of Filipino staff members of the FAC, BAC, and BFAR through the advisory services of Auburn University-FAA personnel.

## ACCOMPLISHMENTS

The basic institutional framework for a coordinated fisheries aquaculture production program has been successfully established in the Philippines as a result of the IFP-APP (see Appendix table 2, Avault et al. 1978, USAID 1978). This is not to say that there are no problems or needs remaining in aquacultural development in the Philippines. However, institutions for resolving aquacultural research and extension needs, the FAC, BAC, and the Extension Division of BFAR, have been established and are functioning on a sound basis.

The FAC and BAC are now serving important institutional functions for the GRP in aquacultural research, teaching, and extension training. The physical plants of the two centers include modern laboratories, classrooms, dormitory accommodations, and extensive research pond facilities. The core staffs of the FAC and BAC were trained at Auburn in general aquaculture and in specialized subject areas such as nutrition, economics, parasites and diseases, fishpond engineering, and fish processing. Researchers are now actively engaged in freshwater and brackishwater aquacultural research, teaching, administration, and extension training activities at the respective centers. PCARR has included the FAC and BAC in its network of research stations and has designated them national centers for research in freshwater and brackishwater aquaculture, respectively.

The extension component of the IFP-APP has been developed in the BFAR of the Ministry of National Resources. An Extension Division with an Aquaculture Section was formally established in the BFAR in 1976, following a Presidential decree (704) which recognized the national importance of aquaculture and the need to develop a stronger fisheries extension program. In 1974, two regions were selected as pilot areas for an intensified extension effort as part of the APP, figure 2. In these areas, brackishwater aquacultural production and interest in new and improved methods of aquaculture have increased significantly. As a result of extension activity, the practice of growing fish in paddies with rice is being adopted by scores of low-income families after nationwide field trials demonstrated that this age-old polyculture system is once again technically and economically feasible when modern technology is applied.

Throughout the IFP and APP, resident advisors from Auburn-FAA were directly involved on a daily basis in assisting host country personnel to design and implement programs in all three areas of project activities: research, training, and extension. Significant activities of these advisors included numerous lectures, seminars, and consultations to private and public interests regarding the technical aspects of aquaculture; demonstration trials in private ponds; initiation of research on improved methods of rice-fish culture as well as other aquacultural research; and teaching the first course ever offered in fisheries at CLSU. A number of reports by resident and short-term advisors to the IFP-APP also resulted, Appendix 2.

In succeeding sections of this report, activities and accomplishments of the three primary components of the projects—the FAC, BAC, and BFAR extension—will be discussed. Major efforts during the IFP, especially in the initial 2 years, were concentrated on the construction of research ponds and buildings at the centers, the selection and training of core staff members, and the planning and initiation of research projects. Therefore, this report will focus on the principal research, teaching, and extension activities completed during the APP, some of which were initiated during the IFP.

## THE FRESHWATER AQUACULTURE CENTER

The FAC is located in the central Luzon area of the Philippines, on the campus of CLSU, Munoz, Nueva Ecija, figure 2. The location is ideal because the Center has available the resources of CLSU, a progressive agricultural university which is developing rapidly and is oriented to teaching and outreach programs for the 4.3 million residents of Central Luzon—particularly the low-income rural families. Central Luzon, commonly referred to as the rice bowl of the Philippines, has 325,000 hectares of irrigated rice paddies suitable for rice-fish polyculture. Pantabangan Reservoir, one of the largest freshwater reservoirs in the country (8,000 hectares), is located near the FAC. Also in this area are Candaba Swamp, with an aggregate area of about 30,000 hectares during the rainy season (June-November), other lands marginally suitable for traditional agricultural crops, and numerous streams. Collectively, these resources have the potential to significantly increase freshwater aquaculture in Central Luzon.

The FAC had its beginning as a component of the IFP. Major construction of the physical plant began in March 1971. Most of the ponds and buildings were completed by late 1973, and the center was officially inaugurated during November 1973. Construction of the trainee dormitory and some of the other buildings, however, was not completed until 1977.

Problems caused by typhoons and contractors who did not perform on schedule delayed completion of the facilities.

Development of the FAC facilities and its staff was initially a responsibility of the UPCF. In July 1977, after the center became fully operational, the UPCF and the NSDB relegated all responsibilities for administration to CLSU by memorandum of agreement.

The FAC now operates as an adjunct of CLSU. Its primary purpose is to conduct freshwater fisheries research and training. Funding for the center appears to be adequate to provide a firm basis for sustained operations. The budget for 1978 was approximately $131,000[3], which was derived from several sources, including its mother institution (CLSU), NSDB, PCARR, the International Foundation for Science, and the International Center for Living Aquatic Resources Management, Inc. USAID's assistance, which included the purchase of commodities, funds for training participants, and technical advisory services through contract AID/ea-180 with Auburn, ended in March 1979, with the termination of the APP.

## Physical Facilities

The physical plant at FAC is excellent and suitable for comprehensive aquacultural research. Prior to the IFP-APP, there were no physical facilities at the site. Seventy-four research ponds with a total water area of 7.6 hectares were constructed during the projects. These research units comprise one of the largest experimental pond systems in Asia. The ponds were constructed in series to allow for proper experimental design and statistical analysis of research data. Water is supplied to the ponds from an irrigation canal, a well, and a 1.1-hectare reservoir.

The main building complex at the FAC was completed during the IFP-APP. It is located adjacent to the research ponds and consists of the following:

| *Structure* | *Size, sq. meters* |
|---|---|
| Laboratory-administrative building | 372 |
| Maintenance shop | 165 |
| Research laboratory | 390 |
| 10-room dormitory (40 occupants) | 707 |
| Pond supervisor's residence | 113 |
| Elevated water tank | 20 |

Three senior staff cottages (each 113 square meters) and a fisheries building (1,072 square meters) with offices, classrooms, and laboratories are located on the main campus of CLSU, about 1 kilometer from the FAC.

The buildings are supplied with basic equipment, such as office fixtures, microscopes, balances, autoclave, spectrophotometer, chemicals and apparatus for water analysis, equipment for making and analyzing fish feeds, aquaria, and holding tanks. The dormitory is equipped with a kitchen, beds, and a study room. Most of the commodities, such as equipment, supplies, and vehicles for the project, were provided by USAID. Construction was financed primarily from funds generated under PL-480, Title I. Auburn-FAA advisors assisted Filipino staff in planning, designing, and equipping the facilities.

## Personnel

The FAC technical staff is adequately trained to administer and carry out aquacultural research and training programs. Six of the core staff, including the FAC Director and Assistant Director, received graduate degrees from Auburn University. CLSU-FAC staff members who attended Auburn are listed in Appendix 1. The FAC staff consists of 40 personnel: 7 senior and 5 junior technical staff and 27 support staff. Three of the technical staff possess a Ph.D. degree (Auburn), three an M.S. degree (Auburn), and six a B.S. degree.

Dr. John Grover, a technical advisor from Auburn-FAA, resided at CLSU from 1972 to 1976 and provided technical assistance to the FAC staff. Dr. Homer R. Schmittou, who served as chief of party for the Auburn-FAA advisory team from 1971 to 1976, and Johnie Crance, who served as chief of party from 1976 to 1979, assisted with project logistics and support, and with technical assistance as needed. Auburn-FAA advisors on short-term assignments provided specialized technical assistance. Three U.S. Peace Corps Volunteers were assigned to the FAC for varying periods during the APP and provided a total of about 20 work-months of assistance.

## Activities

Activities in which the staff of the FAC are involved can be divided into three general subject areas: (1) research, (2) training, and (3) extension. Activities during the period of March 1971 through December 1977 were summarized in 12 successive reports. All are semi-annual (i.e., January to June and July to December) except the first, which covers the period from March 8, 1971, to June 30, 1972. The reports, including titles of completed research reports written by the FAC and BAC staffs during the APP, are listed in Appendix 3. Publications authored or co-authored by FAC researchers at the centers are listed in Appendix 4. The titles of theses and dissertations written by FAC and BAC staff members who completed graduate studies at Auburn University are listed in Appendix 5.

**Research.** Research at the FAC focused on efforts to develop and improve monoculture and polyculture systems of freshwater aquaculture. The emphasis during the last 2 years was on integration of fish farming with agricultural practices. Research on rice-fish culture in particular has attracted international attention. The improvement and re-introduction of this polyculture system by FAC researchers is probably the center's most important accomplishment because the practice has great potential for helping a large number of small-scale rice farmers. Farm families who adopt rice-fish culture benefit from improved nutrition as well as increased income.

Rice-fish polyculture involves the planting of pest-resistant, high-yielding varieties of rice, and the simultaneous stocking of tilapia fingerlings in the same paddy. *Tilapia nilotica* is the preferred species but other tilapias or common carp (*Cyprinus carpio*) can be used. The procedures followed at the FAC are generally those recommended by the GRP Ministry of Agriculture for normal rice production. The procedure involves the construction of a dike slightly higher than that normally used to grow rice so that the water depth in the rice paddy can be maintained at 10-20 centimeters, and digging a 1.0 x 0.5-meter trench down the middle of the rice paddy to provide a refuge for the fish. Fish are stocked at a rate of 5,000 tilapia or 3,000 common carp plus 4,000 tilapia per hectare. Screens are maintained at the water inlets and outlets to prevent loss or introduction of fish. Normal fertilization practices for rice farming are followed. Pesticides with low toxicity to fish are used when needed, and prescribed amounts and application procedures are followed. The fish and rice are harvested after 90 to 120 days.

FAC researchers in cooperation with BFAR, Bureau of Plant Industry, and the Bureau of Agricultural Extension

[3] Exchange rate of $1 U.S. = ₱7.50.

**Rice-cum-fish field trials at the FAC. Note the central canal that serves as a refuge for the fish.**

workers have field tested these rice-fish culture procedures nationwide. Yields of fish as high as 250 kilograms per hectare per 120-day period have been obtained in rice-fish field trials. Average yields of more than 150 kilograms of fish per hectare per crop were achieved without reducing rice production. Farmers who adopt the practice of rice-fish culture can expect to net from fish alone at least ₱167 per hectare per crop based on an estimated value of ₱5 per kilogram of fish. (The retail price of tilapia is currently ₱6 to ₱8 per kilogram.)

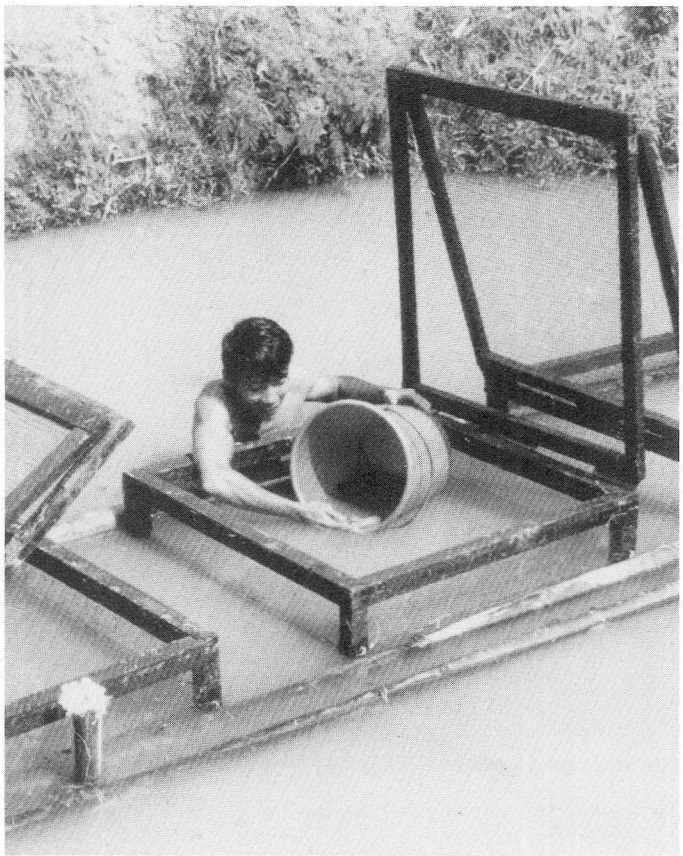
Many farmers are expressing strong interest in adapting rice-fish culture because it requires little additional investment and essentially no changes in rice cultural practices.

**Weighing part of the fish harvest from a field trial of rice-cum-fish culture at the FAC.**

However, the shortage of tilapia and carp fingerlings has restricted the area of paddies that can be stocked. A hatchery and training center for extension agents is to be developed adjacent to the FAC by the BFAR with assistance from USAID. The facilities will be used to produce and distribute tilapia and carp fingerlings for use in rice paddies and to extend rice-fish culture technology to rice farmers. A USAID-GRP project entitled "Freshwater Fisheries Production," which is a follow-on to the IFP-APP, will provide these facilities. Justification for the project was based largely on a fish marketing survey in Central Luzon conducted by Dr. E. W. McCoy, Auburn-FAA advisor, in cooperation with the BFAR in 1977, Appendix 2. The survey indicated that per capita consumption of fish was low and demand for additional fish high in the area. Technical advisors provided under the contract with Auburn University, Jack Snow and William Trimble, assisted in the selection and evaluation of the freshwater hatchery-extension training center site and in the design of the facilities to be constructed, Appendix 2. Johnie Crance assisted USAID and the GRP in developing the project paper for the Freshwater Fisheries Development Project.

Another important area of research at the FAC has been the refinement and demonstration of procedures for intensive methods of tilapia culture using ponds or cages. Locally available organic fertilizers and supplemental feeds are used. *Tilapia nilotica* has been the species of choice in these intensive culture systems. Dr. Rafael D. Guererro, III, a researcher at the FAC who received his Ph.D. degree from Auburn University, is recognized internationally for his work on sex reversal of tilapia. Monosex culture of tilapia, an application of his work, has good potential for increasing yields in intensive culture systems.

**Teaching—academic.** The FAC senior staff is actively engaged in the academic programs of the CLSU College of Inland Fisheries (CIF). The Assistant Director and Research Coordinator of the FAC is also the Dean of the CIF, and the FAC Director serves as Assistant Dean and Chairman of the



**Researcher at the FAC stocking tilapia for an experiment in cage culture.**

Department of Fisheries Management in the CIF. Other staff members of FAC also have dual appointments as faculty members of the CIF.

Dr. John Grover, the Auburn technical advisor to the FAC, offered the first course in fisheries at CLSU during the school year 1972-73. It was a 3-unit elective course entitled "Introduction to Inland Fisheries." As interest in the development of the inland fisheries resources of the Philippines increased and additional staff members were trained, additional fisheries courses were offered. In June 1974, a Department of Inland Fisheries was created in the College of Agriculture. The Department offered a unique program that integrated the sciences of agriculture and fish farming and offered the degree, Bachelor of Science in Agriculture, major in Inland Fisheries. Of the original four faculty members of the department, three had just completed their advanced training in fisheries at Auburn. The first eight students of the department graduated in 1976.

To help meet the needs of the country's inland fishing industry for well trained manpower, the Department of Inland Fisheries was elevated to the College of Inland Fisheries in June 1976. It has three departments: Aquatic Biology, Aquaculture, and Fisheries Management. The College was charged with the task of implementing a work-oriented curriculum, leading to a Bachelor of Science degree in Inland Fisheries. The program offers specialization in Aquaculture and Inland Fisheries, with thesis and field practice options.

The present teaching and research competency of the College of Inland Fisheries is among the best in Southeast Asia. Three of the faculty have Ph.D. degrees, two have M.S. degrees, and four have B.S. degrees. The fields of specialization of the faculty members include aquatic biology, aquaculture, fisheries management, fishpond engineering, fish nutrition, and fish parasitology. The faculty of CLSU-CIF is encouraged to engage actively in research. With their dual appointments in the CIF and the FAC, the faculty members have contributed significantly to the advancement of freshwater fisheries.

In keeping with CLSU's commitment to rural development, the College has focused its thrusts on instruction, research, and the operation of community-oriented production projects. The new curriculum, Bachelor of Science in Inland Fisheries, is now being implemented. As of June 15, 1977, there were 52 third-year and 70 second-year students enrolled in the College. Eight other students in the program leading to a Bachelor of Science in Agriculture with a major in Inland Fisheries are now in their last semester of study. This curriculum will be phased out to give full attention to the new degree program in inland fisheries.

An M.S. degree curriculum in aquaculture has been designed for implementation in 1980. A list of courses offered in the CIF is presented in Appendix 6. Students working for a B.S. in Inland Fisheries under the thesis option are expected to contribute to the progress of the industry by helping to solve problems in priority areas, such as fish seed production and improvement of fish culture techniques.

To provide facilities for its students and service to the community, the College operates three projects: (1) Recreational Fishing, (2) Tilapia Hatchery, and (3) Fish Production. These projects are located in the University Park.

**Training—extension.** Training and extension activities by the FAC staff include instruction at the center, the village level, and nationwide. An example of activities by FAC staff members during the period June 1977 to May 1978 includes the following:

(1) Six short courses conducted for 139 fish farmers and GRP technicians. Subjects taught were tilapia cage culture, rice-fish culture, and hatchery and culture methods for tilapia.

(2) Attendance and participation by staff members in 32 local, national, and international conferences, seminars, workshops, and symposia.

(3) Participation in nationwide field testing of rice-fish culture.

Two BFAR extension workers are stationed at the FAC and assist in extension activities in the local area. FAC staff members have prepared extension materials and served on committees that developed extension literature. Leaflets and other extension materials developed under the IFP-APP by the various organizations involved are listed in Appendix 7.

## THE BRACKISHWATER AQUACULTURE CENTER

The BAC is located centrally in the Philippine archipelago on the island of Panay. The island is an important area for fish culture since approximately 20 percent of all the brackishwater ponds in the Philippines are located there, and because ponds in Panay are some of the most productive in the country. The location of the center is typical in terms of terrain and climate of areas in the Philippines where brackishwater aquaculture is practiced.

The BAC, which is administered by the University of the Philippines as a sub-unit of the UPCF, was funded by the UPCF, NSDB, and PCARR on the GRP side, and by the United States through USAID and PL-480 funds. In 1978, the operating budget for the center was approximately $123,000. This amount was substantially more than in previous years and reflected the fact that, for the first time, the budget allocation was based on estimates of actual needs. Continued use of

this basis is expected to be advantageous for the future operation of the BAC.

Construction of the center began in May 1972, and by January 1974 most of the original physical plant had been completed. At this time, research activities began in the BAC's own facilities; previous to this, research on a limited scale had been conducted in ponds of the BFAR and private owners.

## Physical Facilities

Starting from nothing, the BAC has developed into one of the largest and best equipped centers for brackishwater research in Asia. By the end of the IFP (1974), the center had 74 earthen ponds with a total water area of 8.45 hectares. During 1978, subdivision of 1 of the original ponds and construction of 8 new ones brought the total number of ponds to 180, and the water area to approximately 18 hectares. As at the FAC, BAC ponds were designed and laid out to permit replicated experiments and statistical analysis of results. The 40-hectare site of the BAC is situated on a coastal plain bordered on one side by an inlet from the sea and on the other by a river. Theoretically, both water sources can be used to fill and drain the ponds by means of tidal fluctuations; however, only the inlet from the sea was actually operational as a water source during the IFP-APP.

In addition to the ponds, the BAC includes a wet lab (110 square meters) that was built during the APP. It comprised a total of approximately 100 tanks and aquaria, freshwater and seawater reservoirs, sand-gravel pre-filter and recirculating filters, and electrically operated aeration.

By the end of the IFP, the BAC consisted of two buildings in addition to the field facilities. The headquarters building (625 square meters) contained a small laboratory for basic soil and water analysis, staff offices, and the wet lab described above. The utility building (364 square meters) served as a garage for station vehicles, workshop, general storage area, and shelter for two 72KVA, diesel-operated generators that provided power for the center.

During the final year of the APP, the physical plant of the BAC was expanded greatly by construction of a new headquarters complex and dormitory at a cost of approximately $560,000 (PL-480 funds). The main complex (1,168 square meters) included offices for the staff, two classrooms (118 square meters total), a research laboratory (75 square meters), a special microbiological lab, library, conference room, walk-in refrigerator-freezer (not operational at end of APP), and a darkroom. The dormitory (660 square meters) has complete living facilities for 20 students, including a cafeteria that can accomodate approximately 100 people.

New construction during the APP also included a general storage building (84 square meters), feed processing and storage building (200 square meters), and a duplex house for the pond manager and security officer. Staff housing was not provided for the rest of the personnel because most of them are reluctant to live at the center owing to its isolated location.

## Personnel

Throughout the IFP, the research section of the BAC remained at a cadre level since the physical facilities were still under construction and research activities were limited. Also, during this period future members of the research staff were undergoing graduate training overseas. With the beginning of the APP, three staff members, newly returned from abroad, reported to the center and a resident technical advisor, Dr. Dan Leary, arrived from Auburn-FAA. A year later an additional staff member returned, bringing the senior staff to five. Of these, one had earned a Ph.D. and two had earned M.S. degrees from Auburn University under project sponsorship. One of the remaining two had received an M.S. degree from the University of Liverpool, England, and the other was a graduate of UPCF with 2 years of additional fisheries training in Japan. By the end of the APP, the experience gained during 4 years of intensive experience, coupled with formal training, had forged this staff into one of the most competent groups of aquacultural scientists in the Philippines.

Development of the other echelons of the BAC staff took place concurrently during the APP. The number of junior biologists increased from 4 to 15 and the support staff from 21 to 37. Besides this increase in numbers, the staff grew in their ability to work together as a team over the course of the two projects.

In addition to the resident advisor, who was present at the BAC from September 1974 through August 1978 to assist the host country staff in day to day operation of the center, the project provided short-term technical assistance as needed in the form of consultants from Auburn-FAA and other universities.

The BAC was fortunate to receive the services of four Peace Corps Volunteers during the IFP and APP. Each of these made a significant contribution during his association with the center by providing technical abilities that were not present in the Filipino staff.

## Activities

The role of the BAC was the same as that of its sister station, the FAC: (1) research, (2) training, and (3) extension. As indicated above, these activities have been described in a series of semi-annual technical reports, Appendix 2. By the end of the APP, the staff of the BAC had not yet published articles in refereed journals; however, the importance of doing so was clear to them and they were in the process of preparing several papers for publication, Appendix 4.

**Research.** The principal focus of the two BAC research

**A research biologist at BAC examining fry being reared in "hapas" (netting enclosures) as part of an experiment on reproduction of *Tilapia mossambica*.**

projects was increasing the production of milkfish, which is by far the most important fish cultured in the Philippines. In the latter part of the APP, increasing emphasis was being given to the culture of tilapia also.

By the end of the APP, research activities of the BAC could be called truly a research program, but this was not always the case. When the newly arrived and inexperienced senior staff first undertook the running of the center, research consisted of an assortment of unrelated experiments that covered a wide variety of topics. Gradually the staff evolved a systematic approach that focused on a limited number of fundamental problem areas. At present the center has identified four of these: (1) comparative evaluation and improvement of lab lab[4] and plankton culture systems for fishponds, (2) investigation of acid sulfate soils[5] in relation to fish production in brackishwater fish ponds, (3) improved survival of milkfish fry and fingerlings, and (4) utilization of agricultural wastes and by-products as supplemental feeds for fish. All research at the BAC focuses on a step-by-step attack on these fundamental questions, and it appears the center is on the verge of making a substantial contribution of new information to the fish-farming community in the Philippines.

A number of research findings highlight the progress that was made during the APP. For instance, experiments demonstrated that polyculture of milkfish with male *Tilapia mossambica*[6] resulted in substantial increases in yield. When tilapia were stocked at the rate of 2,000 to 4,000 per hectare along with the customary number of milkfish (3,000 per hectare), the total yield of fish was increased by polyculture from 470 kilograms per hectare in the case of milkfish alone to 680 kilograms when 4,000 tilapia per hectare were included. Competition between the two species resulted in a decrease in production of milkfish to 390 kilograms per hectare under polyculture conditions, but value of the harvest increased nonetheless since the difference in price between the two fishes is slight (₱4 to ₱5 per kilogram for tilapia 70 grams or larger vs. ₱5 to ₱6.5 per kilogram for milkfish 250 grams or larger). The ecological efficiency of polyculture has been demonstrated conclusively in the case of freshwater fishculture and undoubtedly will apply to brackishwater too when further studies have developed effective techniques.

Another contribution of the BAC pertained to augmenting the natural production of food in ponds by increasing the area of underwater substrate on which lab lab could grow. This was accomplished by installing panels of nylon netting (30 centimeters wide) across fishponds like a series of parallel tennis court nets to increase surface area by 15, 30, or 60 percent of the pond bottom area. The surfaces of the panels were oriented vertically and they were fixed in position with the upper edges just below the water surface and the bottom edges approximately 20 centimeters above the pond bottom. Each panel was inoculated by rubbing lab lab into the meshes prior to installation. Throughout the experiment, milkfish were observed browsing the lab lab that grew on these panels; after 120 days of culture, fish production showed a clear relationship to the additional substrate. Mean production of the fish was significantly higher (0.05 level) in fishponds with 60 percent added substrate (575 kilograms per hectare) than in control ponds without netting (480 kilograms per hectare). At both 15 percent and 30 percent added substrate, there was a slight increase in fish production to 500 kilograms per hectare, but this was not different statistically. Despite the relatively high cost of netting, the procedure appears to be favorable from an economic standpoint. Further study of this approach seems warranted, particularly for small ponds such as those for fry and fingerlings.

**Researchers at the BAC separating male *Tilapia mossambica* fingerlings for stocking in a feeding trial using all-male fish (faster growing than female tilapia).**

Another area of investigation at the BAC that shows great promise is stock manipulation. The term applies to the practice of stocking selected sizes of fish at intervals during the culture and partially harvesting the pond periodically. The principal advantage of this system is that it results in a more uniform standing crop of fish and a better balance between the amount of natural food produced in the pond and the biomass of fish that it supports. When the customary procedure of stocking all fingerlings at the same time and size is followed, the biomass of fish present initially cannot consume all of the food that is available; therefore, some is wasted. Later, food production cannot keep up with the demands of the fish and the food producing organisms are browsed out of existence.

A BAC experiment that compared the traditional method of management and stock manipulation showed the mean production of fish increased from 650 kilograms per hectare in the control ponds (traditional management) to 850 kilograms in the stock manipulation ponds. Also, the standing crop of fish was much more uniform during the culture period when stock manipulation was practiced. Further development of this technique promises to offer a significant advance in milkfish culture technology.

The problem of acid sulfate soils in brackishwater fishponds first became apparent shortly after the research program got underway. A fish kill in BAC ponds was traced to previously unsuspected acid sulfate soils by Dr. H. R.

[4] The Filipino term for a complex community of benthic flora and fauna that is one of the two most effective natural food sources known for milkfish, the other being plankton.

[5] These are problem soils that develop high levels of mineral acidity ($H_2SO_4$) on oxidation, for instance on draining submerged soils for use for agricultural or aquacultural purposes. The problem is believed to be common in brackishwater fishponds because often ecological conditions in such areas favor the formation of acid sulfate soils.

[6] Male tilapia were used to prevent reproduction and avoid overcrowding of the pond and consequent stunting caused by excessive reproduction by tilapia.

Schmittou, of Auburn-FAA, then chief technical advisor to the IFP. Subsequently, the BAC staff learned that these soils are a problem to varying degrees in most brackishwater fishponds in the Philippines, and probably in other areas where similar aquaculture is practiced.

The BAC staff attacked the soils problem from two directions. A proposal was submitted (with outstanding assistance from Peace Corps Volunteer, Thomas Potter) to USAID for $32,500 in additional funding to conduct a special research project on acid sulfate soils. This request was approved eventually, but significant progress was not made in the project during the APP owing to unavoidable delay in procuring a technician to head the study. Meanwhile, the center also began investigating practical measures to lessen the effects of acid sulfate soils. Based on literature sources and empirical evidence, the staff formed the hypothesis that liming and adding high levels of organic matter to affected ponds would lessen the problems caused by such soils. Field trials at the BAC tested these ideas. High levels of organic matter (8 tons of chicken manure per hectare) and, to a lesser degree, liming rates of 4 to 8 tons per hectare seemed to have a marked benefit on fish production; however, contamination of the experimental ponds made it impossible to form definite conclusions. Work on this important problem will continue in the field and laboratory in 1979.

An important limitation to further development of milkfish culture is the total dependency of the industry on wild fry caught from the sea. Even though milkfish were spawned in captivity for the first time in 1977, it probably will be years before this breakthrough can be translated into commercial production of fry. One way to increase the limited supply of fry is by reducing mortality. Estimates place loss of fry at approximately 50 percent from the time they are purchased by fish farmers until they are harvested for sale as food fish; losses from the time of capture to the time of sale for stocking have not been estimated, but probably are at least as high.

**Research assistants of BAC mixing supplemental feeds for fish from agricultural by-products such as rice bran, rice mill sweepings, distillery wastes, leaf meal from *Leucaena* trees, and rumen contents from local slaughter houses.**

**Researchers at the BAC sorting the harvest from an experiment on the polyculture of milkfish and tilapia.**

When the APP ended, the BAC staff was in the process of making the first study ever conducted in the Philippines to determine the levels and causes of fry mortality during capture and distribution to fish farmers. This study was preliminary to future efforts by the center to devise and introduce to fry collectors improved techniques for capturing, handling, and holding fry.

Another area of BAC research activity that appeared promising at the close of the APP was the use of agricultural by-products and wastes to increase fish production. Ninety-day feeding trials in which *Tilapia mossambica* were given supplemental feeding of either rice bran, rice mill sweepings, or *Ipomea* leaves resulted in increased yields (979 kilograms, 957 kilograms, and 926 kilograms per hectare, respectively) compared with fertilization alone (830 kilograms); however, only rice by-products gave an increased profit. Further studies are underway to identify other possible feedstuffs and combinations of single ingredients that would be more efficient supplemental feeds.

Research is also underway in a closely associated subject area, combined culture of animals and fish. This practice is well established in connection with freshwater fishculture, and preliminary results indicate that it has similar potential for use in brackishwater. The center has completed one study involving the daily addition of fresh pig manure from a nearby

**Pig pen built over fishpond as part of experiment in pig-fish combination culture at the BAC. Pig manure and uneaten feed washed into the pond daily provide food for the fish and fertilization for the pond.**

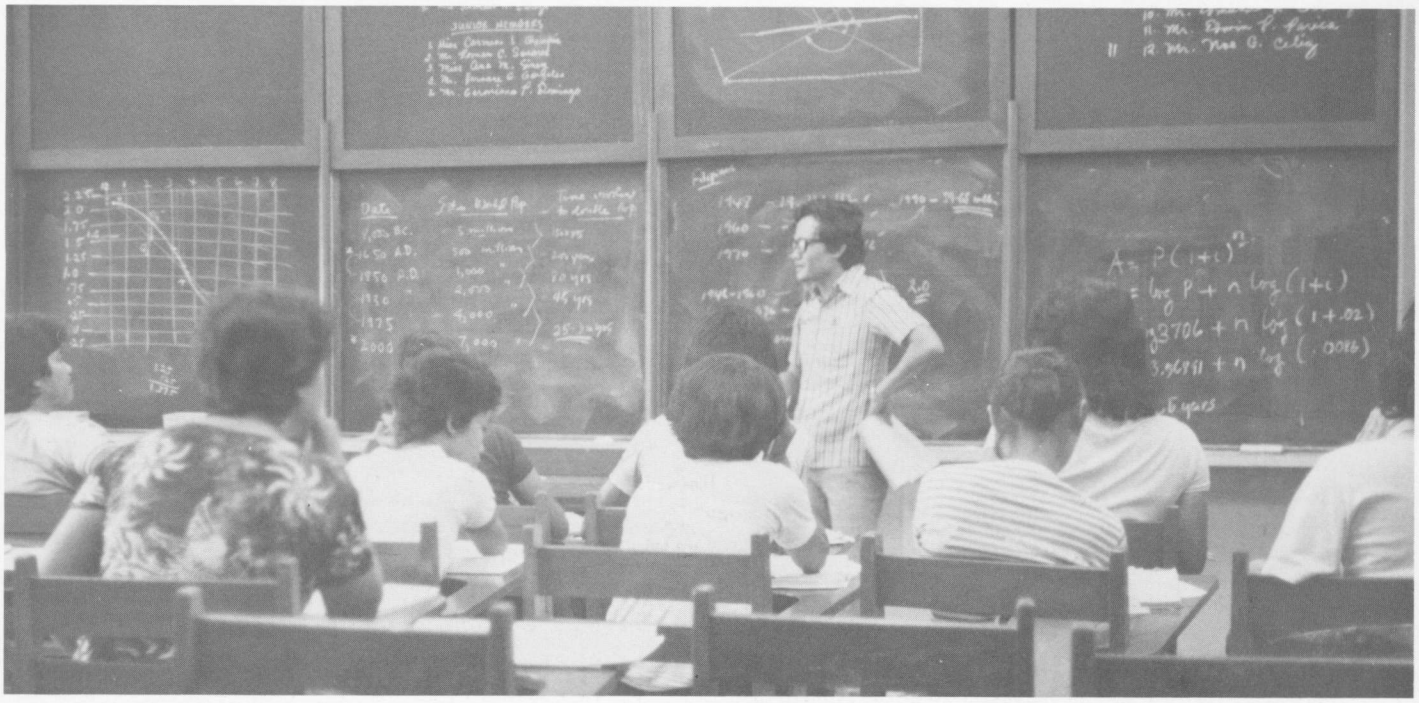
piggery to fishponds stocked with a polyculture of milkfish and *Tilapia mossambica*. Mean production after 120 days was 500 kilograms per hectare in ponds that received pig manure, compared with 412 kilograms per hectare in control ponds. When the APP ended, a follow-up experiment was underway in which pigs were being grown in pens directly above the fishponds where uneaten pig feed as well as pig wastes could enter the water. There appears to be excellent potential for fishculture in combination with a variety of animals commonly raised in the Philippines; e.g. pigs, chickens, ducks, rabbits, and cattle. The staff of the BAC intends to intensify the effort devoted to development of such combined cultures.

**Teaching—academic.** The academic programs, both graduate and undergraduate, that the staff of the BAC conducted during the APP probably were the most important contributions to aquacultural development that the center has made to date.

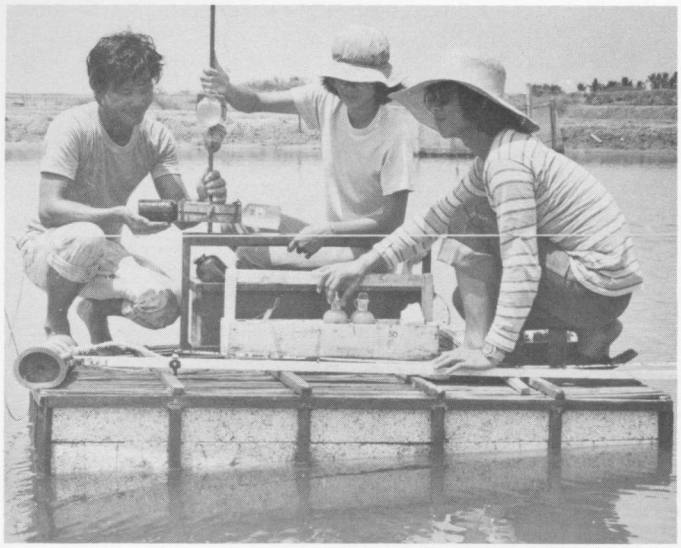
In November 1974, the UPCF instituted a graduate program leading to an M.S. degree in aquaculture. The program was offered at the BAC by the staff of the center but administratively was a part of the UPCF, the degree granting institution. The program began with two graduate students, and scarcely anything else. There were no funds, classrooms, books, or supplies allocated to it. Nonetheless, the program continued and even grew over the next two semesters to a total of five students.

Graduate training made a dramatic leap forward in June 1976, the result of a memorandum of agreement between UP and SEAFDEC[7]. The latter organization agreed to provide all funds for the program (in 1978 the budget amounted to $178,000), an administrative staff, and the physical facilities of the newly completed education and training center at its headquarters in Tigbauan. The University's contributions to the arrangement were the authority to grant academic degrees, and the entire graduate faculty. The University retained administrative control over the program through the BAC Director, who also heads graduate training activities. In 1977 a number of SEAFDEC scientists also joined the program as adjunct faculty members of UPCF. At present the

[7] The Southeast Asian Fisheries Development Center is a consortium of six nations (Japan, the Philippines, Singapore, Thailand, Malaysia, and Vietnam) devoted to fisheries development in the region. The main facilities of SEAFDEC's Aquaculture Division are located in Tigbauan, Iloilo, approximately a 1-hour drive from the BAC.



**Dr. Arsenio Comacho, Director of the BAC, lecturing to students in the graduate program that is offered at the Center.**



**Graduate students at the BAC preparing to measure primary productivity in one of the experimental ponds by means of the light-dark bottle method.**

graduate faculty comprises 16 members, 4 from the BAC and 12 from SEAFDEC; 9 hold doctoral degrees and the rest M.S. degrees.

The program is designed to require 2 years beyond the B.S. level and consists of 24 semester hours of course work plus an original research problem and thesis. A total of 10 courses is offered, Appendix 8, all aquaculture oriented; however, future plans call for an expansion to cover a broader range of subject matter. By the end of the APP, 2 students had been graduated, 3 were in the final stages of thesis preparation, and 46 were at various earlier stages of training. Enrollment in the program for the immediate future is expected to stabilize at approximately 20 new students per year.

Graduates of the program will help relieve one of the most serious constraints to the development of aquaculture in the Philippines; i.e. shortage of trained manpower. The students already have made a significant contribution by substantially increasing, through their thesis projects, the amount of aquacultural research in the country. High performance is expected from them since in general they have superior academic records and good motivation; also, the research will be supervised by some of the Philippine's best trained aquaculturists. A list of student research projects appears in Appendix 9.

The quality of the students is an important, positive development because in the past fisheries curricula generally did not attract the most able students. Also, many of them already have working experience in government agencies, academic institutions, or private industry and will return after graduation to organizations where their newly acquired expertise can be put to good use immediately. The emphasis that the BAC staff placed on the graduate program was at the expense of research to some extent, but it is expected that a multiplier effect of the aquacultural scientists that the program produced will more than compensate in the long run for the temporary reduction in research activities of the center.

In addition to the graduate program, the BAC staff taught courses in the undergraduate fisheries curriculum of UP (Iloilo campus) from inception in November 1974, Appendix 8. Enrollment has increased since then from 10 to 109 students. Growing local interest in fisheries led to the establishment in January 1978 of a Division of Fisheries within the Iloilo branch of UP to facilitate the expansion of education in this specialty. The BAC director is chairman of the division in addition to his many other responsibilities.

**Training—extension.** Extension was intended to be one of the main activities of the BAC, but actually this aspect of the program remained quite limited throughout the IFP and APP owing to limitations in time, personnel, and especially funding. (No funds were allocated to the center for this purpose during the projects.)

Extension activities of the BAC were limited primarily to providing resource persons for extension training programs

**Peace Corps Volunteer of the BAC demonstrating the use of a pond water sampler that he designed to extension workers of the Bureau of Fisheries and Aquatic Resources.**

offered by SEAFDEC and BFAR, and for local national meetings of fish farmers' federations. Occasionally, direct contacts were made with fish farmers who sought assistance.

A special extension activity, made possible by funding from the APP, was a 2-day seminar on aquacultural economics given in 1977 by Dr. E. W. McCoy, an economist from Auburn University. Approximately 70 persons representing the local business, government, and academic communities attended. The interest of fish farmers was particularly keen, as evidenced by their active exchanges with Dr. McCoy.

The BAC staff, recognizing the importance of a more effective extension program, initiated an attempt in January 1977 to establish linkage with the regional office of the BFAR for improving communication between researchers and fish farmers. Although the effort was not successful because of resistance from the Director of the BFAR, it was instrumental in part for the establishment later that year of an ad hoc GRP-USAID committee, RELCOM (Research-Extension Linkage Committee), to investigate the problem of research-extension linkage and recommend ways to improve it.

As a result of the RELCOM report, the BAC and the regional office of the BFAR began a joint extension project, for the first time, in March 1978 when the BFAR assigned an extension technician to work with the BAC full time. Under BAC leadership, personnel of the two agencies developed a "technology package" incorporating the best technology for producing milkfish that was available from research reports and commercial sources. At the end of the APP, this technology was undergoing field tests in BAC ponds with joint funding and supervision by both organizations. Once effectiveness of the methodology is demonstrated in a series of successful trials, the BAC will assist in training BFAR extension workers to disseminate it to fish farmers throughout the region. In the next step of the project, BAC and BFAR personnel will develop extension literature on the technology package for wider distribution.

Development of such a package will be a significant contribution because, for the first time, consistent guidelines will be available to extension workers and fish farmers to help them manage ponds effectively. The initial package will need updating frequently as improved techniques are developed, and these continuing efforts can provide a sound basis for further cooperation between the BAC and the BFAR.

### Official Recognition of BAC Efforts

The fish farming industry was aware of the efforts of the BAC staff to increase aquaculture production. In evidence, the National Federation of Fish-farm Producers, the major organization representing this industry in the Philippines, awarded a commendation to the center at its annual convention in 1977. President Marcos presented the award to the BAC Director, who received it in behalf of the center.

## EXTENSION PROGRAM OF THE BUREAU OF FISHERIES AND AQUATIC RESOURCES

Prior to 1976 there was no GRP agency having a formally established aquacultural extension program. Extension activities were carried out by the BFAR on an ad hoc basis. The development of an aquacultural extension program was a major component of the IFP-APP. It was programmed to follow the development of the research components constituted within the FAC and BAC. Auburn-FAA personnel assisted the GRP in the conduct of extension-outreach activities throughout the IFP-APP. They helped BFAR develop an aquacultural extension plan, select and train extension personnel, determine equipment needs of extension workers, and gave other technical advisory services pertaining to the development of the aquacultural extension program in BFAR.

In May 1975, BFAR was given the responsibility for conducting a National Fisheries Extension Program by virtue of Presidential Decree No. 704. Subsequently, in 1976, an Extension Division was formally established within BFAR. The Division has four sections: Inland Fisheries (Aquaculture), Municipal Fisheries, Commercial Fisheries, and Fish Processing.

When the BFAR Extension Division was established it was faced with four primary constraints: (1) an insufficient number of trained extension workers, (2) lack of transportation (vehicles) for extension workers, (3) lack of basic equipment for extension workers, and (4) the lack of a well conceived plan for phased implementation of extension activities. The APP assisted the BFAR in eliminating these deficiencies and developing stronger linkages between the extension program of BFAR and the research programs of FAC and BAC.

Two BFAR extension workers participated in training programs sponsored by the U.S. Department of Agriculture (USDA) at the University of Wisconsin and one participated in a similar program at the University of Missouri. The participants were taught extension concepts, principles, and methods. They also observed fisheries extension programs in Alabama and other states in the Southeastern United States. Nine extension personnel received aquaculture training at Auburn University, and two of the nine received an M.S. degree in fisheries. The extension workers who participated in training programs in the United States have returned to BFAR and now occupy key positions in that agency, Appendix 1.

Aquacultural extension activities were concentrated in two pilot areas of the Philippines during the APP, figure 2. These areas were Region V, the Bicol River Basin (the provinces of Camarines Norte, Camarines Sur, Cantanduanes, Masbate and Sorsogon), and Panay Island (the provinces of Iloilo, Capiz, Alkan and Antique, all of which are in Region VI).

The Chief of the BFAR Extension Division, who serves as a staff assistant to the director of the Bureau, monitors and evaluates extension field activities in the regions and helps solve logistical problems. Planned programs of work are implemented in the provinces by the regional extension staffs who serve under the respective regional directors.

The aquacultural extension program was implemented in the two pilot regions beginning in 1975 and 1976 according to the sequence given below.

**Data gathering.** Data were collected, compiled, and assessed for use as benchmark information and for subsequent evaluation of extension efforts. These data included the number and size of fishponds, production inputs and outputs, and locations of financial institutions, suppliers of fertilizer, pesticides, and fry.

**Training.** New extension workers were hired and trained in the technical aspects of aquaculture, oriented to work plans and program objectives, briefed on aquacultural resources of the area, and assigned to specific work locations.

**Distribution of equipment.** Jeeps provided by USAID were distributed to 18 extension teams in the two pilot regions. Additional equipment, such as cameras, projectors, and portable generators, was also made available to the regions for use by extension workers.

**Field implementation.** Extension workers conducted meetings with fish farmers, representatives of the private

sector and government agencies, and other concerned individuals. They discussed ways and means for increasing aquacultural production, introduced the public to BFAR's extension program, organized discussion groups, selected cooperators for field trials and demonstrations, and began direct assistance to fishpond owners.

**Evaluation of results.** An evaluation of individual field trials was made. Production data for 1977 and 1978 are incomplete. Therefore, a final evaluation of the overall program using baseline data as a comparison could not be made at this time.

The BFAR aquacultural extension program was operational in the two pilot regions in late 1976. By the end of September 1978, the number of inland fisheries extension workers assigned to regions V and VI were 30 and 26, respectively. During FY 1977, the aquacultural extension workers in the two pilot areas made a total of 1,066 individual visits to fishpond operators and provided advisory services, assisted in setting up four new rice-fish culture demonstration trials and two milkfish demonstration trials, rendered assistance to 97 fish farmers who had ongoing demonstration trials, conducted a survey of government-owned fishponds, and conducted 36 meetings/seminars for fishpond operators.

Numerous milkfish farmers from the two pilot regions have reported significant increases in production since adopting new practices recommended by extension workers. It is too early, however, to evaluate the extension efforts in terms of overall increased aquacultural production for the two regions because an inadequate supply of fish seedlings, shortages of fertilizers, and difficulties in obtaining financing for aquacultural activities have impeded the adoption of improved aquacultural technology by some fish farmers. Furthermore, the statistics available are not adequate to make such an evaluation. An improved system for gathering accurate data from the aquacultural subsector on a timely basis is needed. Aquacultural extension programs are being developed in the other 11 regions of the Philippines using as a model the approach taken in regions V and VI during the APP. About 150 additional aquacultural extension workers were assigned to the 11 other regions. However, there are a number of obstacles to developing on a national scale an extension capability similar to those created in regions V and VI. For example, considerably more transportation and communication facilities are needed, along with improved training programs for extension workers, including orientation and instruction prior to field assignments, and periodic instruction in extension concepts, methods, and aquacultural technology.

Despite the problems and needs that still exist, an aquacultural extension program has been developed within the BFAR. The basic concept and program direction appear sound. Linkages between the BFAR and researchers at FAC and BAC have been established by assigning extension workers to the centers to coordinate extension and research programs. These relationships are expected to grow and strengthen. Also, there is growing public awareness and interest in aquacultural extension. The overall success of the extension program in increasing aquacultural production and improving the nutrition of Filipinos must be determined later, but it appears now that such efforts will help to accomplish these objectives.

## RECOMMENDATIONS

The primary function of this publication is to report on the progress and achievements, as well as various constraints, experienced in this USAID and GOP supported aquacultural development project. However, it seems appropriate to include recommendations based on the significant experience and personal knowledge gained by the four ICA resident advisors serving the project over a period of nearly 8 years—approximately 15 man-years of day-to-day involvement with Filipino fish farmers and GOP fisheries personnel under local conditions.

Extension is the key element in a successful and progressive aquacultural program at the farmer's level. Extension has progressed well in regions V and VI where significant effort has been expended in implementing effective extension programs. It is doubtful, however, that BFAR has the funds or adequately trained extension workers to implement a meaningful countrywide program. Hence it is recommended that BFAR establish extension services in other regions gradually, with due consideration to selecting regions that hold greatest potential on a priority basis. Also, BFAR should make a concerted effort to improve research-extension linkages at the national level. Presently it is on a regional basis.

The lack of fish seed and shortages of workers adequately trained in hatchery management have been correctly assessed as the major limiting factors in rice-fish culture and freshwater aquaculture in general. The Fisheries Sector Study for the Philippines (1977) documents this in detail. Hence, the Freshwater Fisheries Development Project is most timely and its implementation at the earliest possible date is recommended.

The USAID should keep abreast of problems and opportunities to assist the most disadvantaged fish farmer or segments of the aquaculture industry. Specific examples in which USAID assistance may be needed include (1) milkfish fry collection and methods of reducing fry mortality, (2) clam, oyster, and mussel culture, (3) tilapia production technology, and (4) acid soil problems as encountered in brackishwater fish ponds.

USAID's involvement in artisan fisheries (municipal fisheries) with elements of marketing, improved quality, and economics is also recommended.

## APPENDIX 1

PARTICIPANTS TRAINED UNDER THE IFP-APP

| Name of participant | GRP agency | Training venue | No. months | Degree received | Present assignment |
|---|---|---|---|---|---|
| Catalino de la Cruz | CLSU-FAC | Auburn University | 36 | Ph.D. | Dir. FAC; Asst. Dean, CLSU-CIF |
| Rafael Guerrero | CLSU-FAC | Auburn University | 28 | Ph.D. | Asst. Dir., FAC; Dean, CLSU-CIF |
| Emmanuel Cruz | CLSU-FAC | Auburn University | 24 | Ph.D | Researcher, FAC; Chairman Aquaculture Dept., CLSU-CIF |
| Rodolfo Arce | CLSU-FAC | Auburn University | 24 | M.S. | Researcher, FAC; Instructor, CLSU-CIF |
| Oscar Quines | CLSU-FAC | Auburn University | 26 | M.S. | Researcher, FAC; Asst. Prof. Vet. Med., CLSU |
| Ruben Sevilleja | CLSU-FAC | Auburn University | 25 | M.S. | Researcher, FAC; Instructor, CLSU-CIF |
| Renato Recometa | CLSU-FAC | Auburn University | 6 | — | Researcher, FAC; Instructor, CLSU-CIF |
| Arsenio Camacho | UP-BAC | Auburn University | 36 | Ph.D. | Director, BAC; Assoc. Prof., UPCF |
| Romeo Fortes | UP-BAC | Auburn University | 36 | M.S. | Researcher, BAC; Asst. Prof., UPCF |
| Virgilio Dureza | UP-BAC | Auburn University | 18 | M.S. | Asst. Director, BAC; Asst. Prof., UPCF |
| Romulo Aure | UP-BAC | Auburn University | 6 | — | Pond Superintendent, BAC |
| Rodolfo Ventura | UPCF | Auburn University | 40 | M.S. | Researcher, UPCF—Dilliman |
| Gaudiosa Almazan | UPCF | Auburn University | 40 | Ph.D. | Researcher, UPCF—Dilliman |
| Joel Canlas | UPCF | Auburn University | 40 | M.S. | Researcher, UPCF—Dilliman |
| Jose Carreon | UPCF | Auburn University | 36 | Ph.D. | Researcher, UPCF—Dilliman |
| Florian Orejana | UPCF | U. of Washington | 36 | Ph.D. | Researcher, UPCF—Dilliman |
| Ricardo Lim | BFAR | Auburn University | 21 | M.S. | Extension Div., BFAR, Manila |
| Melchor Tayamen | BFAR | Auburn University | 27 | M.S. | Extension Coordinator, Manila |
| Abraham Gaduang | BFAR | U. of Wisconsin | 4 | — | Chief Extension Div., BFAR, Manila |
| Joemari Gerochi | BFAR | U. of Wisconsin | 4 | — | Senior Executive Asst., BFAR, Manila |
| Eduardo Clement | BFAR | Auburn University | 6 | — | Fisheries Extension Specialist, BFAR, Region VI |
| Billy Blanco | BFAR | Auburn University | 6 | — | Supervising Fisheries Extension Specialist, BFAR, Manila |
| Rolando Edra | BFAR | U. of Missouri | 4 | — | Supervising Fisheries Extension Specialist, Manila |
| Avelino Sanico | BFAR | Auburn University | 24 | — | OIC, BFAR, Region X |
| Primitivo Clave | BFAR | Auburn University | 6 | — | Reg. Director, BFAR, Region II |
| Apolonio Alapan | BFAR | Auburn University | 6 | — | Extension Specialist, II, BFAR |
| Jose Marquez | BFAR | Auburn University | 6 | — | Supervising Extension Specialist, BFAR, Region X |
| Katherine Apolinario | BFAR | Auburn University | 6 | M.S. | Researcher, Nat. Inst. Science and Technology, Manila |
| Amado C. Campos | CLSU | Taiwan | 1 | — | President, CLSU |
| Rogelio O. Juliano | UPCF | Taiwan | 1 | — | Dean, UPCF |
| Felix R. Gonzales | BFAR | Taiwan | 1 | — | Director, BFAR |
| Francisco Pili | BFAR | Taiwan | 1 | — | Director, BFAR, Region V |
| Catalino de la Cruz | CLSU | Southeast Asia[1] | 1 | — | Director, FAC; Asst. Dean, CLSU-CIF |
| Abraham Gaduang | BFAR | Southeast Asia[1] | 1 | — | Chief Extension Div., BFAR, Manila |

[1] Tour of four Southeast Asian countries: Malaysia, Thailand, Japan, and Taiwan.

## APPENDIX 2

### Reports Resulting from the APP


AVAULT, JAMES W. JR., WALLACE KLUSSMAN AND R. O'NEAL SMITHERMAN. 1978. End-of-project Evaluation of the Aquaculture Production Project. Mimeo. Rept. 30 pp.

BARNHISEL, RICHARD I. 1976. Acid Problem at the Brackishwater Aquaculture Center, Leganes, Iloilo, Philippines. Mimeo. Rept. 10 pp.

CRANCE, J. M. 1978. Aquaculture in Malaysia, Thailand, Japan, and Taiwan. Auburn Univ., International Center for Aquaculture (to be published).

GRANT, CHARLES J. 1976. Report on a Visit as Soil Consultant to the Brackishwater Aquaculture Center at Leganes, the Philippines. Mimeo. Rept. 7 pp.

MCCOY, E. W., M. L. HOPKINS, AND R. C. SEVILLEJA. 1978. Fish Marketing in Central Luzon, Philippines. A Study of the Existing Demand and Supply Situation, 1978. Auburn Univ. International Center for Aquaculture, Res. and Dev. Ser. No. 21 Proj. AID ea/180. 58 pp.

SCHMITTOU, H. R. 1977. A study to Determine the Spawning Grounds of Milkfish and Environmental Conditions that Influence Fry Abundance and Collection along the Antique Coast of Panay Island, Philippines. Proc. Eighth Ann. Meeting, World Mariculture Society, Jan. 9-14, 1977. pp. 91-98.

SNOW, J. R. 1976. Recommendations for Development of a Freshwater Fish Hatchery Center in Central Luzon, Philippines. Mimeo. Rept. 13 pp.

TRIMBLE, WILLIAM C. 1978. Suitability of Two Sites at Central Luzon State University for Locating a Freshwater Fish Hatchery and Extension Training Center. Mimeo. Rept. 12 pp.

TRIMBLE, WILLIAM C. 1978. A Multi-purpose Brackishwater Hatchery for the Brackishwater Aquaculture Center, Leganes, Iloilo, Philippines. 18 pp.

USAID. 1978. An Evaluation of Auburn University's Programs (Ann Henshaw and Bruce Kimsey). Mimeo. Rept. 27 pp.


## APPENDIX 3

### IFP-APP Reports from 1971-1976 with Titles of Research Completed at the FAC and BAC from July 1, 1974, through December 31, 1976[1]

1. Inland Fisheries Project—Annual Technical Report FY 71-72 (March 8, 1971-June 31, 1972). 55 pp.

2. Inland Fisheries Project—Technical Report First Half of FY 72-73 (July 1, 1972—December 31, 1972). 100 pp.

3. Inland Fisheries Project—Technical Report No. 3. Second Half of FY 72-73 (January 1, 1973—June 30, 1973). 46 pp.

4. Inland Fisheries Project—Technical Report No. 4. First Half of FY 74 (July 1, 1973-December 31, 1973). 83 pp.

5. Inland Fisheries Project—Technical Report No. 5. Second Half of FY 74 (January 1, 1974-June 30, 1974), 96 pp.

6. Inland Fisheries Project[2]—Technical Report No. 6. First Half of FY 75 (July 1, 1974—December 31, 1974). 100 pp.

**A. Research Completed—Freshwater Aquaculture Center**

(1) Carp Polyculture in Fertilized and Unfertilized Ponds.
(2) Rice-fish Culture: Production of Rice IR-26 and Tilapia.
(3) Rearing of Milkfish Fry in Nylon Net Enclosures (Bitinan).
(4) *Clarias batrachus* Natural Reproduction.
(5) Pond Culture of Sex-reversed *Tilapia mossambica* and *Tilapia zillii* with Ethyltestosterone.
(6) Bangus Length-weight Study.
(7) Cage Culture of Male and Female *Tilapia mossambica* with and without Supplementary Feeding in a Fertilized Pond.
(8) Monosex Culture of Male and Female *Tilapia mossambica* in Ponds at Three Densities.
(9) Culture of Male *Tilapia mossambica* with Rice IR-26.
(10) Parasites and Diseases of Freshwater Fishes, Common Carp Fingerlings.
(11) Production of Bangus in Combination with Common Carp and Thai Hito in Fertilized Freshwater Ponds.

**B. Research Completed—Brackishwater Center**

(1) Bangus Production in Newly Constructed Ponds with Plankton as a Food Base.
(2) The Rate of Growth of Bangus Fry/Fingerlings in Newly Constructed Brackishwater Ponds.
(3) Monoculture and Polyculture of Bangus and Shrimp *Penaeus* sp. in Brackishwater Ponds.

7. Inland Fisheries Project Philippines—Technical Report No. 7. Second Half of FY 75 (January 1, 1975—June 30, 1975). 113 pp.

**A. Research Completed—Freshwater Aquaculture Center**

(1) Bioassay of Gusathion A on Some Common Freshwater Fishes of the FAC.
(2) Polyculture Systems Utilizing Male Tilapia, Dalag, Thai Hito, and Common Carp.
(3) Pond Evaluation of *Tilapia mossambica* Treated with Methyltestosterone for Sex Reversal at Varying Duration and Stocked at Different Rates.
(4) Use of Dalag for Biological Control of Tilapia Reproduction.
(5) Culture of *Tilapia mossambica* Treated with Methyltestosterone and Estrone for Sex Reversal.
(6) Culture of Freshwater Shrimps in Fertilized Ponds with and without Tilapia spp.
(7) Culture of Male *Tilapia mossambica* with Dalag in Fertilized Ponds at Two Densities.
(8) Culture of Male *Tilapia mossambica* and Dalag in Fertilized Ponds with Supplementary Feeding.
(9) Pond Evaluation of *Tilapia nilotica.*
(10) A Preliminary Study on the Culture of Common Carp and Male *Tilapia mossambica* with Rice.
(11) Comparative Growth Rates and Competition Between *Clarias macrocephalus* and *Clarias batrachus* at Two Densities.
(12) Production of *Tilapia mossambica* Fry for Sex Reversal Treatment in Nylon Net Enclosures (Bitinan).

**B. Research Completed—Brackishwater Aquaculture Center**

(1) Monoculture and Polyculture of Bangus and All-male Tilapia in Brackishwater Ponds.
(2) Simultaneous Culture of Bangus Fry Inside Happas and Bangus Fingerlings at Large in Same Ponds.
(3) Bangus Production in Newly Constructed Ponds with Plankton and Lab-lab for Three Consecutive Cultures Using Various Single and Combination Fertilizers.
(4) Bangus Production in a Newly Constructed Pond.

8. Inland Fisheries Project Philippines—Technical Report No. 8. First Half of FY 1976 (July 1, 1975—December 31, 1975). 111 pp.

**A. Research Completed—Freshwater Aquaculture Center**

(1) Cage Culture of *Tilapia zillii* at Two Densities with and without Supplemental Feeding in a Fertilized Pond.
(2) Trials on Induced Spawning of Freshwater Fishes at the FAC.
(3) Thai Catfish Fecundity and its Relation to Fish Size.
(4) Bioassay of Fintrol (Antimycin A) on Some Freshwater Fishes.
(5) Sex Reversal of *Tilapia nilotica* with Methyltestosterone.
(6) Polyculture of Sex-reversed *Tilapia* spp. and Freshwater Shrimps.
(7) Rearing of Bangus Fry in Nylon Net Enclosures (Bitinan).
(8) Natural Spawning of the Thai Catfish, *Clarias batrachus.*
(9) Polyculture of Male *Tilapia mossambica* and Male *T. nilotica* in Fertilized Ponds at Two Stocking Densities.
(10) Survey of the Higher Aquatic Flora in Ponds and Drainage Canals of the FAC.
(11) Production of Common Carp and Sex-reversed *Tilapia mossambica* in Rice Paddies.

[1] Later technical reports were still in preparation when the APP ended.

[2] The Aquaculture Production Project (APP) Agreement was signed in June 1974. Since the Inland Fisheries Project terminated in June 1974, that title for reports subsequent to No. 4 is technically a misnomer, but was used by mutual decision of the parties involved to avoid confusion.

**B. Research Completed—Brackishwater Aquaculture Center.**

(1) Polyculture of Bangus and Shrimps.
(2) Mono and Polyculture of Bangus and All-male *Tilapia mossambica* in Brackishwater Ponds (Trial II).
(3) Evaluation of the Use of Sub-divided Ponds Using Nets to Increase Experimental Units.
(4) Bioassay of Two Fish Toxicants, *Tuba (Jathropa* sp.), a Locally Available Fish Poison, and Antimycin A.

9. Inland Fisheries Project Philippines—Technical Report No. 9. First Half of FY 76 (January 1, 1976-June 30, 1976). 181 pp.

**A. Research Completed—Freshwater Aquaculture Center**

(1) Observations on the Rearing and Breeding of *Macrobrachium* sp. in Aquaria.
(2) Observations on the Culture of *Corbicula manilensis* in Fertilized Ponds with *Tilapia nilotica.*
(3) Polyculture of Freshwater Shrimps and Milkfish.
(4) A Survey of the Plankton in Fertilized Tilapia Ponds of the FAC.
(5) A Study on the Food Habits of *Clarias batrachus* Fingerlings.
(6) Effects of Two Inorganic Fertilizers and Three Stocking Densities on Bangus Production in Freshwater.
(7) Culture of *Tilapia nilotica* at Two Densities with Fertilization and Supplemental Feeding.
(8) Pond Evaluation of Tilapia Hybrids Treated for Sex Reversal.
(9) Culture of *Chlorella* with *Tilapia nilotica* in Earthen Ponds.
(10) Pond Evaluation of *Tilapia zillii* Treated with Ethyltestosterone for Sex Reversal.
(11) Use of Estrone for the Production of Monosex Female *Tilapia mossambica.*
(12) Preliminary Study on the Protein Requirements of *Tilapia mossambica.*
(13) Preliminary Study on the Protein Requirements of *Tilapia mossambica* Fry.
(14) Effects of Two levels of Ipil-ipil Leaf Meal as Supplemental Feed on the Reproductive Performance of *Tilapia mossambica* in Fertilized Ponds.
(15) Preliminary Study on the Protein Requirements of *Clarias batrachus.*
(16) Value of Vitamin-mineral Supplement to Thai Hito Raised in Concrete Tanks.

**B. Research Completed—Brackishwater Aquaculture Center**

(1) The Effectiveness of *Leucaena* Leaf Meal as a Supplemental Feed for Bangus in Brackishwater Fishponds.
(2) Mixed Culture of Bangus Fry and Fingerlings in Brackishwater Ponds with Plankton.
(3) Evaluation of the Use of Subdivided Ponds Using Nets to Increase Experimental Limits (Trial II).
(4) The Culture of Tilapia in Brackishwater Ponds Using Tenpounder to Control Reproduction (Trial II).
(5) Simultaneous Culture of Bangus Fry Inside Hapas and Bangus Fingerlings Loose in Same Ponds (Trial II).
(6) Preliminary Study on the Artificial Reproduction of Bangus (Sabalo).

10. Inland Fisheries Project Philippines—Technical Report No. 10. Second Half of FY 76 (July 1, 1976-December 31, 1976). 168 pp.

**A. Research Completed—Freshwater Aquaculture Center**

(1) Culture of *Tilapia nilotica* and *Macrobrachium* Species Separately and in Combination in Fertilized Freshwater Fishponds.
(2) Preliminary Study on the Protein Requirements of Common Carp Fingerlings.
(3) Preliminary Study on the Protein Requirements of Nile Tilapia (*Tilapia nilotica*) Fingerlings.
(4) Preliminary Study on the Protein Requirements of Tilapia Brood Stock Raised in Hapas.
(5) Polyculture of *Tilapia nilotica, T. zillii,* and *Cyprinus carpio.*
(6) The Effect of Varying Levels of Chicken Manure Application and Clipping of Pectoral Spines on the Production of Thai Catfish.
(7) Bioassay of Nicotine Sulfate on Java Tilapia *(Tilapia mossambica)* and Thai Catfish *(Clarias batrachus).*
(8) Production of *Tilapia nilotica* in Rice Paddies at Five Densities.
(9) Screening of Materials as Feed Supplement in a Polyculture System Using Nile Tilapia and Common Carp. I. Supplemental Feeding of Rice Bran, Copra Meal, and Chicken Manure vs. Organic Fertilizer.
(10) Culture of *Tilapia nilotica* in Ponds at 20,000 per hectare with Supplemental Feeding and Different Fertilization Schemes.
(11) Bioassay of Synthetic Pyrethroid on Java Tilapia *(Tilapia mossambica)* and Thai Catfish *(Clarias batrachus).*

**B. Research Completed—Brackishwater Aquaculture Center**

(1) Preliminary Study on the Use of Rice Straw as an Additional Substrate for Fishfood Organisms.
(2) Mass Culture of Food Organisms Using Different Fertilizers and Nutrient Media.
(3) The Effect of Stock Manipulation on Growth and Production of Milkfish in Ponds.
(4) Culture of Tilapia in Brackishwater Ponds using Tarpon to Control Reproduction.
(5) Milkfish Trials on the Use of Chicken Manure, Shredded Rice Straw, and Urea.
(6) Milkfish Production at Two Levels of Organic Matter Content in Pond Soil.
(7) A Preliminary Investigation on Methods for Determining the Suitability of Soils for Fishpond Development.
(8) A Comparison of Isonitrogenous Applications of Urea and Ammonium Fertilizers in Brackishwater Fishponds.
(9) Production Response of Milkfish, *Chanos chanos* (Forskal), to Additional Substrate for Fishfood in Brackishwater Ponds.
(10) Relationship between Primary Production and Milkfish Production in Brackishwater Ponds Using Organic and Combination of Organic and Inorganic Fertilizers.

11. Inland Fisheries Project Philippines—Technical Report No. 11. First Half of FY 1977.

**A. Research Completed—Freshwater Aquaculture Center**

(1) Pond Culture of Tilapia Hybrid (Male *T. nilotica* x Female *T. mossambica*) at Two Densities.
(2) Polyculture of *Tilapia nilotica, T. zillii, Cyprinus carpio,* and *Macrobrachium* sp. in Fertilized Ponds.
(3) Milkfish Rearing in Hapas Stationed in Feed-supplemented Production Ponds.
(4) Production of *Tilapia nilotica* in Rice Paddies at Five Densities.
(5) Preliminary Study on the Culture of Common Carp *(Cyprinus carpio)* and Male *Tilapia mossambica* with Rice.
(6) Production of Common Carp in Rice Fields at Three Stocking Densities.
(7) Polyculture of Nile Tilapia and Common Carp in Paddy Fields at Four Stocking Densities.
(8) Yield Comparison of Rice and Fish Grown Separately and Combined Rice-fish Culture.
(9) Screening of Materials as Feed Supplement in a Polyculture System Using Nile Tilapia and Common Carp. Phase II—Supplemental Feeding of Rice Bran, Copra Meal, and Chicken Manure in Fertilized Ponds.
(10) Screening of Materials as Feed Supplement in a Polyculture System Using Nile Tilapia and Common Carp. Phase III-Feeding Varying Levels of Rice Bran.
(11) Preliminary Study on the Protein Requirements of Tilapia Hybrids.

12. Inland Fisheries Project Philippines—Technical Report No. 12. Second Half of FY 1977.

**A. Research Completed—Freshwater Aquaculture Center**

(1) Polyculture of Nile Tilapia, Common Carp, and *Anodonta woodiana* in Fertilized Ponds.
(2) Polyculture of Milkfish (*Chanos chanos* Forskal), All-male Nile Tilapia *(Tilapia nilotica),* and Snakehead *(Ophicephalus striatus)* in Freshwater Ponds with Supplemental Feeding.
(3) Culture of *Tilapia nilotica* in Rice Paddy Fields with and without Supplemental Feeding.
(4) Effect of Different Stocking Weight on the Culture of *Tilapia nilotica* in Paddy Field.
(5) Effect of Varying Ratio on the Polyculture of *Tilapia nilotica* and *Cyprinus carpio* under Rice Paddy Conditions.

(6) Effect of Carbofuran Placement on Fish Survival in Rice Fields.
(7) Effect of Furadan Placement on *Tilapia nilotica* and *Cyprinus carpio* Survival in Paddy Fields.
(8) Development of Fish-paddy Facility for Rotational Rice and Fish Cropping.
(9) Screening of Feedstuffs as Ingredients in the Ration of Freshwater Fishes. Phase I—Utilization of Fish Meal, Rice Bran, Soybean Meal, Mulberry Leaf Meal, Ipil-ipil Leaf Meal, Binlid, Sorghum, and Copra Meal in the Ration for Nile Tilapia.
(10) Preliminary Study on the Protein Requirements of All-male Java Tilapia *(Tilapia mossambica)* Stocked at Different Densities in Hapas.
(11) Screening of Materials as Feed Supplement in a Polyculture System Using Nile Tilapia, Common Carp, and Snakehead. Phase IV—Feeding of Copra Meal at Varying Levels.

## APPENDIX 4

## Publications and Manuscripts Authored or Co-authored by FAC and BAC Researchers


ARCE, RODOLFO G. 1976. An Overview of Agro-fish Farming in Central Luzon. Paper presented at First Regional Agricultural Resources System Research Congress for Central Luzon. El Grande Hotel, Paranaque, Rizal. July 26-29, 1975. 6 pp.

ARCE, RODOLFO G. AND CATALINO R. DE LA CRUZ. 1977. Design Layout Considerations in a Freshwater Rice-fish Culture Farm in the Philippines. Paper presented at Joint South China Seas Project/ SEAFDEC Regional Workshop on Aquaculture Engineering. SCCS Gen/77/15 SEAFDEC, Iloilo, Philippines. Nov. 27-Dec. 3, 1977. pp 335-346.

ARCE, RODOLFO G. AND CATALINO R. DE LA CRUZ. 1978. Improved Rice-fish Culture in the Philippines. 15 pp. (In press).

CRUZ, E. M. AND I. L. LAUDENCIA. 1977. Protein Requirements of *Tilapia mossambica* Fingerlings. Phil. J. Biol. 6 (2):177-182.

CRUZ, E. M. AND I. L. LAUDENCIA. 1977. Preliminary Study on the Protein Requirements of *Clarias batrachus*. Fish. Res. J. Phil. 1 (2):43-45.

GROVER, J. H. 1975. Production of Milkfish in Combination with Common Carp and Thai Catfish in Fertilized Freshwater Ponds. Phil. Fish. 11 (1 and 2):1-16.

GROVER, J. H. 1977. Rice-fish Culture and the Green Revolution. FAO Technical Conference on Aquaculture, Kyoto, Japan. May 26-June 2, 1976. Experience Paper 17. 3 pp.

GROVER, J. H. AND G. T. BANACIA. 1975. Preliminary Yield Trial with Carp Polyculture in Fertilized and Unfertilized Ponds. Phil. J. Fish. 11 (1 and 2):17-22.

GUERRERO, L. A. AND RAFAEL D. GUERRERO, III. 1976. Culture of Freshwater Shrimps in Fertilized Ponds. Paper presented at FAO Technical Conference on Aquaculture, Kyoto, Japan. May 26-June 2, 1976. Experience Paper. 3 pp.

GUERRERO, RAFAEL D., III. 1975. Culture of Monosex Male *Tilapia mossambica* and *Ophicephalus striatus* in Fertilized Ponds with Supplementary Feeding. Phil. J. Fish. 12 (1 and 2):65-68.

GUERRERO, RAFAEL D., III. 1975. Use of Oral Androgens for the Production of All-male *Tilapia aurea* (Steindachner). Trans. Amer. Fish. Soc. 104 (2):342-348.

GUERRERO, RAFAEL D., III. 1976. Culture of *Tilapia nilotica* at Two Densities with Fertilization and Supplemental Feeding. Fish. Res. J. Phil. 1 (1):39-43.

GUERRERO, RAFAEL D., III. 1978. Cage Culture of Nile Tilapia. Copyright 1978 by Agrix. Pub. Corp. E. P. Dev. Corp., Bldg. 79, Dona Hemandy Ave. Corner 13th Street, Quezon City, Philippines. 8 pp.

GUERRERO, RAFAEL D., III. 1978. Pond Culture of Nile Tilapia. Copyright 1978 by Agrix Pub. Corp. Penthouse, Puzon Bldg., Gilmore Corner Rodriguez Blvd., Quezon City, Philippines. 4 pp.

GUERRERO, RAFAEL D., III, AND T. A. ABELLA. 1976. Induced Sex Reversal of *Tilapia nilotica* with Methyltestosterone. Fish Res. J. Phil. 1 (2):46-49.

GUERRERO, RAFAEL D., III, AND T. A. ABELLA. 1978. Culture of *Tilapia nilotica* (male) X *T. mossambica* (female) Hybrid in Fertilized Ponds at Two Densities. (Manuscript in preparation for publication.)

GUERRERO, RAFAEL D., III, AND L. A. GUERRERO. 1975. Monosex Culture of Male and Female *Tilapia mossambica* in Ponds at Three Stocking Rates. Phil. J. Biol. 4 (2):30-34.

GUERRERO, RAFAEL D., III, AND L. A. GUERRERO. 1976. Culture of *Tilapia nilotica* and *Macrobrachium* sp. Separately and in Combination in Fertilized Fishponds. Phil. J. Biol. 14 (2):232-235.

GUERRERO, RAFAEL D., III, L. A. GUERRERO, AND JOHN H. GROVER. 1975. Notes on the Culture of Freshwater Shrimps in Central Luzon. Paper presented at the International Conference on Prawn Farming. Vung Tau, Vietnam. 7 pp.

GUERRERO, RAFAEL D., III, R. M. MAGANA, AND U. U. CARGADO, 1977. Production of Tilapia Fry in Floating Net Enclosures. FAO Aqua. Bull. 8 (3-4):4.

GUERRERO, RAFAEL D., III, AND E. P. VILLANUEVA. 1978. Notes on the Pond Culture of *Macrobrachium idella*. (Manuscript in preparation for publication.)

HEINRICHS, E. A., G. B. AQUINO, J. A. MCMENNAMY, H. ARBOLEDA, N. N. NAVASERO AND R. C. ARCE. Increasing Insecticide Efficiency in Lowland Rice. Agricultural Mechanization in Asia. 1977. Farm Machinery Industrial Research Corp. Vol. VIII, No. 3. pp. 41-47.


The following reports had been approved by the BAC Publications Committee and manuscripts were in preparation for publication when the APP ended.


CAMACHO, ARSENIO S. Use of Agricultural By-products as Feeds for Tilapia in Brackishwater Fishponds.

CAMACHO, ARSENIO S. AND LOURDES A. DUREZA. Feeding Trial Using Ipil-ipil Leaf Meal in Pelletized Feeds for *Tilapia mossambica*.

CHOLIK, FUAD AND ROMEO D. FORTES. The Effect of the Different Densities of Artificial Shelters on the Growth and Survival of *Penaeus monodon* Raised from Fry to Juveniles.

DUREZA, VIRGILIO A. AND CARMEN L. GEMPIS. Production Response of Milkfish in Brackishwater Ponds with Added Substrates.

FORTES, NORMA R. AND CRISPINO SACLAUSO. An Evaluation of the Effect of Fertilizer on Water and Soil-water System.

FORTES, ROMEO D. Mixed Culture of Milkfish and Tilapia in Brackishwater Ponds with Tarpon as Biological Control for Tilapia Reproduction.

FRITZ, LAWRENCE AND HERNANE J. GONZALES. Primary Productivity and Fish Yield in Brackishwater Ponds.

LEARY, DANIEL F. AND CARLOS C. BAYLON. A Successful Method for Establishing Grasses (*Cynodon* spp.) on Acidic Soils to Minimize Erosion.


## APPENDIX 5

## Theses and Dissertations by Filipino Participants who Received Graduate Degrees from Auburn University Under IFP-APP Sponsorship


ALMAZAN, GAUDIOSA. 1974. Studies on Oxygen Consumption by Microbial Organisms during Decomposition of Aquatic Plants. M.S. Thesis. December 11, 1974. 41 pp.

ALMAZAN, GAUDIOSA. 1977. Evaluation of the Secchi Disk as an Index of Plankton Diversity in Fish Ponds. Ph.D. Dissertation. August 26, 1977. 49 pp.

APOLINARIO, KATHERINE MARTELINO. 1975. Recovery and Utilization of Boneless Flesh Mechanically Separated from Tilapia *(Tilapia aurea)*, Buffalo fish *(Setiolius cyprinellus* x *Ictiobus niger)*, and Channel Catfish *(Ictalurus punctatus)*. M.S. Thesis. August 26, 1975. 44 pp.

ARCE, RODOLFO G. 1974. Effects of Applications of Agricultural Limestone on Water Chemistry, Phytoplankton Productivity, and Tilapia Production in Soft-water Ponds. M.S. Thesis. December 11, 1974. 37 pp.

CAMACHO, ARSENIO SABANGAR. 1974. Characterization of Thiamine Deficiency in Channel Catfish (*Ictalurus punctatus*, Rafinesque) Fed Heated and Non-heated Catfish Processing Waste. Ph.D. Dissertation. August 27, 1974. 85 pp.

CANLAS, JOEL ROGUE. 1975. The Parasitic and Bacterial Loads of Channel Catfish, *Ictalurus punctatus*, Raised in Two Farm Ponds. M.S. Thesis. December 10, 1975. 45 pp.

CARREÓN, JOSE ASAHAN. 1978. Studies on the Culture of Larval Striped Bass *Morone saxatilis* (Walbaum) in Closed Recirculating Systems. Ph.D. Dissertation. June 6, 1978.

DE LA CRUZ, CATALINO DEL ROSARIO. 1974. The Effects of Water Circulation and Aeration on Water Quality and Production of Catfish in a Closed System. Ph.D. Dissertation. August 27, 1974. 139 pp.

CRUZ, EMMANUEL. 1975. Determination of Nutrient Digestibility in Various Classes of Natural and Purified Feed Materials for Channel Catfish. Ph.D. Dissertation. December 1975.

DUREZA, VIRGILIO APURA. 1976. The Determination of the Efficiency of Three Aeration Systems in the Production of Channel Catfish in Earthen Ponds. M.S. Thesis. March 18, 1976. 43 pp.

FORTES, ROMEO DINO. 1973. Studies on Chlorophyll in Pond Waters. M.S. Thesis. August 24, 1973. 51 pp.

GUERRERO, RAFAEL DINEROS, III. 1974. The Use of Synthetic Androgens for the Production of Monosex Male *Tilapia aurea* (Steindachner). Ph.D. Dissertation. March 18, 1974. 112 pp.

LIM, RICARDO R. 1977. Growth, Survival, and Sexual Maturity of the Initial Year Class of Common Carp *(Cyprinus carpio)* in West Point Reservoir, Alabama and Georgia. M.S. Thesis. August 26, 1977. 29 pp.

QUINES, OSCAR DR. 1978. The Effect of Environmental Stress on Channel Catfish *(Ictalurus punctatus)* Fingerlings Experimentally Infected with *Flexibacter Columnaris*. M.S. Thesis. December 8, 1978. 31 pp.

SEVILLEJA, RUBEN CADIENTE. 1978. Fish Marketing in Central Luzon, Philippines. M.S. Thesis. August 24, 1978. 83 pp.

TAYAMEN, MELCHOR MADARONG. 1977. The Inducement of Sex Reversal in *Sarotherodon niloticus*. M.S. Thesis. December 8, 1977. 40 pp.

VENTURA, RODOLFO FEIJO. 1974. A Survey of Methods in Artificial Breeding of Grass Carp. M.S. Thesis. December 11, 1974. 41 pp.

## APPENDIX 6

### Courses offered by Central Luzon State University, College of Inland Fisheries

| *Department–course* | *Semester credits* |
|---|---|
| I. Department of Aquatic Biology | |
| A. Ichthyology | 5 |
| B. Aquatic Biology | 5 |
| C. Parasites and Diseases | 4 |
| D. Aquatic Invertebrates | 4 |
| E. Aquatic Flora | 4 |
| F. Marine Fisheries | 3 |
| G. Estuarine Ecology | 3 |
| II. Department of Aquaculture | |
| A. Aquaculture | 3 |
| B. Fishpond Management | 4 |
| C. Fish Processing | 4 |
| D. Hatchery Management | 4 |
| E. Fish Nutrition | 4 |
| F. Research Methodology | 2 |
| III. Department of Fisheries Management | |
| A. Fishpond Engineering | 5 |
| B. Limnology | 4 |
| C. Fishery Laws | 2 |
| D. Inland Fisheries Management | 3 |
| E. Fishery Skills | 3 |
| IV. All Departments | |
| Undergraduate Thesis or Field Practice | 2 |
| Seminar | 1 |
| Special Problems | 3 |

## APPENDIX 7

### Leaflets and Other Extension Literature Developed During the IFP-APP

1. Fishpond Fertilizers and Fertilization. IFP Fish Culture Leaflet (IFP FCL) No. 1. 4 pp.
2. Platform Method of Fishpond Fertilization. IFP FCL No. 2. 2 pp.
3. Plankton Method for Raising Bangus. IFP FCL No. 3. 1 p.
4. Length-weight Table for Bangus. IFP FCL No. 4. 3 pp.
5. Bangus Transfer from one Salinity to Another. IFP FCL No. 5. 3 pp.
6. A Simple Salinometer. IFP FCL No. 6. 2 pp.
7. Problems of Freshwater Catfish Culture. IFP FCL No. 7. 2 pp.
8. Primer on Paddy Culture of Rice. R. G. Arce. 7 pp.
9. Notes on Cage Culture of Nile Tilapia. R. D. Gurrero, III. 1 p.
10. Cage Culture of Nile Tilapia. R. D. Guerrero, III. 8 pp.
11. Pond Culture of Nile Tilapia. R. D. Guerrero, III. 4 pp.
12. The Philippines Recommends for Tilapia. PCARR, Tilapia Committee. 28 pp.
13. The Philippines Recommends for Bangus. PCARR, Bangus Committee.
14. Grow Lumut in your Fishpond. BFAR. 2 pp.
15. Standard Operating Procedure in the Issuance of 25-year Lease Fishpond Agreement. BFAR. 2 pp.
16. Brief Life History of Bangus. BFAR. 1 p.
17. Determination of the Elevation of Swampland. BFAR. 2 pp.
18. Plankton. BFAR. 1 p.
19. Freshwater Aquaculture. CLSU (brochure).
20. College of Inland Fisheries. CLSU (brochure).
21. Fisheries Extension. BFAR (periodic newspaper).
22. Diseases and Parasites of Cultured Fish. E. M. Cruz.
23. Know Your Tilapia. R. D. Guerrero, III.
24. Seining, Segregation, and Maturity of Spawners. R. D. Recomeeta.
25. How to Grow Large Tilapia. R. D. Guerrero, III.
26. Some Characteristics of Mangrove Soils which Influence their Quality for Use in Fishponds. T. Potter. 6 pp.

## APPENDIX 8

### Courses Offered by UP-SEAFDEC Graduate Program and Undergraduate Courses Offered by UP (Iloilo Branch)

**UP-SEAFDEC graduate program**

| *Title* | *Credits* |
|---|---|
| Advanced Aquaculture | 5 |
| Hatchery Management | 3 |
| Pond Construction | 3 |
| Pond Limnology | 3 |
| Fish Diseases | 3 |
| Pond Management | 4 |
| Fish Nutrition | 3 |
| Fundamentals of Research Design | 3 |
| Special Problems | 3 |
| Seminar | 1 |

**UP (Iloilo Branch) undergraduate courses**

| *Title* | *Credits* |
|---|---|
| General Fisheries | 3 |
| Aquaculture I | 5 |
| Aquaculture II | 5 |
| Aquaculture III | 4 |
| Fish Diseases | 3 |
| Limnology | 5 |
| Inland Fisheries Management | 3 |
| Ecology of Fishes | |
| Fishing Gear | 2 |
| Ichthyology I | 5 |
| Ichthyology II | 3 |
| Morphometry | 3 |
| Refrigeration | 3 |
| Aquatic Invertebrates[1] | 3 |
| Organic Chemistry for Fisheries[1] | 4 |
| Analytical Chemistry for Fisheries[1] | 5 |
| Aquatic Flora[1] | 3 |

[1]BAC staff not involved in teaching these courses.

## APPENDIX 9

## Theses Completed by Graduate Students and Graduate Student Research Projects in Progress at the BAC as of September 1978

### Theses Completed

1. The Relationship between Primary Production in Brackishwater Ponds Using Organic and Combination Organic-inorganic Fertilizers.
2. The Effect of Stock Manipulation on Growth and Production of Milkfish in Brackishwater Fishponds.
3. Study of the Effect of the Number of Artificial Shelters on Survival and Growth of *Penaeus monodon* fry in Ponds.

### Research Projects In Progress

1. Phosphorus Dynamics in Brackishwater Fishponds.
2. Effects of Varying Salinities and Hormone Levels on Growth and Survival and Sex Reversal of the Cichlid Fry *Tilapia mossambica* Treated with Methyltestosterone.
3. Intensive Feeding of Milkfish Fry in Net Enclosures Using Complete and Incomplete Diets at Various Protein Levels.
4. Histological Studies on Ovarian Development of Captive Ablated and Unablated *Penaeus monodon*.
5. Study of the Quantitative Requirement for Dietary Protein of *Penaeus monodon* Juveniles in a Controlled Environment.
6. Evaluation of Some Management Schemes Used in Mass Production of Prawn Juveniles in a Controlled Environment.
7. Survival and Growth Rate of Transplanted Mussels and Evaluation of Different Substrates and Binding Materials.
8. Food and Feeding Habits of Milkfish Fry Collected Along the Coast of Antique.
9. The Effects of Age and Population Density of Phytoplankton on Feeding and Survival Rates of *Penaeus monodon* larvae.
10. Growth and Survival of Milkfish Fry Fed with Lab-lab in Nursery Boxes Maintained under Semi-controlled Conditions.
11. Formulation and Evaluation of a Feed for *Penaeus monodon* in Ponds.
12. Variations of Orthophosphate Concentration in Phosphorus Enriched Soil-water Systems.
13. Comparative Study of Methods for Quantitative and Qualitative Evaluation of Lab-lab in Ponds.
14. The Effect of Salinity and Manipulation of Milkfish Fry Stocking Density.
15. The Meiofauna of Brackishwater Ponds and Their Relation to Food Habits of Cultured *Penaeus monodon*.
16. Etiology, Histopathology, and Treatment of Experimentally Induced Fin-rot in Marine Fishes.
17. Effects of Various Lipid Sources on the Growth and Survival Rates of *Penaeus monodon* from Post Larvae to Juveniles in a Controlled Environment.
18. Growth and Body Composition of Milkfish Fingerlings Fed Various Sources of Protein in a Controlled Environment.